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Plenary Lecture 1

Application of Paraconsistent Annotated Logic Program EVALPSN to Intelligent Control/Safety Verification

Prof. Kazumi Nakamatsu
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Abstract: Paraconsistent logic is well known as a formal logic that can deal with contradiction in the framework of logical system consistently. One of paraconsistent logics called annotated logic has been proposed by Prof. Newton da Costa, and its logic program has also been proposed by Prof. V.S. Subrahmanian et al. later as a tool of dealing with knowledge bases.
Some paraconsistent annotated logic programs with strong negation have been developed for dealing with non-monotonic reasoning such as default reasoning, defeasible reasoning, defeasible deontic reasoning, plausible reasoning, etc. by Kazumi Nakamatsu. Recently He has proposed a paraconsistent annotated logic program called Extended Vector Annotated Logic Program with Strong Negation (EVALPSN), which can deal with conflict resolving, defensible deontic reasoning, plausible reasoning, etc. The EVALPSN reasoning function has been applied to various intelligent controls and safety verification systems such as pipeline valve control, traffic signal control, railway interlocking safety verification, etc. In this lecture, some of these applications of EVALPSN with some simulation systems will be introduced.
Moreover, a special EVALPSN that can deal with before-after relations between processes (time intervals), which has been named bf(before-after) -EVALPSN has been developed. It has been shown that bf-EVALPSN can be applied to real-time process order control. It will also be introduced how to apply bf-EVALPSN to intelligent real-time process order control and safety verification with examples.

Brief Biography of the Speaker: Kazumi Nakamatsu received the Ms. Eng. and Dr. Sci. from Shizuoka University and Kyushu University, Japan, respectively. He is a full Professor at School of Human Science and Environment, University of Hyogo, Japan.
His research interests encompass various kinds of logic and their applications to Computer Science, especially paraconsistent annotated logic programs and their applications. He has developed some paraconsistent annotated logic programs called ALPSN(Annotated Logic Program with Strong Negation), VALPSN(Vector ALPSN), EVALPSN(Extended VALPSN) and bf-EVALPSN (before-after EVALPSN) recently, and applied them to various intelligent systems such as a safety verification based railway interlocking control system and process order control. He is an author of over 150 papers and book chapters, and edited 7 books published by prominent publishers.

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Kazumi Nakamatsu has chaired various international conferences, workshops and invited sessions, and he has been a member of numerous international program committees of workshops and conferences in the area of Artificial Intelligence and Computer Science. He serves as Editor-in-Chief of the International Journal of Reasoning-based Intelligent Systems by Inderscience Publishers(UK) and an editorial board member of many international journals. He has contributed numerous invited lectures at international workshops, conferences, and academic organizations. He also is a recipient of some conference and paper awards. He is a member of Japan AI Society, IEEE, etc.

Paraconsistent Annotated Logic Program and its Application to Intelligent Control Systems

Kazumi Nakamatsu,[1] Jair M. Abe,[2] Seiki Akama[3]

Abstract—We have developed an annotated logic program called an Extended Vector Annotated Logic Program with Strong Negation(abbr. EVALPSN), which can deal with defeasible deontic reasoning and contradiction. We also have extended EVALPSN to deal with before-after relation between processes, which was named before-after(abbr. bf)EVALPSN. We have already applied EVALPSN and bf-EVALPSN to various kinds of intelligent control. In this paper, we review how to apply EVALPSN to traffic signal control and bf-EVALPSN to the safety verification of process order control.

Keyword— paraconsistent annotated logic program, traffic signal control, EVALPSN, bf-EVALPSN, intelligent control system.

I. Introduction

We have developed an annotated logic program called EVALPSN(Extended Vector Annotated Logic Program with Strong Negation)[9] in order to deal with defeasible deontic reasoning and contradiction in a framework of the same paraconsistent logic programming.

EVALPSN has been applied to various kinds of intelligent control such as air traffic control[4], [6]. In this paper, we introduce EVALPSN based intelligent traffic signal control as one example[5], [8]. The basic idea of the traffic signal control is that the conflict can be managed by the defeasible deontic reasoning of EVALPSN. We show how to formalize the traffic signal control in defeasible deontic reasoning by EVALPSN.

Moreover, we have developed EVALPSN toward treating before-after relations between processes(time intervals) and applied it to process order control, which has been named bf(before-after)-EVALPSN[10]. Bf-EVALPSN based before-after relation reasoning system consists of two kinds of efficient inference rules called the basic bf-inference rule and the transitive bf-inference rule that can be implemented as a bf-EVALPSN. We would like to review bf-EVALPSN based process order control with a simple example in this paper.

This paper is a review paper for paraconsistent annotated logic program called EVALPSN and organized as follows: first, we review EVALPSN briefly and introduce the basic traffic signal control based on EVALPSN; then, we introduce bf-EVALPSN with a simple example; and last, we conclude this paper.

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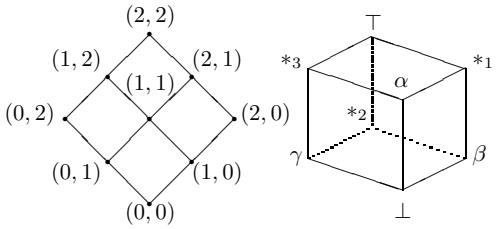

Fig. 1. Lattice $\mathcal{T}_v(2)$ and Lattice $\mathcal{T}_d$

II. EVALPSN

In this section, we review EVALPSN briefly[3]. Generally, a truth value called an *annotation* is explicitly attached to each literal in annotated logic programs[1]. For example, let p be a literal, μ an annotation, then $p{:}\,\mu$ is called an *annotated literal*. The set of annotations constitutes a complete lattice. An annotation in EVALPSN has a form of $[(i, j), \mu]$ called an *extended vector annotation*. The first component (i, j) is called a *vector annotation* and the set of vector annotations constitutes the complete lattice,

$$\mathcal{T}_v(n) = \{(x, y) \mid 0 \leq x \leq n, 0 \leq y \leq n, x, y, n \text{ are integers}\}$$

in Fig.1. The ordering($\preceq_v$) of $\mathcal{T}_v(n)$ is defined as : let (x_1, y_1), $(x_2, y_2) \in \mathcal{T}_v(n)$,

$$(x_1, y_1) \preceq_v (x_2, y_2) \text{ iff } x_1 \leq x_2 \text{ and } y_1 \leq y_2.$$

For each extended vector annotated literal $p : [(i, j), \mu]$, the integer i denotes the amount of positive information to support the literal p and the integer j denotes that of negative one. The second component μ is an index of fact and deontic notions such as obligation, and the set of the second components constitutes the complete lattice,

$$\mathcal{T}_d = \{\bot, \alpha, \beta, \gamma, *_1, *_2, *_3, \top\}.$$

The ordering ($\preceq_d$) of $\mathcal{T}_d$ is described by the Hasse's diagram in Fig.1. The intuitive meaning of each member of $\mathcal{T}_d$ is

$$\begin{aligned}
&\bot(unknown), \quad \alpha(fact), \quad \beta(obligation),\\
&\gamma(non-obligation), \quad *_1(factandobligation),\\
&*_2(obligationandnon-obligation),\\
&*_3(factandnon-obligation),\\
&\top(inconsistency).
\end{aligned}$$

Then, the complete lattice $\mathcal{T}_e(n)$ of extended vector annotations is defined as the product, $\mathcal{T}_v(n) \times \mathcal{T}_d$. The ordering ($\preceq_e$)

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of $\mathcal{T}_e(n)$ is defined: let $[(i_1, j_1), \mu_1]$, $[(i_2, j_2), \mu_2] \in \mathcal{T}_e$,

$$[(i_1, j_1), \mu_1] \preceq_e [(i_2, j_2), \mu_2]$$
$$\text{iff}$$
$$(i_1, j_1) \preceq_v (i_2, j_2) \text{ and } \mu_1 \preceq_d \mu_2.$$

There are two kinds of *epistemic negation* ($\neg_1$ and $\neg_2$) in EVALPSN, both of which are defined as mappings over $\mathcal{T}_v(n)$ and $\mathcal{T}_d$, respectively.

DEFINITION 1 (epistemic negations $\neg_1$ and $\neg_2$ in EVALPSN)

$$\neg_1([(i,j),\mu]) = [(j,i),\mu],\ \forall \mu \in \mathcal{T}_d,$$
$$\neg_2([(i,j),\bot]) = [(i,j),\bot],\ \neg_2([(i,j),\alpha]) = [(i,j),\alpha],$$
$$\neg_2([(i,j),\beta]) = [(i,j),\gamma],\ \neg_2([(i,j),\gamma]) = [(i,j),\beta],$$
$$\neg_2([(i,j),*_1]) = [(i,j),*_3],\ \neg_2([(i,j),*_2]) = [(i,j),*_2],$$
$$\neg_2([(i,j),*_3]) = [(i,j),*_1],\ \neg_2([(i,j),\top]) = [(i,j),\top].$$

If we regard the epistemic negations as syntactical operations, the epistemic negations followed by literals can be eliminated by the syntactical operations.

There is another negation called *strong negation* ($\sim$) in EVALPSN, and it is treated as well as classical negation[2].

DEFINITION 2 (strong negation $\sim$)
Let F be any formula and $\neg$ be $\neg_1$ or $\neg_2$.

$$\sim F =_{def} F \rightarrow ((F \rightarrow F) \wedge \neg(F \rightarrow F)).$$

DEFINITION 3 (well extended vector annotated literal)
Let p be a literal.

$$p{:}[(i,0),\mu] \qquad \text{and} \qquad p{:}[(0,j),\mu]$$

are called *well extended vector annotated literals*, where i, j are non-negative integers and $\mu \in \{\ \alpha,\ \beta,\ \gamma\ \}$.

DEFINITION 4 (EVALPSN)
If $L_0, \cdots, L_n$ are weva-literals,

$$L_1 \wedge \cdots \wedge L_i \wedge \sim L_{i+1} \wedge \cdots \wedge \sim L_n \rightarrow L_0$$

is called an *EVALPSN clause*. An *EVALPSN* is a finite set of EVALPSN clauses.

Here we comment that if the annotations α and β represent fact and obligation,

$$\begin{aligned}&\text{fact is represented by} \quad [(m,0),\alpha],\\ &\text{obligation is done by} \quad [(m,0),\beta],\\ &\text{forbiddance is done by} \quad [(0,m),\beta],\\ &\text{permission is done by} \quad [(0,m),\gamma],\end{aligned}$$

respectively, in EVALPSN, where m is a non-negative integer.

III. Traffic Signal Control in EVALPSN

We take an intersection in which two roads are crossing described in Fig.2 as an example for introducing our method based on EVALPSN. We suppose an intersection in Japan, which means "cars have to keep left". The intersection has four traffic signals $T_{1,2,3,4}$, which have four kinds of lights, green, yellow, red and right-turn arrow. Each lane connected to the intersection has a sensor to detect traffic amount. Each

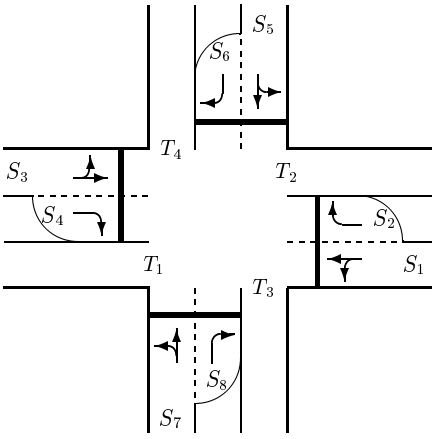

Fig. 2. Intersection

sensor is described as $S_i (1 \leq i \leq 8)$ in Fig.2. For example, the sensor S_6 detects the right turn traffic amount confronting the traffic signal T_1. Basically, the traffic signal control is performed based on the traffic amount sensor values. The chain of signaling is as follows :

$$\rightarrow \text{ red } \rightarrow \text{ green } \rightarrow \text{ yellow } \rightarrow \text{ right arrow } \rightarrow \text{ red } \rightarrow .$$

For simplicity, we assume that the lengths of yellow and all red signaling time are constant, therefore, the signaling time of yellow and all red are supposed to be included in those of green and right-turn arrow, respectively as follows :

$$\begin{aligned}&T_{1,2}\\ &\quad \rightarrow \text{ red } \rightarrow \text{ red } \rightarrow \text{ green } \rightarrow \text{ arrow } \rightarrow \text{ red } \rightarrow,\\ &T_{3,4}\\ &\quad \rightarrow \text{ green } \rightarrow \text{ arrow } \rightarrow \text{ red } \rightarrow \text{ red } \rightarrow \text{ green } \rightarrow .\end{aligned}$$

Only the turns from green to arrow and from arrow to red is controlled mainly. The turn from red to green of the front traffic signal follows the turn from right-turn arrow to red of the neighbor one. Moreover, the signaling is controlled at each unit time $t \in \{0, 1, 2, \ldots, n\}$. The traffic amount of each lane is regarded as permission for or forbiddance from signaling change such as green to right-turn arrow. For example, if there are many cars waiting for the signal turn from green to right-turn arrow, it can be regarded as the permission for the signal turn from green to right-turn arrow, on the other hand, if there are many cars moving through the intersection with green, it can be regarded as the forbiddance from the signaling change with green to right-turn arrow. We formalize such contradiction and its resolution by deontic defeasible reasoning in EVALPSN. We assume that minimum and maximum signaling times are previously given for each traffic signal and each signaling time must be controlled between the minimum and maximum. We consider the four states of the traffic signals, state 1 ($T_{1,2}$ are red and $T_{3,4}$ are green), state 2 ($T_{1,2}$ are red and $T_{3,4}$ are right-turn arrow), state 3 ($T_{1,2}$ are green and $T_{3,4}$ are red), state 4 ($T_{1,2}$ are right-turn arrow and $T_{3,4}$ are red). Due to space restriction,

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we take only the case 1 into account to introduce the traffic signal control in EVALPSN.

$$
\begin{aligned}
&{S^{rb}}_1(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim MIN_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_5(t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_7(t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\gamma], \qquad (1)
\end{aligned}
$$

$$
\begin{aligned}
&{S^{rb}}_3(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim MIN_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_5(t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_7(t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\gamma], \qquad (2)
\end{aligned}
$$

$$
\begin{aligned}
&{S^{rb}}_2(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim MIN_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_5(t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_7(t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\gamma], \qquad (3)
\end{aligned}
$$

$$
\begin{aligned}
&{S^{rb}}_4(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim MIN_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_5(t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_7(t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\gamma], \qquad (4)
\end{aligned}
$$

$$
\begin{aligned}
&{S^{rb}}_6(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&{S^{rb'}}_7(t):[(2,0),\alpha] \wedge \\
&\sim MIN_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_5(t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_7(t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\gamma], \qquad (5)
\end{aligned}
$$

$$
\begin{aligned}
&{S^{rb}}_8(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&{S^{rb'}}_5(t):[(2,0),\alpha] \wedge \\
&\sim MIN_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_5(t):[(2,0),\alpha] \wedge \\
&\sim {S^{rb}}_7(t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\gamma], \qquad (6)
\end{aligned}
$$

$$
\begin{aligned}
&{S^{rb}}_5(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim MAX_{3,4}(b,t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\beta], \qquad (7)
\end{aligned}
$$

$$
\begin{aligned}
&{S^{rb}}_7(t):[(2,0),\alpha] \wedge \\
&T_{1,2}(r,t):[(2,0),\alpha] \wedge \\
&T_{3,4}(b,t):[(2,0),\alpha] \wedge \\
&\sim MAX_{3,4}(b,t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,1),\beta], \qquad (8)
\end{aligned}
$$

$$
\begin{aligned}
&MIN_{3,4}(g,t):[(2,0),\alpha] \wedge T_{3,4}(g,t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,2),\beta], \qquad (9)
\end{aligned}
$$

$$
\begin{aligned}
&MAX_{3,4}(g,t):[(2,0),\alpha] \wedge T_{3,4}(g,t):[(2,0),\alpha] \\
&\rightarrow T_{3,4}(a,t):[(0,2),\gamma], \qquad (10)
\end{aligned}
$$

$$
\begin{aligned}
&T_{3,4}(g,t):[(2,0),\alpha] \wedge T_{3,4}(a,t):[(0,1),\gamma] \\
&\rightarrow T_{3,4}(a,t+1):[(2,0),\beta], \qquad (11)
\end{aligned}
$$

$$
\begin{aligned}
&T_{3,4}(g,t):[(2,0),\alpha] \wedge T_{3,4}(a,t):[(0,1),\beta] \\
&\rightarrow T_{3,4}(g,t+1):[(2,0),\beta]. \qquad (12)
\end{aligned}
$$

IV. Traffic Signal Control Simulation

Suppose that the traffic signals $T_{1,2}$ are red and the traffic signals $T_{3,4}$ are green, and the minimum signaling time of green has been already passed.

- If the sensors $S_{1,3,5}$ detect more traffic amount than the criteria and the sensors $S_{2,4,6,7,8}$ do not detect at the time t, then, the EVALPSN clause (7) is fired and the forbiddance $T_{3,4}(a,t):[(0,1),\beta]$ is derived, furthermore, the EVALPSN clause (12) is also fired and the obligatory result $T_{3,4}(g,t+1):[(2,0),\beta]$ is obtained.
- If the sensors $S_{1,3}$ detect more traffic amount than the criteria and the sensors $S_{2,4,5,6,7,8}$ do not detect at the time t, then, the EVALPSN clause (8) is fired and the permission $T_{3,4}(a,t):[(0,1),\gamma]$ is derived, furthermore, the EVALPSN clause (11) is also fired and the obligatory result $T_{3,4}(a,t+1):[(2,0),\beta]$ is obtained.

We used the cellular automaton model for traffic flow and compared the EVALPSN traffic signal control to fixed-time

traffic signal control in terms of the numbers of cars stopped and moved under the following conditions.

[Condition 1]

We suppose that : cars are flowing into the intersection in the following probabilities from all 4 directions, right-turn 5%, left-turn 5% and straight 20% ; the fixed-time traffic signal control, green 30, yellow 3, right-arrow 4 and red 40 unit times ; the length of green signaling between 3 and 14 unit times, and the length of right-arrow signaling between 1 to 4 unit times.

[Condition 2]

We suppose that : cars are flowing into the intersection in the following probabilities ; from South, right-turn 5%, left-turn 15% and straight 10% ; from North, right-turn 15%, left-turn 5% and straight 10% ; from West, right-turn, left-turn and straight 5% each ; from East, right-turn and left-turn 5% each, and straight 15% ; other conditions are the same as the Condition 1.

We measured the sums of cars stopped and moved for 1000 unit times, and repeated it 10 times under the conditions. The average numbers of cars stopped and moved are shown in Table.I. This simulation results say that ; the number of cars moved when the EVALPSN control is larger than that when the fixed control, and the number of cars stopped when

TABLE I
SIMULATION RESULTS

	fixed-time control		EVALPSN control	
	car stopped	car moved	car stopped	car moved
Condition 1	17690	19641	16285	23151
Condition 2	16764	18664	12738	20121

the EVALPSN control is smaller than that when the fixed time control. Taking only the simulation into account, it is concluded that the EVALPSN control is more efficient than the fixed time one.

V. BEFORE-AFTER EVALPSN

In this section, we review bf-EVALPSN. The details are found in [10]

In bf-EVALPSN, a special annotated literal $R(p_m, p_n, t) : [(i, j), \mu]$ called *bf-literal* whose non-negative integer vector annotation (i, j) represents the before-after relation between processes Pr_m and Pr_n at time t is introduced. The integer components i and j of the vector annotation (i, j) represent the after and before degrees between processes $Pr_m(p_m)$ and $Pr_n(p_n)$, respectively, and before-after relations are represented paraconsistently in vector annotations.

DEFINITION 5(bf-EVALPSN)

An extended vector annotated literal,

$$R(p_i, p_j, t) : [(i, j), \mu]$$

is called a *bf-EVALP literal* or a *bf-literal* for short, where (i, j) is a vector annotation and $\mu \in \{\alpha, \beta, \gamma\}$. If an EVALPSN clause contains bf-EVALP literals, it is called a *bf-EVALPSN clause* or just a *bf-EVALP clause* if it contains no strong negation. A *bf-EVALPSN* is a finite set of bf-EVALPSN clauses.

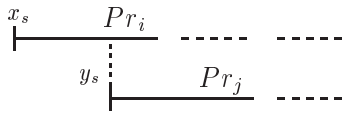

Fig. 3. Before(be)/After(af)

Fig. 4. Disjoint Before(db)/After(da)

We provide a paraconsistent before-after interpretation for vector annotations representing bf-relations in bf-EVALPSN, and such a vector annotation is called a *bf-annotation*. Exactly speaking, there are fifteen kinds of bf-relation according to before-after order between four start/finish times of two processes.

Before(be)/After(af) are defined according to the bf-relation between each start time of two processes. If one process has started before/after another one starts, then the bf-relations between them are defined as "before/after", which are represented as the figure in Fig.3.

We introduce other kinds of bf-relations as well as before(be)/after(af).

Disjoint Before(db)/After(da) are defined as there is a time lag between the earlier process finish time and the later one start time, which are described as the figure in Fig. 4.

Immediate Before(mb)/After(ma) are defined as there is no time lag between the earlier process finish time and the later one start time, which are described as the figure in Fig.5.

Joint Before(jb)/After(ja) are defined as two processes over lap and the earlier process had finished before the later one finished, which are described as the figure in Fig.6.

S-included Before(sb)/After(sa) are defined as one process had started before another one started and they have finished at the same time, which are described as the figure in Fig.7.

Included Before(ib)/After(ia) are defined as one process had started/ finished before/after another one started/finished, which are described as the figure in Fig.8.

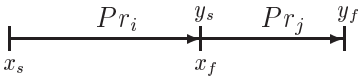

Fig. 5. Immediate Before(mb)/After(ma)

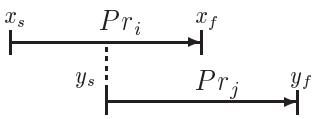

Fig. 6. Joint Before(jb)/After(ja)

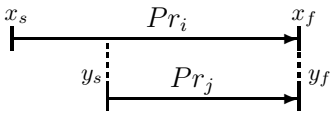

Fig. 7. S-included Before(sb)/After(sa)

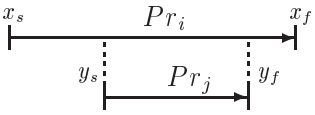

Fig. 8. Included Before(ib)/After(ia)

F-included Before(fb)/After(fa) are defined as the two processes have started at the same time and one process had finished before another one finished, which are described as the figure in Fig.9.

Paraconsistent Before-after(pba) is defined as two processes have started at the same time and also finished at the same time, which is described as the figure in Fig.10.

The epistemic negation over bf-annotations, be, af, db, da, mb, ma, jb, ja, ib, ia, sb, sa, fb, fa, pba is defined and the complete lattice of bf-annotations is shown in Fig.11.

DEFINITION 6 (Epistemic Negation $\neg_1$ for Bf-annotations) The epistemic negation $\neg_1$ over the bf-annotations is obviously defined as the following mappings:

$$\begin{aligned}
&\neg_1(\mathtt{af}) = \mathtt{be}, \quad \neg_1(\mathtt{be}) = \mathtt{af}, \quad \neg_1(\mathtt{da}) = \mathtt{db},\\
&\neg_1(\mathtt{db}) = \mathtt{da}, \quad \neg_1(\mathtt{ma}) = \mathtt{mb}, \quad \neg_1(\mathtt{mb}) = \mathtt{ma},\\
&\neg_1(\mathtt{ja}) = \mathtt{jb}, \quad \neg_1(\mathtt{jb}) = \mathtt{ja}, \quad \neg_1(\mathtt{sa}) = \mathtt{sb},\\
&\neg_1(\mathtt{sb}) = \mathtt{sa}, \quad \neg_1(\mathtt{ia}) = \mathtt{ib}, \quad \neg_1(\mathtt{ib}) = \mathtt{ia},\\
&\neg_1(\mathtt{fa}) = \mathtt{fb}, \quad \neg_1(\mathtt{fb}) = \mathtt{fa}, \quad \neg_1(\mathtt{pba}) = \mathtt{pba}.
\end{aligned}$$

Therefore, each bf-annotation can be translated into vector annotatations as

$$\begin{aligned}
&\mathtt{bf} = (0,8), \quad \mathtt{db} = (0,12), \quad \mathtt{mb} = (1,11),\\
&\mathtt{jb} = (2,10), \quad \mathtt{sb} = (3,9), \quad \mathtt{ib} = (4,8),\\
&\mathtt{fb} = (5,7), \quad \mathtt{pba} = (6,6).
\end{aligned}$$

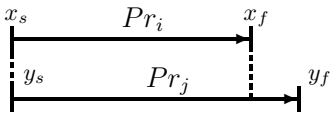

Fig. 9. F-included Before(fb)/After(fa)

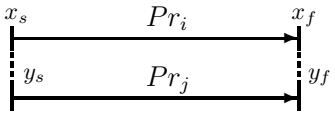

Fig. 10. Paraconsistent Before-after(pba)

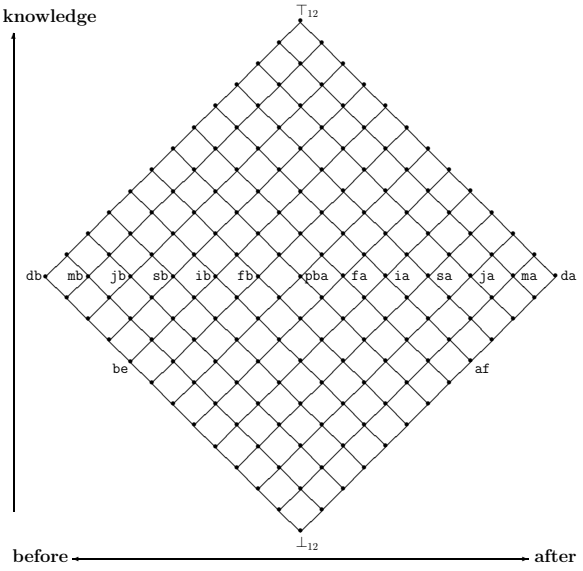

Fig. 11. The Complete Lattice $\mathcal{T}_v(12)_{bf}$ for Bf-annotations

VI. Reasoning System in Bf-EVALPSN

The details of the reasoning system of bf-EVALPSN can be found in [10]. In order to represent the *basic bf-inference rule* in bf-EVALPSN, we newly introduce two literals:

- $st(p_i, t)$ represents that process Pr_i starts at time t, and
- $fi(p_i, t)$ represents process Pr_i finishes at time t.

Those literals are used for expressing process start/finish information and may have one of the vector annotations,

$$\{\bot(0,0), \mathtt{t}(1,0), \mathtt{f}(0,1), \top(1,1)\},$$

where annotations $\mathtt{t}(1,0)$ and $\mathtt{f}(0,1)$ can be intuitively interpreted as "true" and "false", respectively.

First of all, we introduce a group of basic bf-inference rules to be applied at the initial stage (time t_0) called $(0,0)$-*rules*.

(0,0)-rules Suppose that no process has started yet and the vector annotation of bf-literal $R(p_i, p_j, t)$ is $(0,0)$, which shows that there is no knowledge in terms of the bf-relation between processes Pr_i and Pr_j, then the following two basic bf-inference rules are applied at the initial stage.

$(0,0)$-rule-1 If process Pr_i started before process Pr_j starts, then the vector annotation $(0,0)$ of bf-literal $R(p_i, p_j, t)$ should turn to $\mathtt{be}(0,8)$,

$(0,0)$-rule-2 If both processes Pr_i and Pr_j have started at the same time, then the vector annotation $(0,0)$ of bf-literal $R(p_i, p_j, t)$ should turn to $(5,5)$.

$(0,0)$-rule-1 and 2 are translated into the bf-EVALPSN,

$$\begin{aligned}
&R(p_i, p_j, t) : [(0,0), \alpha] \wedge\\
&st(p_i, t) : [\mathtt{t}, \alpha] \wedge\\
&\sim st(p_j, t) : [\mathtt{t}, \alpha]\\
&\rightarrow R(p_i, p_j, t) : [(0,8), \alpha] \qquad (13)
\end{aligned}$$

$$R(p_i,p_j,t):[(0,0),\alpha] \wedge$$
$$st(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$st(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(5,5),\alpha] \quad (14)$$

Suppose that $(0,0)$-rule-1 or 2 has been applied, then the vector annotation of bf-literal $R(p_i,p_j,t)$ should be one of $(0,8)$ or $(5,5)$. Therefore, we need to consider two groups of basic bf-inference rules to be applied for following $(0,0)$-rule-1 and 2, which are named $(0,8)$-*rules* and $(5,5)$-*rules*, respectively.

(0,8)-rules Suppose that process Pr_i has started before process Pr_j starts, then the vector annotation of bf-literal $R(p_i,p_j,t)$ should be $(0,8)$. We have the following inference rules to be applied for following $(0,0)$-rule-1.

$(0,8)$-rule-1 If process Pr_i has finished before process Pr_j starts, and process Pr_j starts immediately after process Pr_i finished, then the vector annotation $(0,8)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{mb}(1,11)$.

$(0,8)$-rule-2 If process Pr_i has finished before process Pr_j starts, and process Pr_j has not started immediately after process Pr_i finished, then the vector annotation $(0,8)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{db}(0,12)$.

$(0,8)$-rule-3 If process Pr_j starts before process Pr_i finishes, then the vector annotation $(0,8)$ of bf-literal $R(p_i,p_j,t)$ should turn to $(2,8)$.

$(0,8)$-rule-1, 2 and 3 are translated into the bf-EVALPSN,

$$R(p_i,p_j,t):[(0,8),\alpha] \wedge$$
$$fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$st(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(1,11),\alpha] \quad (15)$$

$$R(p_i,p_j,t):[(0,8),\alpha] \wedge$$
$$fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$\sim st(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(0,12),\alpha] \quad (16)$$

$$R(p_i,p_j,t):[(0,8),\alpha] \wedge$$
$$\sim fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$st(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(2,8),\alpha] \quad (17)$$

(5,5)-rules Suppose that both processes Pr_i and Pr_j have already started at the same time, then the vector annotation of bf-literal $R(p_i,p_j,t)$ should be $(5,5)$. We have the following inference rules to be applied for following $(0,0)$-rule-2.

$(5,5)$-rule-1 If process Pr_i has finished before process Pr_j finishes, then the vector annotation $(5,5)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{sb}(5,7)$.

$(5,5)$-rule-2 If both processes Pr_i and Pr_j have finished at the same time, then the vector annotation $(5,5)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{pba}(6,6)$.

$(5,5)$-rule-3 If process Pr_j has finished before process Pr_i finishes, then the vector annotation $(5,5)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{sa}(7,5)$.

Basic bf-inference rules $(5,5)$-rule-1, 2 and 3 are translated into the bf-EVALPSN,

$$R(p_i,p_j,t):[(5,5),\alpha] \wedge$$
$$fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$\sim fi(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(5,7),\alpha] \quad (18)$$

$$R(p_i,p_j,t):[(5,5),\alpha] \wedge$$
$$fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$fi(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(6,6),\alpha] \quad (19)$$

$$R(p_i,p_j,t):[(5,5),\alpha] \wedge$$
$$\sim fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$fi(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(7,5),\alpha] \quad (20)$$

If one of $(0,8)$-rule-1,2, $(5,5)$-rule-1,2 and 3 has been applied, a final bf-annotation such as $\mathtt{jb}(2,10)$ between two processes should be derived. However, even if $(0,8)$-rule-3 has been applied, no bf-annotation could be derived. Therefore, a group of basic bf-inference rules called $(2,8)$-rules should be considered for following $(0,8)$-rule-3.

(2,8)-rules Suppose that process Pr_i has started before process Pr_j starts and process Pr_j has started before process Pr_i finishes, then the vector annotation of bf-literal $R(p_i,p_j,t)$ should be $(2,8)$ and the following three rules should be considered.

$(2,8)$-rule-1 If process Pr_i finished before process Pr_j finishes, then the vector annotation $(2,8)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{jb}(2,10)$.

$(2,8)$-rule-2 If both processes Pr_i and Pr_j have finished at the same time, then the vector annotation $(2,8)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{fb}(3,9)$.

$(2,8)$-rule-3 If process Pr_j has finished before Pr_i finishes, then the vector annotation $(2,8)$ of bf-literal $R(p_i,p_j,t)$ should turn to $\mathtt{ib}(4,8)$.

Basic bf-inference rules $(2,8)$-rule-1,2 and 3 are translated into the bf-EVALPSN,

$$R(p_i,p_j,t):[(2,8),\alpha] \wedge$$
$$fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$\sim fi(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(2,10),\alpha] \quad (21)$$

$$R(p_i,p_j,t):[(2,8),\alpha] \wedge$$
$$fi(p_i,t):[\mathtt{t},\alpha] \wedge$$
$$fi(p_j,t):[\mathtt{t},\alpha]$$
$$\rightarrow R(p_i,p_j,t):[(3,9),\alpha] \quad (22)$$

$$R(p_i, p_j, t) : [(2, 8), \alpha] \wedge$$
$$\sim fi(p_i, t) : [\mathtt{t}, \alpha] \wedge$$
$$fi(p_j, t) : [\mathtt{t}, \alpha]$$
$$\rightarrow R(p_i, p_j, t) : [(4, 8), \alpha] \quad (23)$$

The application orders of all basic bf-inference rules are summarized in Tab. II.

TABLE II
APPLICATION ORDERS OF BASIC BF-INFERENCE RULES

vector	rule	vector	rule	vector	rule	vector
$(0,0)$	rule-1	$(0,8)$	rule-1	$(0,12)$		
			rule-2	$(1,11)$		
			rule-3	$(2,8)$	rule-1	$(2,10)$
					rule-2	$(3,9)$
					rule-3	$(4,8)$
	rule-2	$(5,5)$	rule-1	$(5,7)$		
			rule-2	$(6,6)$		
			rule-3	$(7,5)$		

Now we introduce the *transitive bf-inference rule*, which can reason a vector annotation of bf-literal transitively.

Suppose that there are three processes Pr_i,Pr_j and Pr_k starting sequentially, then we consider to derive the vector annotation of bf-literal $R(p_i, p_k, t)$ from those of bf-literals $R(p_i, p_j, t)$ and $R(p_j, p_k, t)$ transitively. We describe only the variation of vector annotations in the following rules.

Transitive Bf-inference Rules

$\mathbf{TR0}$ $(0,0) \wedge (0,0) \rightarrow (0,0)$
$\mathbf{TR1}$ $(0,8) \wedge (0,0) \rightarrow (0,8)$
$\mathbf{TR1-1}$ $(0,12) \wedge (0,0) \rightarrow (0,12)$
$\mathbf{TR1-2}$ $(1,11) \wedge (0,8) \rightarrow (0,12)$
$\mathbf{TR1-3}$ $(1,11) \wedge (5,5) \rightarrow (1,11)$
$\mathbf{TR1-4}$ $(2,8) \wedge (0,8) \rightarrow (0,8)$
$\mathbf{TR1-4-1}$ $(2,10) \wedge (0,8) \rightarrow (0,12)$
$\mathbf{TR1-4-2}$ $(4,8) \wedge (0,12) \rightarrow (0,8)$
$\mathbf{TR1-4-3}$ $(2,8) \wedge (2,8) \rightarrow (2,8)$
$\mathbf{TR1-4-3-1}$ $(2,10) \wedge (2,8) \rightarrow (2,10)$
$\mathbf{TR1-4-3-2}$ $(4,8) \wedge (2,10) \rightarrow (2,8)$
$\mathbf{TR1-4-3-3}$ $(2,8) \wedge (4,8) \rightarrow (4,8)$
$\mathbf{TR1-4-3-4}$ $(3,9) \wedge (2,10) \rightarrow (2,10)$
$\mathbf{TR1-4-3-5}$ $(2,10) \wedge (4,8) \rightarrow (3,9)$
$\mathbf{TR1-4-3-6}$ $(4,8) \wedge (3,9) \rightarrow (4,8)$
$\mathbf{TR1-4-3-7}$ $(3,9) \wedge (3,9) \rightarrow (3,9)$
$\mathbf{TR1-4-4}$ $(3,9) \wedge (0,12) \rightarrow (0,12)$
$\mathbf{TR1-4-5}$ $(2,10) \wedge (2,8) \rightarrow (1,11)$
$\mathbf{TR1-4-6}$ $(4,8) \wedge (1,11) \rightarrow (2,8)$
$\mathbf{TR1-4-7}$ $(3,9) \wedge (1,11) \rightarrow (1,11)$
$\mathbf{TR1-5}$ $(2,8) \wedge (5,5) \rightarrow (2,8)$

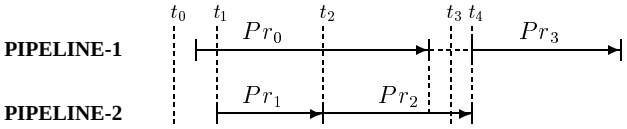

Fig. 12. Pipeline Process Schedule

$\mathbf{TR1-5-1}$ $(4,8) \wedge (5,7) \rightarrow (2,8)$
$\mathbf{TR1-5-2}$ $(2,8) \wedge (7,5) \rightarrow (4,8)$
$\mathbf{TR1-5-3}$ $(3,9) \wedge (5,7) \rightarrow (2,10)$
$\mathbf{TR1-5-4}$ $(2,10) \wedge (7,5) \rightarrow (3,9)$
$\mathbf{TR2}$ $(5,5) \wedge (0,8) \rightarrow (0,8)$
$\mathbf{TR2-1}$ $(5,7) \wedge (0,8) \rightarrow (0,12)$
$\mathbf{TR2-2}$ $(7,5) \wedge (0,12) \rightarrow (0,8)$
$\mathbf{TR2-3}$ $(5,5) \wedge (2,8) \rightarrow (2,8)$
$\mathbf{TR2-3-1}$ $(5,7) \wedge (2,8) \rightarrow (2,10)$
$\mathbf{TR2-3-2}$ $(7,5) \wedge (2,10) \rightarrow (2,8)$
$\mathbf{TR2-3-3}$ $(5,5) \wedge (4,8) \rightarrow (4,8)$
$\mathbf{TR2-3-4}$ $(7,5) \wedge (3,9) \rightarrow (4,8)$
$\mathbf{TR2-4}$ $(5,7) \wedge (2,8) \rightarrow (1,11)$
$\mathbf{TR2-5}$ $(7,5) \wedge (1,11) \rightarrow (2,8)$
$\mathbf{TR3}$ $(5,5) \wedge (5,5) \rightarrow (5,5)$
$\mathbf{TR3-1}$ $(7,5) \wedge (5,7) \rightarrow (5,5)$
$\mathbf{TR3-2}$ $(5,7) \wedge (7,5) \rightarrow (6,6)$

VII. PROCESS ORDER CONTROL EXAMPLE IN BF-EVALPSN

In this section, we present the process order control method with a simple example for pipeline process order verification. We assume a pipeline system consists of two pipelines, PIPELINE-1 and 2, which deal with pipeline processes Pr_0, Pr_1, Pr_2 and Pr_3. The process schedule of those processes are shown in Fig. 12. Moreover, we assume that the pipeline system has four safety properties $SPR-i (i = 0, 1, 2, 3)$.
$\underline{SPR-0}$ process Pr_0 must start before any other processes, and process Pr_0 must finish before process Pr_2 finishes,
$\underline{SPR-1}$ process Pr_1 must start after process Pr_0 starts,
$\underline{SPR-2}$ process Pr_2 must start immediately after process Pr_1 finishes,
$\underline{SPR-3}$ process Pr_3 must start immediately after processes Pr_0 and Pr_2 finish.

All the safety properties can be translated into the following bf-EVALPSN clauses.

$$\sim R(p_0, p_1, t) : [(0, 8), \alpha] \rightarrow st(p_1, t) : [\mathtt{f}, \beta], \quad (24)$$

$$\sim R(p_0, p_2, t) : [(0, 8), \alpha] \rightarrow st(p_2, t) : [\mathtt{f}, \beta], \quad (25)$$

$$\sim R(p_0, p_3, t) : [(0, 8), \alpha] \rightarrow st(p_3, t) : [\mathtt{f}, \beta], \quad (26)$$

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$$st(p_1,t):[\mathtt{f},\beta] \wedge$$
$$st(p_2,t):[\mathtt{f},\beta] \wedge$$
$$st(p_3,t):[\mathtt{f},\beta]$$
$$\rightarrow st(p_0,t):[\mathtt{f},\gamma], \quad (27)$$

$$\sim fi(p_0,t):[\mathtt{f},\beta] \rightarrow fi(p_0,t):[\mathtt{f},\gamma], \quad (28)$$

where bf-EVALPSN clauses (24),(25) and (26) declare that if process Pr_0 has not started before other processes $Pr_i(i = 1,2,3)$ start, it should be forbidden to start each process $Pr_i(i = 1,2,3)$; bf-EVALPSN clause (27) declares that if each process $Pr_i(i = 1,2,3)$ is forbidden from starting, it should be permitted to start process Pr_0; and bf-EVALPSN clause (28) declares that if there is no forbiddance from finishing process Pr_0, it should be permitted to finish process Pr_0.

$$\sim st(p_1,t):[\mathtt{f},\beta] \rightarrow st(p_1,t):[\mathtt{f},\gamma], \quad (29)$$

$$\sim fi(p_1,t):[\mathtt{f},\beta] \rightarrow fi(p_1,t):[\mathtt{f},\gamma], \quad (30)$$

where bf-EVALPSN clause (29)/(30) declares that if there is no forbiddance from starting/finishing process Pr_1, it should be permitted to start/finish process Pr_1, respectively.

$$\sim R(p_2,p_1,t):[(11,0),\alpha] \rightarrow st(p_2,t):[\mathtt{f},\beta], \quad (31)$$

$$\sim st(p_2,t):[\mathtt{f},\beta] \rightarrow st(p_2,t):[\mathtt{f},\gamma], \quad (32)$$

$$\sim R(p_2,p_0,t):[(10,2),\alpha] \rightarrow fi(p_2,t):[\mathtt{f},\beta], \quad (33)$$

$$\sim fi(p_2,t):[\mathtt{f},\beta] \rightarrow fi(p_2,t):[\mathtt{f},\gamma], \quad (34)$$

where bf-EVALPSN clause (31) declares that if process Pr_1 has not finished before process Pr_2 starts, it should be forbidden to start process Pr_2; the vector annotation $(11,0)$ of bf-literal $R(p_2,p_1,t)$ is the greatest lower bound of $\{\mathtt{da}(12,0), \mathtt{ma}(11,1)\}$, which implies that process Pr_1 has finished before process Pr_2 starts; bf-EVALPSN clauses (32)/(34) declares that if there is no forbiddance from starting/finishing process Pr_2, it should be permitted to start/finish process Pr_2, respectively; and bf-EVALPSN clauses (33) declares that if process Pr_0 has not finished before process Pr_2 finishes, it should be forbidden to finish process Pr_2.

$$\sim R(p_3,p_0,t):[(11,0),\alpha] \rightarrow st(p_3,t):[\mathtt{f},\beta], \quad (35)$$

$$\sim R(p_3,p_1,t):[(11,0),\alpha] \rightarrow st(p_3,t):[\mathtt{f},\beta], \quad (36)$$

$$\sim R(p_3,p_2,t):[(11,0),\alpha] \rightarrow st(p_3,t):[\mathtt{f},\beta], \quad (37)$$

$$\sim st(p_3,t):[\mathtt{f},\beta] \rightarrow st(p_3,t):[\mathtt{f},\gamma], \quad (38)$$

$$\sim fi(p_3,t):[\mathtt{f},\beta] \rightarrow fi(p_3,t):[\mathtt{f},\gamma], \quad (39)$$

where bf-EVALPSN clauses (35),(36) and (37) declare that if one of processes $Pr_i(i = 0,1,2)$ has not finished yet, it should be forbidden to start process Pr_3; and bf-EVALPSN clauses (38)/(39) declares that if there is no forbiddance from starting/finishing process Pr_3, it should be permitted to start/finish process Pr_3, respectively.

Here, we show how the bf-EVALPSN process order safety verification is carried out at five time points, t_0, t_1, t_2, t_3 and t_4 in the process schedule(Fig. 12). We consider five bf-relations between processes Pr_0, Pr_1, Pr_2 and Pr_3 represented by the vector annotations of bf-literals,

$$R(p_0,p_1,t),$$
$$R(p_0,p_2,t),$$
$$R(p_0,p_3,t),$$
$$R(p_1,p_2,t),$$
$$R(p_2,p_3,t),$$

which should be verified based on safety properties $SPR-0$,1,2 and 3 in real-time.

[Verification Example in bf-EVALPSN]

We introduce just three process order verification stages at time t_0, t_1 and t_3 due to the space restriction.

Initial Stage (at time t_0) no process has started at time t_0, thus, the bf-EVALP clauses,

$$R(p_0,p_1,t_0):[(0,0),\alpha], \quad (40)$$
$$R(p_1,p_2,t_0):[(0,0),\alpha], \quad (41)$$
$$R(p_2,p_3,t_0):[(0,0),\alpha] \quad (42)$$
$$R(p_0,p_2,t_0):[(0,0),\alpha], \quad (43)$$
$$R(p_0,p_3,t_0):[(0,0),\alpha] \quad (44)$$

are obtained by transitive bf-inference rule **TR0**; then, bf-EVALP clauses (40), (43) and (44) satisfy each body of bf-EVALPSN clauses (24), (25) and (26), respectively, therefore, the forbiddance,

$$st(p_1,t_0):[\mathtt{f},\beta], \quad (45)$$
$$st(p_2,t_0):[\mathtt{f},\beta], \quad (46)$$
$$st(p_3,t_0):[\mathtt{f},\beta] \quad (47)$$

from starting each process $Pr_i(i = 1,2,3)$ is derived; moreover, since bf-EVALP clauses (45),(46) and (47) satisfy the body of bf-EVALPSN clause (27), the permission for starting process Pr_0,

$$st(p_0,t_0):[\mathtt{f},\gamma]$$

is derived; therefore, process Pr_0 is permitted for starting at time t_0.

2nd Stage (at time t_1) process Pr_0 has already started but all other processes $Pr_i(i = 1,2,3)$ have not started yet; then the bf-EVALP clauses,

$$R(p_0,p_1,t_1):[(0,8),\alpha], \quad (48)$$
$$R(p_1,p_2,t_1):[(0,0),\alpha], \quad (49)$$
$$R(p_2,p_3,t_1):[(0,0),\alpha] \quad (50)$$

are obtained, where the bf-EVALP clause (48) is derived by basic bf-inference rule $(0,0)$-rule-1; moreover, the bf-EVALP clauses,

$$R(p_0,p_2,t_1):[(0,8),\alpha], \quad (51)$$
$$R(p_0,p_3,t_1):[(0,8),\alpha] \quad (52)$$

are obtained by transitive bf-inference rule TR1; as bf-EVALP clause (48) does not satisfy the body of bf-EVALPSN clause (24), the forbiddance from starting process Pr_1,

$$st(p_1, t_1) : [\mathtt{f}, \beta] \tag{53}$$

cannot be derived; then, since there is not forbiddance (53), the body of bf-EVALPSN clause (29) is satisfied, and the permission for starting process Pr_1,

$$st(p_1, t_1) : [\mathtt{f}, \gamma]$$

is derived; on the other hand, since bf-EVALP clauses (51) and (52) satisfy the body of bf-EVALPSN clauses (31) and (35) respectively, the forbiddance from starting both processes Pr_2 and Pr_3,

$$st(p_2, t_1) : [\mathtt{f}, \beta], \quad st(p_3, t_1) : [\mathtt{f}, \beta]$$

are derived; therefore, process Pr_1 is permitted for starting at time t_1.

4th Stage (at time t_3) process Pr_0 has finished, process Pr_2 has not finished yet, and process Pr_3 has not started yet; then, the bf-EVALP clauses,

$$R(p_0, p_1, t_3) : [(4, 8), \alpha], \tag{54}$$

$$R(p_1, p_2, t_3) : [(1, 11), \alpha], \tag{55}$$

$$R(p_2, p_3, t_3) : [(0, 8), \alpha] \tag{56}$$

in which the vector annotations are the same as the previous stage are obtained because bf-annotations of bf-EVALP clauses (54) and (55) have been already reasoned, and the before-after relation between processes Pr_2 and Pr_3 is the same as the previous stage; moreover, the bf-EVALP clauses,

$$R(p_0, p_2, t_3) : [(2, 10), \alpha], \tag{57}$$

$$R(p_0, p_3, t_3) : [(0, 12), \alpha] \tag{58}$$

are obtained, where bf-EVALP clause (57) is derived by basic bf-inference rule $(2, 8)$-rule-1; then, bf-EVALP clause (57) satisfies the body of bf-EVALP clause (37), and the forbiddance from starting process Pr_3,

$$S(p_3, t_3) : [\mathtt{f}, \beta]$$

is derived; therefore, process Pr_3 is still forbidden to start because process Pr_2 has not finished yet at time t_3.

VIII. Concluding Remarks

In this paper, we have introduced the process order control method based on a paraconsistent annotated logic program EVALPSN and bf-EVALPSN, which can deal with various kinds of intelligent control.

We would like to conclude this paper by describing the advantages and disadvantages of EVALPSN/bf-EVALPSN based intelligent control.

(Advantages)

- If EVALPSN/bf-EVALPSN are locally stratified it can be easily implemented in Prolog, C language, PLC (Programmable Logic Controller) ladder program etc. In practice, such control programs, EVALPSN/bf-EVALPSN are locally stratified.
- It has been proved that EVALPSN/bf-EVALPSN can be implemented as electronic circuits on micro chips[7]. Therefore, if real-time processing is required in the system, the method might be very useful.
- EVALPSN/bf-EVALPSN based control methods for both intelligent systems and process order verification can be implemented under the same environment.

(Disadvantages)

- Since EVALPSN/bf-EVALPSN itself is basically not a specific tool of formal safety verification, it includes complicated and redundant expressions to construct safety verification systems. Therefore, it should be better to develop safety verification oriented tool or programming language based on EVALPSN/bf-EVALPSN if EVALPSN/bf-EVALPSN can be applied to formal safety verification.

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How to Improve Positional Accuracy in Redundant Omnidirectional Mobile Robots?

Yaser Maddahi, S. M. Hosseini Monsef and Nikos E. Mastorakis

***Abstract*—** Non-systematic errors in wheeled mobile robots are significantly influenced by irregularities on the surface. The presence of non-smoothness on a surface causes the robot to deviate from its desired trajectory, and move towards an undesirable destination. This paper uses a technique, previously proposed by the first author, to alleviate the positional error originating from non-systematic resources during movement of a redundant omnidirectional wheeled mobile robot (OWMR). Kinematic equations of OWMRs form the foundation of this method to help us correct the robot motion, and reduce the errors occurring due to unwanted resources. To correct positioning errors, the expected surface on which the robot will be programmed to move is simulated. Afterward, a platform is fabricated having similar irregularities pattern. The robot is then programmed to travel on the designed platform and passes over designed obstacles. Two factors are obtained using experimental results: longitudinal and lateral. Both factors are then applied to the robot program. Then robot is finally tested on the same platform, and its motion accuracy is compared with the one obtained before applying the calibration factors. For studied case in this paper, non-systematic positional errors are reduced at least 80% that is a reasonable accuracy improvement.

***Keywords*—**Positional error; non-systematic error; wheeled mobile robot; omnidirectional wheel; kinematics.

I. Introduction

THERE exist two main types of error normally occurred during the mobile robot motion: systematic and non-systematic errors. Systematic ones originate from control and mechanical subsystems, which are caused by unavoidable imperfections during design, manufacturing and assembly processes. Non-systematic errors are caused by unexpected phenomena such as slippery floors, over acceleration, fast turning, external forces/torques and non-point wheel contact on the floor [1]. They are significantly influenced by irregularities on the surface such as bumps and cracks. Small obstacles cause the robot wheels to rotate more or less than desired rotation. Thus, the trajectory length travelled by robot will be changed. Since, it is almost impossible to predict or simulate the exact nature of surface irregularities to which the robot will be exposed, it is difficult to present a general quantitative test procedure for non-systematic errors [1]. Therefore, the non-systematic errors should decrease, or the robot should be calibrated, in order to achieve a desirable positioning error.

Calibration is defined as a set of operations that establishes, under specified conditions, the relationship between the values of quantities indicated by a measuring instrument and the corresponding values realized by standards [2]. The calibration approaches, used for calibrating mobile robots, include odometry [3], 3D camera error detection [4], active beacons [5], gyroscope [6], and magnetic compasses [7]. This paper focuses on odometry method. Odometry uses data from the movement of actuators to estimate change in position over time. As compared to other methods, odometry provides a better short-term accuracy allowing very high sampling rates at low costs [8, 9]. The purpose of odometry is to build an incremental model of the motion using measurements of the elementary wheel rotations [9]. For mobile robots, odometry remains to be one of the important means to achieve position error reduction. The odometry method can be applied to correct errors of all types of mobile robots including vehicle-type robots, robots with differential drive and omnidirectional robots.

With respect to Odometry, Tehrani *et al.* [10] developed a modified odometry system to increase positioning accuracy of a three-wheel mobile robot. They mounted the shaft encoders on three free-running wheels to avoid affecting the measurements of the sensors due to slippage of the driving wheels. Borenstein and Feng [11-13] introduced a method for measuring errors in differential drive wheeled mobile robots, and implemented it to correct errors for a number of robots including differential drive and omni-mate mobile robots. Maddahi *et al.* [3, 9, 14-16] applied the UMBmark benchmark test on different types of wheeled mobile robots. Both systematic [9, 14-16] and non-systematic [3] errors were corrected with this method confirming the significance and effectiveness of odometry method in the process of mobile robot calibration.

With respect to the use of odometry in calibrating mobile robots with omnidirectional wheels, Han *et al.* [17] focused on compensating errors of a four-wheeled OWMR which occur due to wheel slippage and bearing defects. Other sources of errors such as uncertainty in wheels diameters and differences in wheel diameters were not considered in their work. A new method has recently been proposed by the first author to reduce both systematic and non-systematic errors in OWMRs

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[18, 19]. The proposed method is used in this paper to calibrate the non-systematic errors of a four-wheeled omnidirectional wheeled mobile robots. The method was built using kinematic formulations of omnidirectional wheels, and was capable of compensating both systematic and non-systematic errors. Results showed that the method was very effective in improving position errors by at least 68%. In another work, they extended the method for a redundant WMR in which the Jacobian matrix is non-square and more complicated to implement [18].

The organization of this paper is as follows. Section II describes the prototype four-wheeled omnidirectional mobile robot followed and the corresponding kinematic formulation. Section III presents experimental results and performance evaluations. Conclusions are outlined in Section V.

II. MODELING OF ROBOT

A. Prototype robot

The prototyped robot has dimension of 8×8×9.5 cm^3 and weight of 375 g (Fig. 1). This robot has four omnidirectional driving wheels with single-row rollers and four motors. The diameter of the omnidirectional wheels is 70 mm and the width is about 10 mm. This robot is equipped with some infrared sensors to detect obstacles. Table I shows some key specifications of described mobile robot such as dimension, weight and maximum speed.

B. Kinematic modeling

The proposed technique is developed based on the kinematic formulations of omnidirectional wheeled mobile robot. The kinematic diagram of the prototype planar robot and associated wheel modeling are illustrated in Fig. 2. Each wheel is assumed to rotate independently. The coordinate systems $\{X_R O_R Y_R\}$ and $\{X_b O_b Y_b\}$ define the global (reference) and generalized (base) frames, respectively. To model this robot, the kinematic equations are firstly defined and then, based on these equations, non-holonomic constraints due to instant no-slip wheel conditions are written as follows [18]:

$$\begin{bmatrix} \dot{\varphi}_1 \\ \dot{\varphi}_2 \\ \dot{\varphi}_3 \\ \dot{\varphi}_4 \end{bmatrix} = J\dot{\mu}_b \tag{1}$$

where J is the Jacobian matrix, and is defined as follows [18]:

$$J = diag\left(\frac{1}{r_1\varphi_1}\ \frac{1}{r_2\varphi_2}\ \frac{1}{r_3\varphi_3}\ \frac{1}{r_4\varphi_4}\right). \tag{2}$$
$$\begin{bmatrix} cos(\alpha_1+\beta_1+\gamma_1) & sin(\alpha_1+\beta_1+\gamma_1) & -l_1\, cos(\beta_1+\gamma_1) \\ cos(\alpha_2+\beta_2+\gamma_2) & sin(\alpha_2+\beta_2+\gamma_2) & -l_2\, cos(\beta_2+\gamma_2) \\ cos(\alpha_3+\beta_3+\gamma_3) & sin(\alpha_3+\beta_3+\gamma_3) & -l_3\, cos(\beta_3+\gamma_3) \\ cos(\alpha_4+\beta_4+\gamma_4) & sin(\alpha_4+\beta_4+\gamma_4) & -l_i\, cos(\beta_4+\gamma_4) \end{bmatrix} R(\theta_b)$$

TABLE I. SPECIFICATIONS OF FOUR-WHEELED PROTOTYPE ROBOT.

Variable	Value
Weight (kg)	0.375
Maximum speed of C. G. (m/min)	9.75
Wheel radius (cm)	3.0
Wheelbase (cm)	3.5
Encoder resolution (pulse/rev)	480
Dimension (L×W×H) (cm)	8×8×9.5

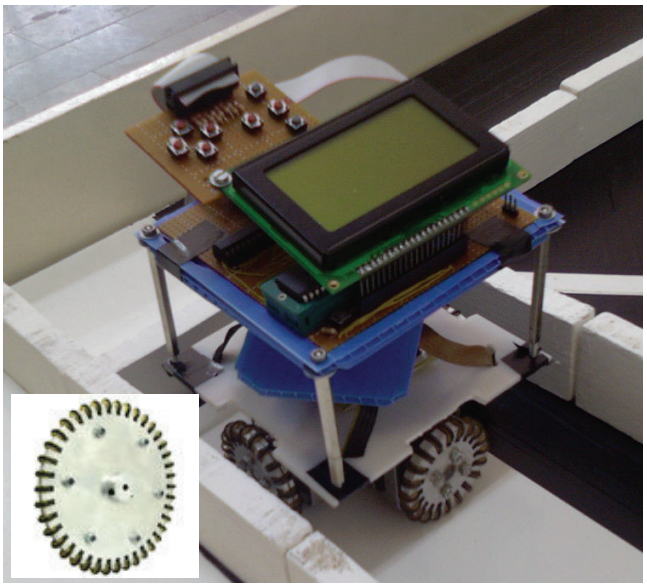

Figure 1. Prototype four-wheeled mobile robot. Inset shows a schematic of the omnidirectional wheel used.

In (1) and (2), $\mu_b = [x_b \quad y_b \quad \theta_b]^T$ is the robot posture with respect to the global coordinate. γ is the angle between the main wheel plane and the axis of rotation of the small circumferential rollers. β denotes the steering angle or angle of wheel plane relative to the robot main body which is usually constant. α is the angle between the wheel shaft and X_R axis when the robot is located in home position [19]. Moreover, $\dot{\varphi}$, r and l are the angular velocity vector, radius and wheelbase (the distance from the center of gravity of the robot to the center of wheels along a radial path) of the i^{th} wheel, respectively. $R(\theta_b)$ is defined as follows:

$$R(\theta_b) = \begin{bmatrix} cos\theta_b & sin\theta_b & 0 \\ -sin\theta_b & cos\theta_b & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

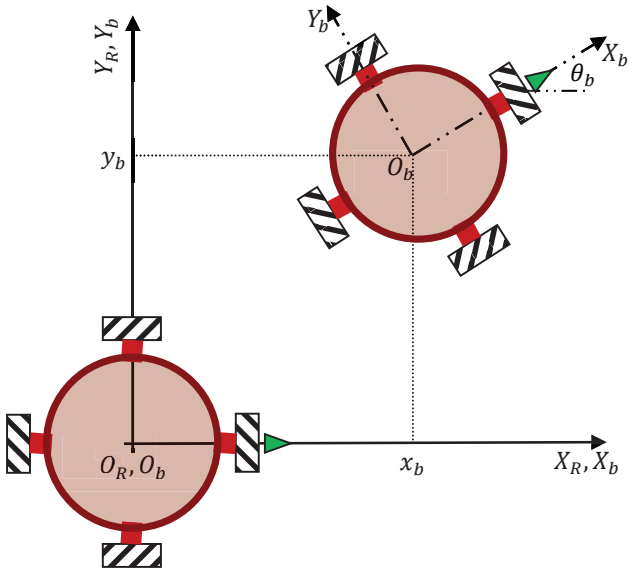

Figure 2. Coordinate systems of a prototyp four-wheeled mobile robot (revised from [18]).

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III. Test Algorithm

Due to the significance of non-systematic errors effects on omnidirectional mobile robots movement, the compensation of non-systematic errors is investigated. Non-systematic errors are usually modeled by introducing surface irregularities using artificial obstacles which can be selected based on the geometry of real working environment of robot [1, 19]. Chosen obstacles for experiments are common electrical cable, such as the ones used in the following experiments, with 5 mm diameter, rounded shape and plastic coating. The distance between the wires should be chosen based on the condition of real environment as instructed in [19]. In this work, the cables are evenly placed along the trajectories (see Fig. 3). In experiments, used for validations in this study, the distance is chosen to be 30 mm in each straight leg with no obstacle located on the vertices. The process implemented here is in-line with previous study on calibration of non-systematic errors [1, 18] by other researchers. The robot is programmed to move along the straight path, shown in Fig. 3. Deviations of robot from the desired path are recorded in order to understand how much lateral and longitudinal positional errors appear when it completes the defined test. To organize the calibration procedure, two corrective coefficients are defined [19]. The first one is the lateral corrective matrix (F_{lat}), which is used to calculate the modified angular velocities in order to achieve the perfect movement along the straight trajectory [18].

$$F_{lat} = \begin{bmatrix} \frac{\dot{\varphi}_{1a}}{\dot{\varphi}_1} & \cdots & 0 \\ & \frac{\dot{\varphi}_{2a}}{\dot{\varphi}_2} & \\ \vdots & & \vdots \\ & & \frac{\dot{\varphi}_{3a}}{\dot{\varphi}_3} \\ 0 & \cdots & \frac{\dot{\varphi}_{4a}}{\dot{\varphi}_4} \end{bmatrix} \quad (4)$$

The lateral corrective factor (F_{lat}) expresses the relationship between the wheel actual ($\dot{\varphi}_a$) and nominal velocities ($\dot{\varphi}$), by measuring the robot orientation angle (θ_e) and position errors (x_e and y_e). The orientation angle, θ_e, is measured using a protractor tool and the robot is commanded to move at a constant speed. Using (4), the lateral corrective factor appropriately to the robot motion equations such that the deviation angle, θ_e, converges to zero, *i.e.,* the robot maintains to stay along the desired path. However, even if the robot is aligned with the desired path, we need to further ensure that it reaches the desired location, *i.e.,* having no longitudinal error $\bar{x}_e$ [19]. This is done by equally adjusting the speeds of the wheels. Thus, a second coefficient, termed longitudinal corrective factor, F_{lon}, is defined [19]:

$$F_{lon} = \frac{L}{\sqrt{(L-\bar{x}_e)^2+(\bar{y}_e)^2}} \quad (5)$$

where L is the length of path and, $\bar{x}_e = \frac{1}{m}\sum_{i=0}^{m} x_{e,i}$ and $\bar{y}_e = \frac{1}{m}\sum_{i=0}^{m} y_{e,i}$.

As described in this section, the implemented compensates for the robot error using lateral (F_{lat}) and longitudinal (F_{lon}) corrective factors. The most integrated approach to implement these factors in the robot equations of motion, is to use them within the Jacobian matrix that relates robot trajectory (position and orientation) variables to the joints (wheels) variables, as shown in Equation (1). Considering the defined corrective factors, the final angular velocities, needed to correct both lateral and longitudinal errors, are defined as [19]:

$$\begin{bmatrix} \dot{\varphi}_{1f} \\ \dot{\varphi}_{2f} \\ \dot{\varphi}_{3f} \\ \dot{\varphi}_{4f} \end{bmatrix} = F_{lon}F_{lat}\,J \begin{bmatrix} 0 \\ 0 \\ \dot{\theta}_e \end{bmatrix} \quad (6)$$

where F_{lat} and F_{lon} are obtained using (4) and (5), respectively. J is defined by Equation (3). As observed, for prototyped robot, β and γ are zero. $\dot{\varphi}_f$ indicated the final angular velocity of each wheel which should be entered in the robot program.

IV. Experimental Results

A. Calibration indices

Two metric proposed in [18] and [19] are used to investigated the effectiveness of the proposed method:

- Radial error (δr_e) which is defined as follows:

$$\delta r_e = \frac{1}{m}\sum_{i=1}^{m}\sqrt{(x_{e,i})^2 + (y_{e,i})^2} \quad (7)$$

$x_{e,i}$ and $y_{e,i}$ are the longitudinal and lateral positional errors, and are defined in Fig. 3.

- Mean error improvement index (δr_m) [19]:

$$\delta r_m = \frac{(\delta r_{m,BF} - \delta r_{m,AF})}{\delta r_{m,BF}} \times 100\% \quad (8)$$

In (8), $\delta r_{m,BF}$ and $\delta r_{m,AF}$ are the mean values of radial errors before and after calibration, respectively.

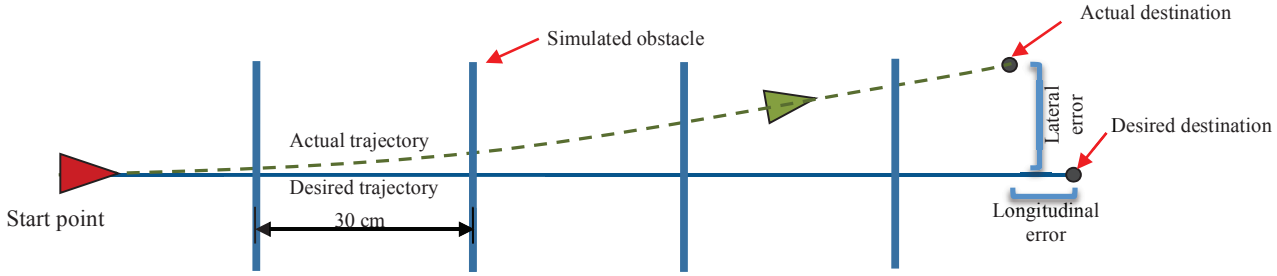

Figure 3. Test trajectories used to coorect non-systematic errors. Vertical lines show simulated obstacles (revised from [21]). Robot is expected to move along the desired trajectory (solid path); while it goes toward an undesirable (actual) destinationdue to the presence of floor irregularities. The positional difference between the actual and desired destinations is alleviated using this odometry-based technique.

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B. Positional errors compensation

Based on the described test technique for this robot, the equations of robot were applied to the prototype robot and over ten trial runs. Figures 4a and 4b illustrate the position errors of the four-wheeled OWMR before and after calibration. In this test, the robot was programmed to travel along two perpendicular trajectories, when (a) the first ($\alpha_1 = \pi/2$) and third ($\alpha_3 = 3\pi/2$) wheels move and the other wheels have no angular velocity (path 4W-1), and (b) the actuators of wheels 1 and 3 are turned off and only the second ($\alpha_2 = \pi$) and fourth ($\alpha_4 = 0$) wheels rotate with the same and opposite angular velocities (path 4W-2). The paths used in this test are depicted in Fig. 4. As observed, the robot motion was corrected with proposed technique, *i.e.,* positional errors converged to zero center of coordinate system in both robots. In the case that more accuracy is needed, the test should be repeated in order to obtain the secondary corrective factors and to re-modify the motion. The new factors will be applied to robot program, Thus, the robot will be influenced by two sets of corrective factors to achieve reasonable position error.

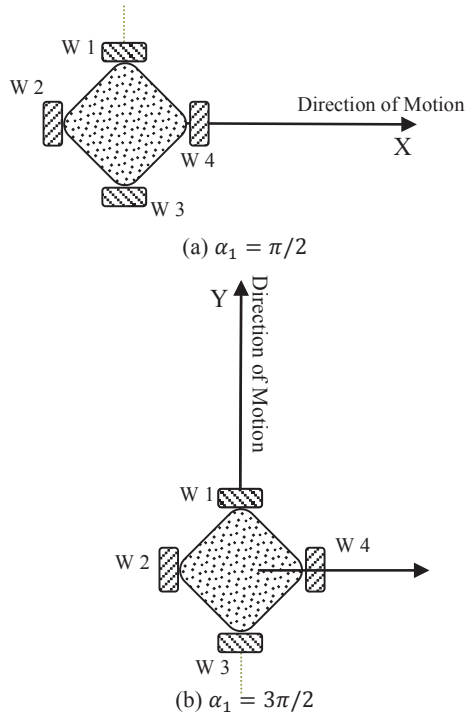

Figure 4. Defined path directions on which the rbot was programmed to move: (a) 4W-1, (b) 4W-1 (recised from [18]).

Table II illustrates the amount of average errors for both robots before and after calibration as well as estimates of Skewness, Kurtosis from measured data. Also, the lateral corrective matrix and longitudinal corrective factor are shown in this table. The sixth column of Table II presents the percentage of error improvement (δr_m) to the variability of data over ten trials, standard deviation is used to measure confidence in statistical conclusions. The results obtained from experimental tests showed that the proposed method is capable of calibrating the errors in prototyped mobile robot. As shown, for tested robot, the mean value of mean values of radial error are improved up to 80%, respectively.

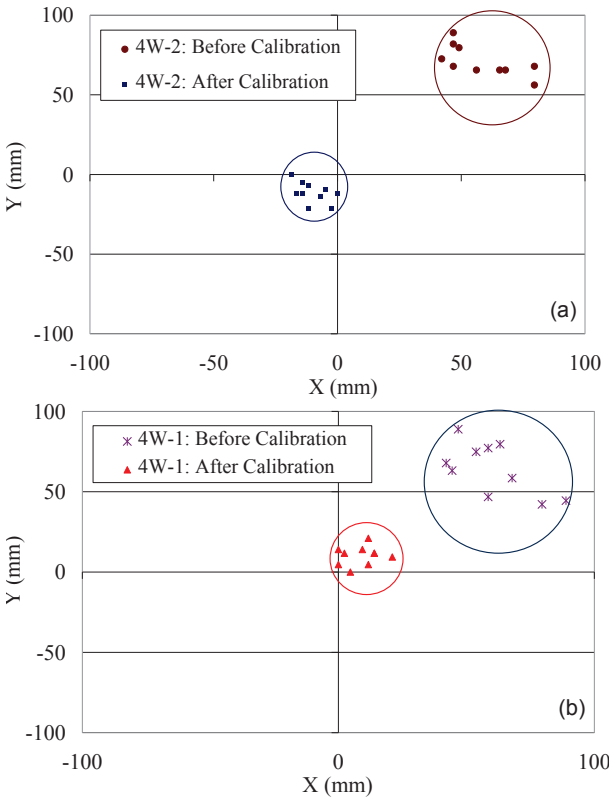

Figure 5. Radial non-systematic positional error of 4W robot in 4W-2 (Fig. 4a) and 4W-1 (Fig. 4b) paths.

TABLE II. TEST INDICES FOR NON-SYSTEMATIC TESTS BEFORE (BF) AND AFTER (AF) CALIBRATION.

	$F_{lat,n}$	$F_{lon,n}$	Mean Error	δr_m (%)
BF	[1.08 0.96; 1.02 0.98]	0.94	91.72	80
AF			15.43	

V. CONCLUSIONS

A kinematic-based calibration technique was reported for accurate calibration and error reduction of a four-wheeled omnidirectional mobile robot. We, firstly, provided an overview of mobile robots positioning methods and then, presented a technique capable of calibrating omnidirectional mobile robot with various mechanisms to correct non-systematic errors. Next, the test method was used to correct the errors of a prototyped omnidirectional mobile robot with omnidirectional wheels. It was demonstrated that the proposed technique is simple to implement and leads to good and reasonable error improvement percentage. Specifically, experimental results showed that the non-systematic errors were improved at least 80%. Based on experimental results done for the prototype robot, the method is helpful as a potential method for calibration of non-systematic errors in robots with omnidirectional wheels. With reference to work done in [18] and [19] and results presented in this paper, this

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method was found as a helpful tool to reduce non-systematic positional errors.

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MEMS Microrobot System with Locomotion Rhythm Generator Using Artificial Neural Networks

Ken Saito, Minami Takato, Yoshifumi Sekine, and Fumio Uchikoba

***Abstract*—**This paper discussed about 4.0, 2.7, 2.5 mm, width, length, height in size hexapod locomotion type microrobot system. The microrobot system consisted by micro-mechanical systems which were fabricated by micro fabrication technology and micro-electro systems which was constructed by integrated circuit (IC) technology. Micro-mechanical systems were equipped with small size rotary type actuators, body frame, link mechanisms, and 6 legs to realize the ant-like switching behavior. Locomotion rhythm generator using artificial neural networks (ANN) was micro-electro system. Both systems were made from silicon wafer. Therefore, both systems could integrate on silicon wafer using micro-electro-mechanical systems (MEMS) technology. ANN consisted by 4 cell body models. Cell body model was analog circuit model which could output oscillatory patterns such as the biological neuron. 4 cell body models were connected mutually by the 12 synaptic models. Thus, ANN could generate the locomotion rhythms using synchronization phenomena of the cell body models such as biological neural networks. Locomotion rhythm generator using ANN realized the locomotion of the robot without using any software programs or analog digital converters. As a result, MEMS microrobot performed forward and backward locomotion, and also changes direction by inputting an external single trigger pulse to the ANN. The locomotion speed of the microrobot was 26.4 mm/min when the step width was 0.88 mm. The power consumption of the system was 250 mWh when the room temperature was 298 K.

***Keywords*—**Artificial neural networks, Locomotion rhythm, MEMS, Microrobot.

I. Introduction

MENY types of microrobot had proposed by researchers for several applications [1]-[5]. In particular, microrobot could play an important role in paramedical use such as cleaning inside the blood vessel. However, thin artery of human is about 5 mm and artery structure of human differs greatly in individuals. Therefore, further miniaturizations and higher functionalization on the microrobot system are required to play an important role in paramedical use. Although the miniaturization of the robot has conventionally been progressed by mechanical machining and assembling, some difficulty has appeared in order to achieve further miniaturizations. In particular, frame parts, actuators, motion controllers, power sources, and sensors [6]. Instead of the conventional mechanical machining, micro fabrication technology based on the integrated circuit (IC) production lines has been studied for making the simple components of the microrobot [7]-[9]. In addition, the development of the actuator is important subjects. The type of the micro actuator by micro fabrication technology is categorized into two groups. For example, uses the field forces. Otherwise uses the property of the material itself [10]-[14]. In particular, shape memory alloy actuator shows a large displacement such as 50 % of the total length in millimeter size. However, micro actuators using field forces or piezoelectric elements to the microrobot had a weakness for moving on the uneven surface. Therefore, microrobot which could locomote by step pattern was desired.

Programmed control by a digital systems based on microcontroller has been the dominant system among the microrobot control. On the other hand, insects realize the autonomous operation using excellent structure and active neural networks control by compact advanced systems. Therefore, some advanced studies of artificial neural networks (ANN) have been paid attention for applying to the robot systems. A lot of studies have reported both on software models and hardware models [15]-[17]. However, using the mathematical neuron models in large scale ANN is difficult to process in continuous time because the computer simulation is limited by the computer performance, such as the processing speed and memory capacity. In contrast, using the hardware neuron model is advantageous because even if a circuit scale becomes large, the nonlinear operation can perform at high speed and process in continuous time. Therefore, the construction of a hardware neuron model which can generate oscillatory patterns was desired.

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Previously, we constructed the 4.0, 2.7, 2.5 mm, width, length, and height size microrobot fabricating the silicon wafer by micro fabrication technology, reported the rotary-type actuator composed of heat stimulated artificial muscle wires in the robot, and also driving waveform of the robot was generated by using packaged IC of ANN [22].

In this paper, we will discuss about 4.0, 2.7, 2.5 mm, width, length, height in size hexapod locomotion type MEMS microrobot system. Firstly, micro-mechanical systems of the MEMS microrobot which were fabricated by micro fabrication technology were shown. Secondly, micro-electro systems which was locomotion rhythm generator using ANN constructed by IC technology was discussed. Finally, hexapod locomotion of MEMS microrobot which was generated by bare chip IC of ANN was shown.

II. Micro-Mechanical Systems of MEMS Microrobot

We constructed the micro-mechanical systems of the MEMS microrobot by using the micro fabrication technology. In this chapter, the basic components of the fabricated MEMS microrobot were shown. The number of the legs of the MEMS microrobot was 6. The structure and the step pattern of the robot was emulated those of an ant. The microrobot consisted of small size rotary type actuators, body frame, link mechanisms, and 6 legs.

A. Mechanical Components

Figure 1 shows the mechanical parts of the MEMS microrobot. The fabrication of the silicon wafer was done by the micro fabrication technology. The shapes were machined by photolithography based inductively coupled plasma (ICP) dry etching [18]. We used the 100, 200, 385, 500 μm thickness silicon wafer depends on each mechanical part.

Figure 2 shows the developed figure of the MEMS

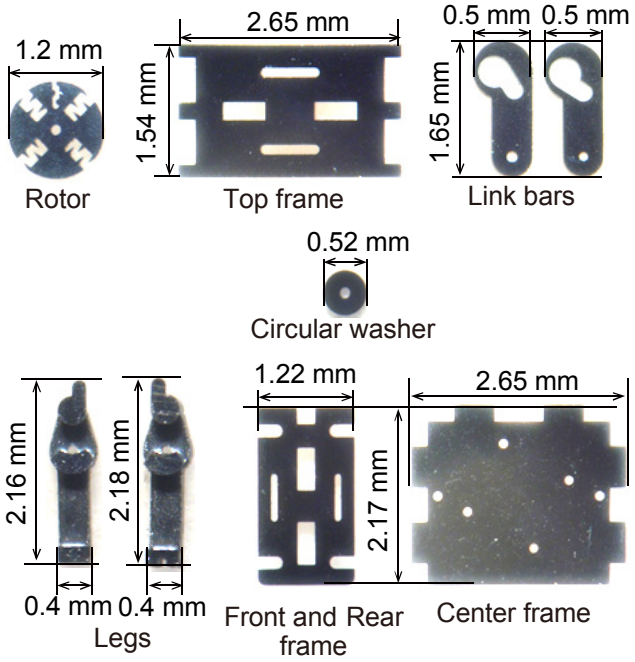

Fig. 1 mechanical parts of the MEMS microrobot

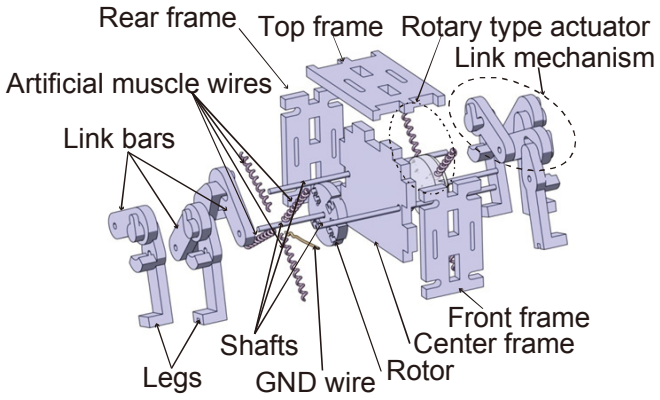

Fig. 2 developed figure of the MEMS microrobot

microrobot. Frame components, rotary type actuators, and link mechanisms were made from silicon wafer. Frame parts consisted of top frame, rear frame, front frame, and center frame. Rotary type actuators consisted of a rotor, GND wire, shaft and 4 pieces of helical artificial muscle wires. The GND wire was connected to the rotor directly. The frame components and the rotary type actuators were connected by the helical artificial muscle wire which was the shape memory alloy [19]. We used the BioMetal® Helix BMX50 to the helical artificial muscle wire (Available online at: [23]). The basic characteristics of the helical artificial muscle wire were as follows. The standard coil diameter of the artificial muscle wire was 0.2 mm where wire diameter was 0.05 mm. The practical maximum force produced 3 to 5 gf where kinetic displacement was 50 %. The standard drive current was 50 to 100 mA where standard electric resistance was 3600 ohm/m. The rotary type actuator generated the locomotion of the robot by supplying the electrical current to the helical artificial muscle wires. The wire shrank at high temperature and extended at low temperature. In this study, the wire was heated by electrical current flowing, and cooled by stopping the flowing. The rotational movement of the each actuator was obtained by changing the flowing sequence. The link mechanisms consisted of a link bars, shafts, and legs. The front leg and the rear leg were connected to the middle leg by link bars, respectively. The middle leg is connected to the rotor by the shaft. Therefore, the rotational phase was same as the rotor. On the contrary, the other two legs are connected by the link bar that generates 90 degree phase shift. Also, backward step was obtained by the counter rotation of the actuator.

MEMS microrobot after assembly was shown in Figure 4. The design size was 4.0, 2.7, 2.5 mm, width, length, height, respectively. The copper wires above the MEMS microrobot were two GND wires and eight signal wires. In the case of connecting the signal wires to the ANN, the MEMS microrobot could locomote. The one side of the artificial muscle wires connected to the copper wires and the other side connected to the rotor by using solder paste.

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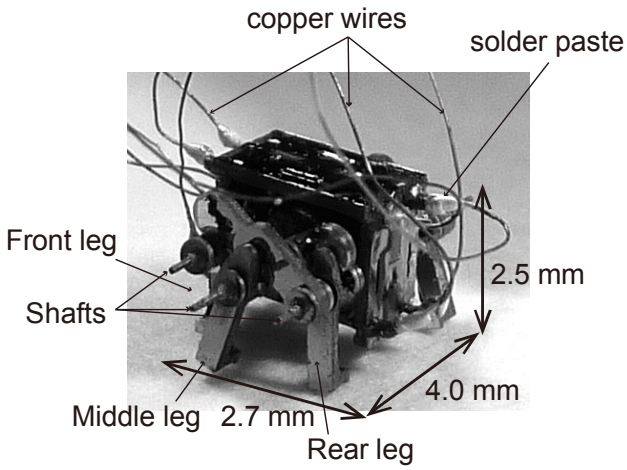

Fig. 3 MEMS microrobot after assembly

B. Locomotion Mechanism

Ants can locomote smoothly on the uneven surface by using step pattern. On the other hand, many microrobots were weak in moving on the uneven surface. Therefore, microrobot which could locomote by step pattern was desired. We replicate the locomotion of an ant by using rotary type actuator and link mechanism. In this section, we will discuss about locomotion mechanisms of the MEMS microrobot.

Figure 4 (a) shows the scematic of locomotion rhythm for MEMS microrobot. To heat the helical artificial muscle wires, it is required to input the pulse width 0.5 s, pulse period 2 s and pulse amplitude 3 V. Therefore, the microrobot required 2 s to finish the 1 cycle locomotion. The MEMS microrobot could move by the rotational actuator. The helical artificial muscle wire had a characteristic of changing length according to temperature. In the case of heating the wire shrunk and in the case of cooling the wire extended. In particular, when heating the helical artificial muscle wires from A to D, the MEMS microrobot would move forward. In contrast, heating the helical artificial muscle wires from D to A, the robot moved backward (figure 4 (b)). The locomotion pattern is 180 degree phase shift on each side to represent the locomotion of an ant. In the case of inputting shorter than pulse width 0.5 s, the artificial muscle wire could not shrunk because the joule heat by drive current was not enough. In contrast, in the case of inputting longer than pulse width 2 s, the artificial muscle wire could not extended because the joule heat by drive current was too much and cooling must be difficult.

III. Micro-Electro Systems of MEMS Microrobot

It is well known that locomotion rhythms of living organisms are generated by central pattern generator (CPG). Previously, we proposed the CPG model using pulse-type hardware neuron model [20-21]. CPG model was board level circuit using surface-mounted components. The board level circuit was 10

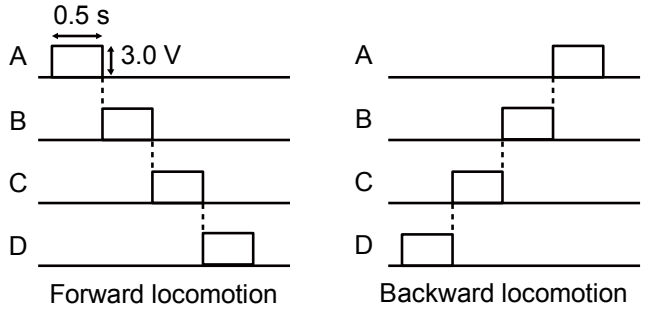

Fig. 4 (a) schematic of locomotion rhythm

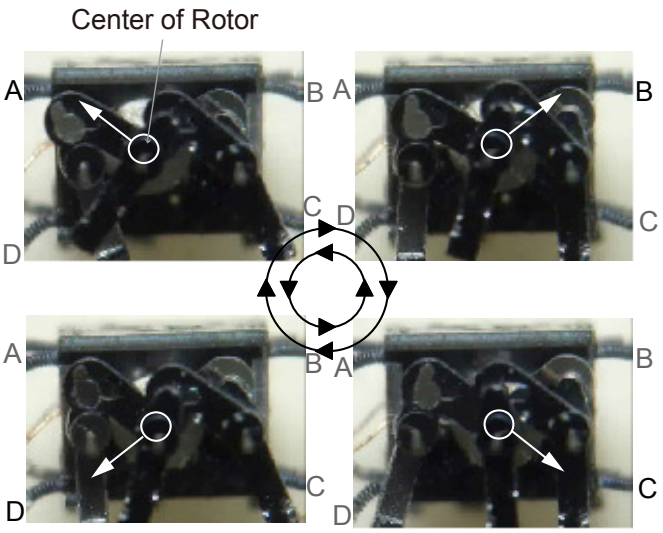

Fig. 4 (b) locomotion of MEMS microrobot

cm square size. Therefore, it was impossible to integrate on the MEMS microrobot system. In addition, we proposed the packaged IC of ANN which could output the driving waveform of the robot [22]. Proposing bare chip IC of ANN can mount on the MEMS microrobot system.

Figure 5 shows the circuit diagram of pulse-type hardware neuron model. The pulse-type hardware neuron model is a basic component of the ANN. The pulse-type hardware neuron model has the same basic features of biological neurons such as threshold, refractory period, spatio-temporal summation characteristics, and enables the generation of continuous action potentials. The pulse-type hardware neuron model consists of a synaptic model and a cell body model. In this study, we use inhibitory synaptic model as a synaptic model. The synchronization phenomena of pulse-type hardware neuron models changes by the connection of the synaptic model. The cell body model connected by excitatory synaptic model cause the in-phase synchronization. The cell body model connected by inhibitory synaptic model cause the anti-phase synchronization. Therefore, we use the inhibitory mutual coupling to generate the driving pulses which can operate the actuators of MEMS microrobot (For more detail, see [21]). The circuit parameters of synaptic model were as follows: C_{ES}=C_{IS2}=1 pF, $M_{ES1\text{-}3}$, $M_{IS1\text{-}5}$: W/L=1. The voltage source V_{DD}=5 V. The circuit parameters of the cell body model were as follows: C_G=39 μF,

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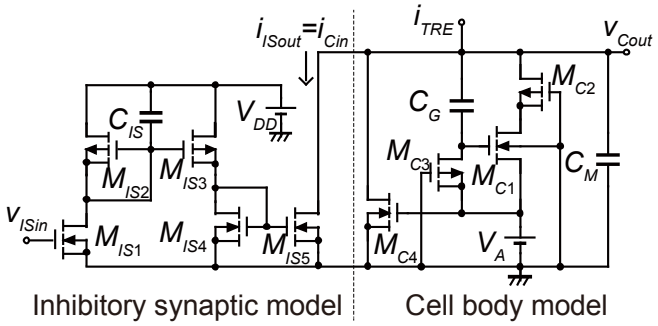

Fig. 5 circuit diagram of pulse-type hardware neuron model

C_M=270 nF, M_{C1}, M_{C2}: W/L=10, M_{C3}: W/L=0.1, M_{C4}: W/L=0.3. The voltage source V_A=3.3 V. The input voltage v_{ISin} of synaptic model were output voltage v_{Cout} of the other cell body model. The input current i_{Cin} of cell body model was output current i_{ISout} of synaptic model.

Using the anti-phase synchronization phenomena, we designed the ANN. The connection diagram of designed ANN was shown in Figure 6. The 4 cell body models are mutually coupled by 12 inhibitory synaptic models. Four output ports were extracted from ANN. In addition, four trigger pulse input port were extracted to ANN. According to the input timing of single external trigger pulse, ANN could change the sequence of driving pulses.

Figure 7 shows the layout pattern and constructed bare chip IC of ANN. The design rule of the bare chip IC was 4 metal 2 poly CMOS 0.35 μm. The chip was a square 1.93 mm x 1.93 mm in size. The sizes of capacitors of cell body model are too large to implement to the bare chip IC. Therefore, the capacitors C_G and C_M were mounted externally of bare chip IC.

Figure 8 shows the example of output waveform of bare chip IC of ANN. ANN is coupled neural networks system which can generate the locomotion rhythms such as living organisms.

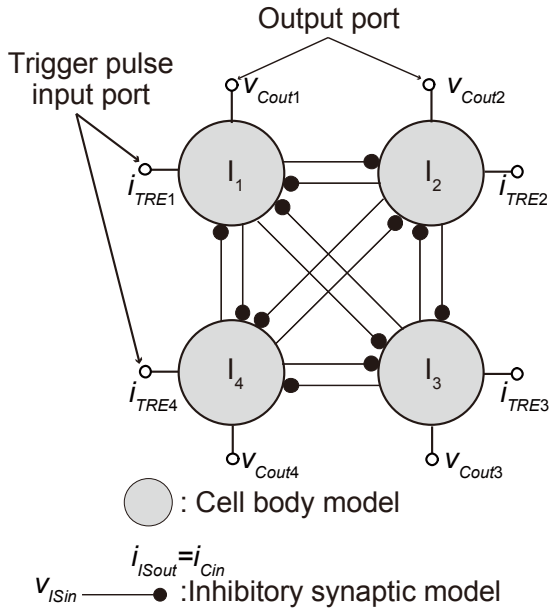

Fig. 6 connection diagram of designed ANN

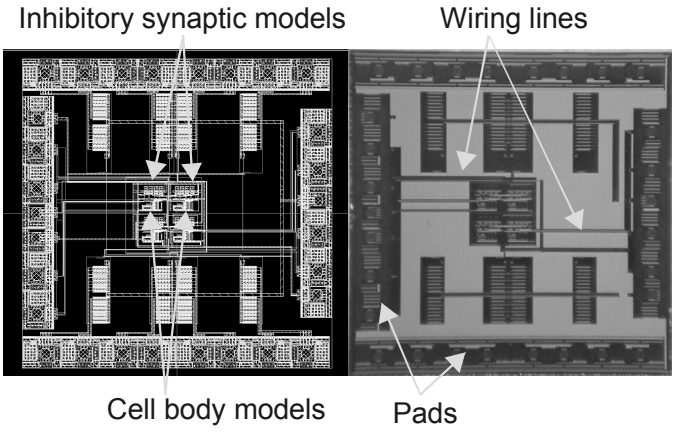

Fig. 7 layout pattern and bare chip IC of ANN

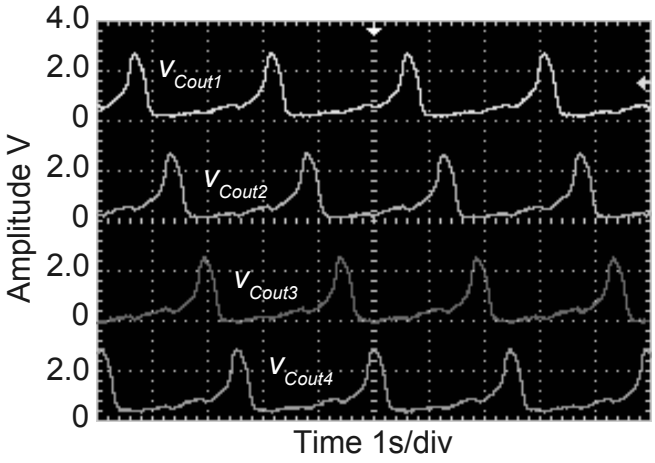

Fig. 8 example of output waveform of ANN

IV. Results and Discussion

Four output ports were extracted from ANN and they were connected to the artificial muscle wires. To heat the helical artificial muscle wires, we required to input the pulse width 0.5 s, pulse period 2 s and pulse amplitude 3 V (such as shown in figure 4 (a) and figure 8). Therefore, the microrobot required 2 s to finish the 1 cycle locomotion. In the case of inputting shorter than pulse width 0.5 s, the artificial muscle wire could not shrunk because the joule heat by drive current was not enough. In contrast, in the case of inputting longer than pulse width 2 s, the artificial muscle wire could not extended because the joule heat by drive current was too much and cooling must be difficult.

Figure 9 shows the example of locomotion of the MEMS microrobot. The bare chip IC of ANN could output the driving pulse of locomotion which is necessary to actuate the MEMS microrobot. Thus, our ANN is effective to generate the locomotion of the MEMS microrobot. The locomotion speed was 26.4 mm/min where the step width was 0.88 mm. (Examples of locomotion videos of MEMS microrobot are available at [24])

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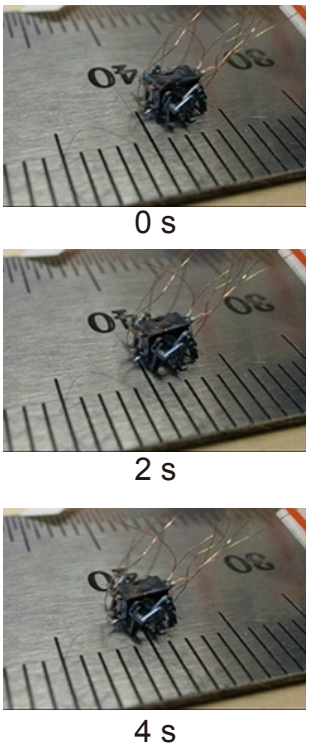

Fig. 9 example of locomotion of the MEMS microrobot

V. Conclusion

In this paper, we discussed about 4.0, 2.7, 2.5 mm, width, length, height in size hexapod locomotion type MEMS microrobot system. As a result, we developed the following conclusion.

Our constructed bare chip integrated circuit of artificial neural networks could output the locomotion rhythm which is necessary to locomote the MEMS microrobot. In particular our constructed bare chip integrated circuit of artificial neural networks could control the movements of MEMS microrobot. The locomotion speed of MEMS microrobot was 26.4 mm/min when the step width was 0.88 mm where the room temperature of measurement environment was 298 K. The power consumption of the microrobot system was 250 mWh. Our MEMS microrobot could locomote by step pattern. Therefore, our robot could locomote more smoothly on the uneven surface compared with the other microrobot.

In the future, we will mount the artificial neural networks directly on the body frame of the MEMS microrobot.

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Using Multimodality and Expressive Avatars in e-Government Interfaces to Increase Usability

D. Rigas, and B. Almutairi

***Abstract*—**This study investigates the use of multimodality and avatars to communicate information in e-government interfaces. The aim was to examine the role of multimodal metaphors such as facially-expressive and full-body avatars in e-government interfaces. Also, it was examined weather these metaphors increase the user performance and reduce information overload. The study combines avatar-based multimodal metaphors to communicate information and their evaluation. The effect of multimodal metaphors on the usability and communication performance of e-government interfaces to increase user trust and the production of empirically derived guidelines for the use of these metaphors in the software engineering process.

***Keywords*—**avatars, e-government interfaces, multimodality, user trust, user interfaces.

I. Introduction

MANY e-government interfaces are crowded and not always communicate information to users correctly. These interfaces often use visual means to communicate information (often text with graphics). The user interaction could improve significantly if additional channels (e.g. auditory) to the visual one are added. This paper presents an empirical study to investigate the usability aspects of an e-government interface that incorporates a combination of traditional metaphors (e.g. text and graphics) with multimodal metaphors (expressive avatars with body gestures). Parameters investigated included users' attitudes towards expressive avatars when employed as virtual messengers as well as the user predisposition to trusting the specific interface. This investigation could help understand the role of expressive avatar within multimodal e-government user interfaces.

An e-government experimental platform, with two interface versions, was developed to serve as a basis for this investigation. The e-government software solution described uses an input interface to send messages and an output interface to receive messages. The study involved two groups of users that used the two interfaces to perform a common set of tasks. The usability of the two interfaces was measured in terms of efficiency, effectiveness, user satisfaction and user predisposition to trust.

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II. Literature Review

A. Multimodal Interaction and Avatars

"*The auditory channel, as a whole, has been neglected in the development of user-interfaces, possibly because there is very little known about how humans understand and process auditory stimuli*" [1]. Multimodal metaphors offer interaction using more than one channel of communication. The additional communication metaphors increase the volume of information communicated and often better understood by users. Rigas et al, suggest that the use of multimodal metaphors in a variety of user interface circumstances [2]. Also, they found that the use of speech and non-speech in interface application helped the users to make fewer mistakes and reduced the time taken when accomplishing their tasks [3]. Other studies have been carried out to test the use of multimodal metaphors in a visual user interface and to evaluate and examine the effect of these metaphors on the usability of computer applications [4 and 5]. An avatar provides a multimodal interaction metaphor that engages the visual and auditory human senses. It is a computer-based character that has been utilized to virtually represent one party in an interactive context [16, 17] with the ability to communicate verbal and non-verbal information [18, 19]. Verbal communication refers to the use of speech and written messages, whereas nonverbal communication can be attained by facial expressions [20]. In general, avatars can be classified as abstract, realistic and naturalistic.

An avatar is a software or tool which can be used to allow users to speak about something through live message formats which can be used to give complaints, suggestions or comments. Use of the avatar is compared with video messages or recorded messages during this study. The efficiency and effectiveness of the messages can be determined by the time and number of mouse clicks as well as user satisfaction.

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B. Usability Evaluation of e-Government Interfaces

Usability is one of the most important factors to evaluate Human-Computer Interaction [6] and software quality [7]. It is defined as the "*extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction*" [8]. An effective system can be developed only by understanding the interfacing requirements, expectations of the users' under the citizen-centric approach, and the barriers that might hinder them to provide the desired services through the Internet [9]. This technology can be used to improve the efficiency of e-government interfaces, interaction between the government services and the public, facilitate economic development, reduce costs, and meet citizens' expectations for service delivery [10 and 11].

C. Trust Factor

Social sciences recognise trust as an important factor that mediates many aspects of human behavior [12, 13 and 14]. There are several definitions of trust but a widely accepted one is: "*a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another*" [15]. Thus, a person (the trustor) who depends on someone else (the trustee) expects to reduce the likelihood or the size of a negative outcome in any situation. When that dependence is misplaced, the expected value of the outcome is lower. The online environment does not allow the natural benefits of face-to-face communication and to directly observe the service provider's behavior. This serves as an assurance mechanism on which humans have depended to form a trust judgment. Based on this trust paradigm, new service paradigms could emerge that could develop passive citizen participation into active citizen participation in public service delivery [22]. As the characteristics or features of online communication have the ability to decrease or increase the level of citizens' trust, it would be valuable to understand the influencing factors and their contribution. This will then help with ensuring that these factors are executed in such a manner that ensures that citizens can place the optimal level of trust in e-government.

III. Aims and Objectives

One of the main aims of this study was to evaluate the usability in terms of effectiveness, efficiency, user satisfaction and the perception of trust in e-government interfaces that incorporate full body expressive avatars in virtual message presentation. It is also focused on the evaluation of the effectiveness and efficiency of supporting auditory messages associated with the live message presentation of the full-body expressive avatar. Furthermore, the study measures user satisfaction and trust in relation to the e-government user interface. The objectives of this study were:

1. Development of experimental multimodal e-government platforms with typical e-government interface functionalities. This platform is referred to as the Avatar enhanced Virtual Message with Body Gestures Platform (VMBG).
2. Evaluation of the two e-government platforms by two groups of users.
3. Measure the efficiency of user performance using the time taken by users to complete the required tasks.
4. Measure the effectiveness of user performance using the frequency of tasks successfully completed by users.
5. Measure the user satisfaction and trust using post-experimental questionnaires to determine and assess the users' attitudes to the e-government platform.

IV. Experimental e-Government Platform

The e-government platform was specially developed for this empirical investigation. The platform provided two different interface versions. It was specially designed to utilise speaking avatars with human-like facial expressions, and speaking avatars full body gestures. Both interface versions of the experimental platform were designed to deliver the same information about software representation of a given message. Each interface was divided into an *input* and *output section.* The software provided three message types. These were *suggestion*, *complaint* and *comment* and they included explanations about specific requests. There were three examples of common message types with three different complexities (easy, moderate, complex). The complexity of these examples was gradually increased. In addition to question type, this study also investigated the effect of two types of evaluation questions; recall and recognition for the usability of the e-government interfaces tested, as well as on users' performance in terms of the output interface's property.

A. Virtual Message with Facial Expressions Condition (VMFE)

Fig. 1 and Fig. 2 shows example screenshots of the avatar e-government interface. The interface provides command buttons to enable the message to be presented. It also provides two separate components for the message process, namely the speaking expressive avatar. The interface is divided into two parts, the first part is the input interface and second part is the output interface. These were designed to include the following components: a text box to present the user with information and a speaking expressive avatar box.

B. Virtual Message with Body Gestures Condition (VMBG)

Fig. 3 and Fig. 4 illustrates an example of this condition with full-body expressive avatars. This approach could be considered as the closest to a face-to-face communication. Three facial expressions were used in the VMFE condition and ten body gestures were used in VMBG.

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Fig. 1 Virtual Message with Facial Expressions condition (VMFE) input interface

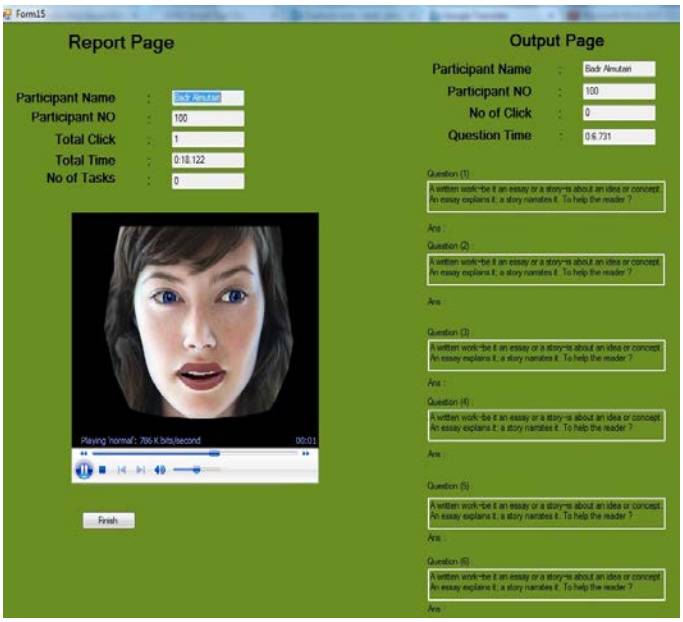

Fig. 2 Virtual Message with Facial Expressions Condition (VMFE) output interface

C. *Experimental Design*

Two groups of users were associated with the evaluation of the VMFE and VMBG conditions. The sample was 30 users in total and participated in the experiment on an individual basis. This experiment data was collected in three stages. The first part was the pre-experimental questions for the profiling of users. The second part investigated the users' evaluation (positive or negative or neutral) when using facial expressions or full body gestures in the experiment. Each expression and gesture was shown to users as still images on the screen. In the third part of the experiment, the experimental conditions were demonstrated to users and the experiment progressed with the tasks. The aim was to obtain an overall viewpoint of the users' perceptions of the same expressions and gestures but in the presence of an interactive context.

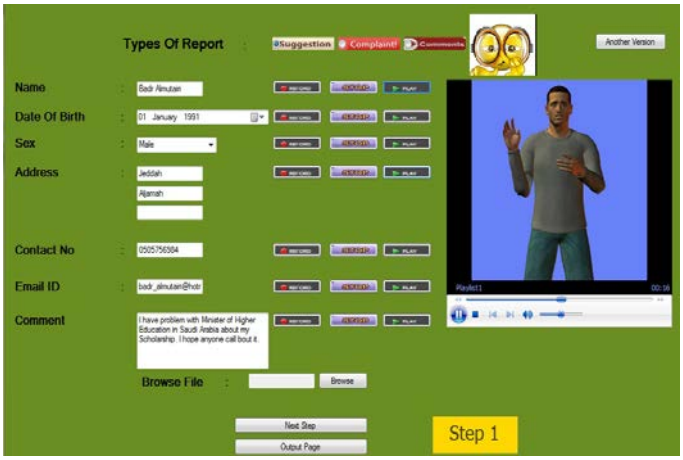

Fig. 3 an example screenshot of VMBG condition input interface for e-government

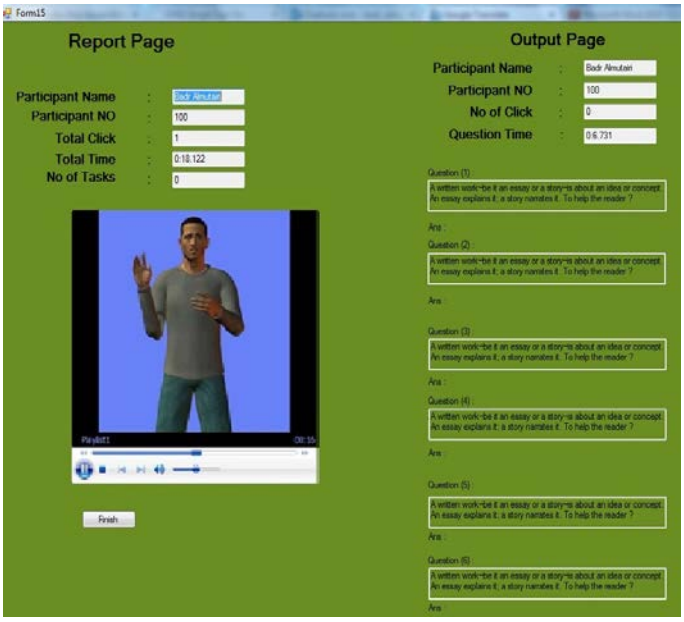

Fig. 4 an example screenshot of VMBG condition output interface for e-government

V. Data Collection

The data collection process was based on experimental observations and questionnaires. For each task, each user was required to complete nine tasks and to answer six questions. The time spent to complete the message tasks and to answer each of the six questions was recorded to help measure the efficiency. However, in order to collect the data related to effectiveness, the correctness of users' answers were checked and the total number of successful users, who completed the message tasks and answered questions was counted for each user. The pre-experimental part of the questionnaire gathered personal data about users such as age, gender and education. It also helped to obtain data related to users' prior experience with computers, Internet and e-government. Finally, the post-experimental part of the questionnaire gathered the users' satisfaction with the e-government platform tested. Users' responses to this questionnaire were used to calculate the satisfaction score for each user in both the control and the experimental groups.

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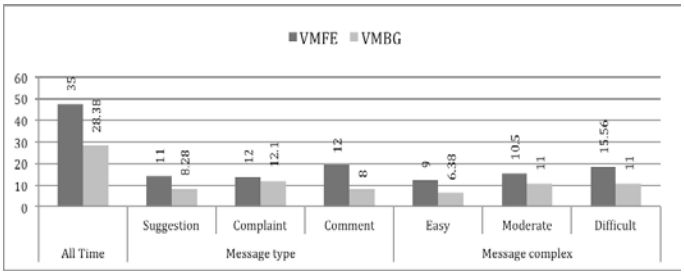

Fig. 5 mean values of time taken by users in both groups to enter all tasks (Input interface)

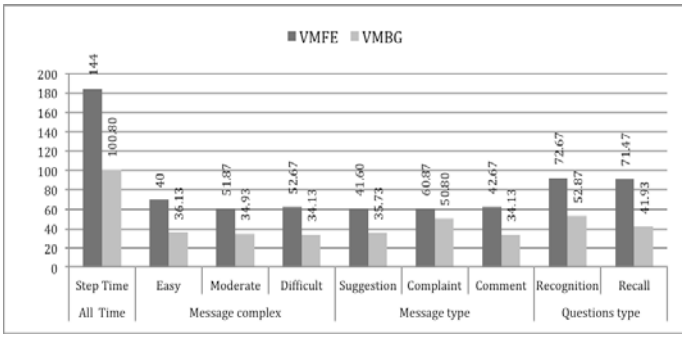

Fig. 6 mean values of time taken by users in both groups to enter all tasks (Output interface)

VI. Efficiency Results

The time taken to perform tasks and answer the required questions was used as a measure of efficiency. This measure was considered for all tasks for the input and output interfaces according to the question type (recall or recognition) and complexity of the message. The control group spent a total of 35 minutes and the experimental group 28.3 minutes. Fig. 5 shows the mean values of the time taken by all users. The experimental group (see Fig. 6) took less time to complete the tasks. The use of avatars appeared to improve efficiency, as tasks took less time - unlike the other group that their users took more time to complete the tasks in the output interface.

VII. Effectiveness Results

The frequencies of correctly completed tasks were used as a measure of effectiveness. This measure was considered for all tasks and questions, according to the question type (recall and recognition), message complexity (easy, moderate and difficult) and message type (suggestion, complain and comment), as well as for each user in both control and experimental groups. This measure was considered for all the tasks for each group per user. Fig. 7 shows the percentage of mouse clicks to enter messages for all tasks for the VMFE and VMBG interface versions of the e-government platform. Users of the VMBG used less mouse clicks that users of the VMFE. The reason for this is the enhanced input interface used by users when using the new avatar tool as full body and improved the performance of communications.

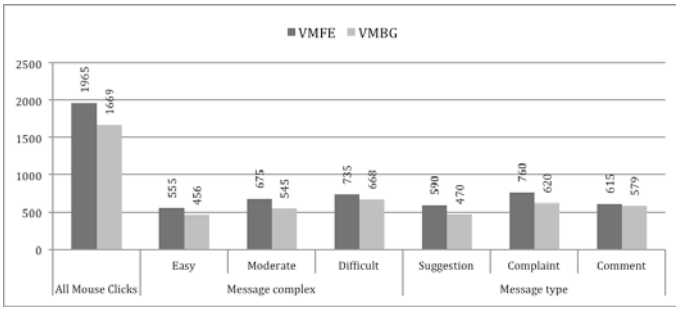

Fig. 7 the mean number of mouse clicks performed by users in both groups to enter messages for all the tasks for the input interface

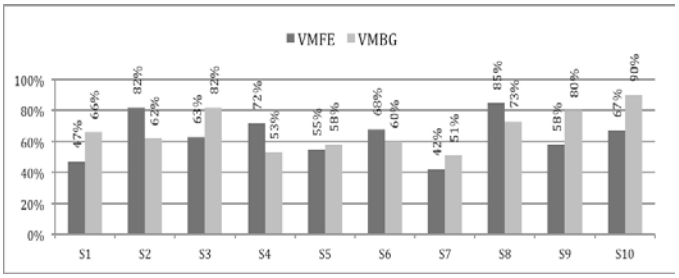

Fig. 8 percentage of users agreeing to each statement of satisfaction, for both VMFE and VMBG groups

Users of the VMFE were 78% correct and VMBG users were 99% correct in the input interface. Users of the VMBG complete more tasks successfully than VMFE users, in terms of the number of correctly entered messages for tasks using the output interface. The VMBG was more effective in communicating messages and considerably assisted the users in the experimental group to achieve a higher effectiveness rate.

VIII. User Satisfaction

Users' responses were gathered using a questionnaire with 10 statements. They were designed to measure the post-experimental user attitude and predisposition to developing trust towards the interface they used. The overall satisfaction score for each user was calculated using the SUS (System Usability Scale) method [21]. Fig.8 shows the mean values of user satisfaction scores.

IX. Discussion

The results obtained provide a comparison point between the interfaces The study also focused on the factors that can affect the role of multimodal interaction metaphors, such as the message type (suggestion, complaint, comment) the message complexity level (easy, moderate and difficult) and the question types (recall and recognition).

The results obtained showed that the full-body expressive avatar significantly improve the efficiency of tasks and users were more effective in the input interface. In addition, the same multimodal metaphor improved users' efficiency and effectiveness when used in the output interface, compared to the avatar facial expression approach for communicating the message content.

Fig. 5 demonstrates that using the multimodal interaction metaphors increased the time needed by users in the control

group to enter messages in the input interface. However, there was a significant reduction in the time needed by users in the experimental group to respond to the evaluation questions in the output interface, as shown in Fig. 6.

The reason was that the full body avatar enhanced the interaction process for each task when users sent messages. Therefore, the tasks took less time to be completed during the use of the input interface. Experimental observations highlighted that users in the experimental group took less time because they were concentrating on the full body avatar. Therefore, users in the experimental group were significantly aided by the addition of these metaphors in the VMBG, in terms of spending less time to answer questions. These results suggest that the use of the full body avatar can significantly improve efficiency than the use of the avatar facial expression metaphors when presenting information.

The VMBG platform was more efficient for both recall and recognition questions than the output interface. On the whole, the experimental findings indicated that the addition of the full body avatar contributed to the memory recall of users. Fig. 6 shows the time taken by users to answer recall and recognition questions. The experimental group had generally lower time for both types of questions. The recall questions taken shorter time to the recognition ones.

The VMBG group outperformed users of VMFE in the number of mouse clicks that measured performance of communication and tasks complete successfully. Fig. 7 shows that the VMBG condition was better than the VMFE for reducing the number of mouse clicks. This was due to the use of the full body avatar in the input interface for the experimental group, in comparison to the sole use of avatar facial expressions to convey messages to the control group. These metaphors enabled the retention of information for a longer. As the experimental group users were able to remember the communicated information for a longer period of time (in comparison with the control group), they were able to attain a considerably greater number of mouse clicks than their control group counterparts. In addition, the multimodal interaction metaphors used in the VMBG were more effective and considerably assisted the users in the experimental group to achieve a higher effectiveness rate.

The VMBG group accomplished a substantially larger number of correct answers than their counterparts in the VMFE for both recall and recognition. In order to successfully answer the recall questions, users had to correctly retrieve from their memory part of the communicated messaging content. The results of this experiment indicated that new multimodal metaphors enabled users to understand the questions better, without distracting their attention away from the presented content. The rates of recognition questions for the VMFE was 55% compared to VMBG at 100%. This demonstrates that users' memory was not aided when they used the interface with the recorded speech.

The multimodal presentation of the message content in the VMBG was shown to be significantly more satisfying than the avatar facial expression interface in the VMFE. The use of full body avatar was more effective for users in the experimental group. Users expressed a positive attitude towards the audio-visual communication of messages. The multimodal aided e-government interface is more likely to result in an agreeable and satisfying experience for the user.

A. Empirically Derived Guidelines

The results of these experiments as well as the results of previous experiments [22-25] enabled the development of a set of empirically derived guidelines for the design of more usable e-government interfaces.

Recoded Speech. It was shown to be a fundamental component in interactive multimodal e-government interfaces. The obtained results demonstrated a significant contribution of recorded speech in delivering a clear and understandable spoken message to users. Users expressed positive views towards the tested e-government interfaces. For example, different tones could be used to stress users‘ attention to specific key words or statements in the delivered message content. The use of recorded speech prevents users from switching their attention away from the graphical representations or visual area of focus. The use of speech output will often reduce the working memory load of users.

Facially-expressive avatars. They were found to be the most liked and best rated by the users. The implementation of these expressions in an avatar during the communication of a message, makes the presentation better understood by users. These expressions could be used to change the tone of the presentation and attract users to think of the presented information.

Expressive avatars with body gestures. Some body gestures in full body avatars help to effectively communicate a message. These gestures are neutral, hands down, hands behind, open hands, walking, contemplate, paws opposite, chin stroking, opposite legs and indicate. These gestures were, also, preferred by users.

Integrating the metaphors. Combining a full body avatar and placing the textual content in the background, during the communication of a message, maximises the benefit of body gestures (e.g. walking and pointing). This is particularly useful when users are guided to specific displayed messages in the interface. The use of a face-only avatar may result in overloading users as they may be searching for the information related to the spoken message.

Non-speech Auditory Stimuli. Earcons and auditory icons are effective in annotating the spoken message expressed by an avatar (e.g. a bell and door or bottle opening can signal the beginning of a message and a door closing can indicate the end of that communication). Earcons can be used to highlight specific key words during communication.

X. Conclusion

This paper examines the impact of multimodal avatar-based interaction in e-government interfaces for ease of use, in terms of efficiency, effectiveness and user satisfaction and trust. This study has been implemented by developing two different experimental e-government platforms. The first platform was based on the use of facially expressive avatars and the second platform full body gestures and facial expressions avatars. These two e-government interface platforms were empirically evaluated by two independent groups of users. These groups

of users evaluated their corresponding interface by performing experimental tasks and answer evaluation questions.

The results obtained from this experiment confirm that expressive avatars improved usability, development of user trust, reduced response time to messages and allowed users to complete tasks more accurately. They also made the use of the interface more pleasing and satisfying to users. Therefore, the use of these particular metaphors improved the performance of users and ease of use of e-government interfaces in terms of effectiveness, efficiency and user satisfaction and trust. It is therefore proposed to include expressive avatars in e-government interfaces, and this need to be considered when designing such interfaces.

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Development of a human movement monitoring system based on wearable devices

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***Abstract*—**It is essential to remotely and continuously monitor the movements of individuals in many social areas, for example, taking care of aging people, physical therapy, athletic training etc. Many methods have been used, such as video record, motion analysis or sensor-based methods. Due to the limitations in remote communication, power consumption, portability and so on, most of them are not able to fulfill the requirements. The development of wearable technology and cloud computing provides a new efficient way to achieve this goal. This paper presents an intelligent human movement monitoring system based on a smartwatch, an Android smartphone and a distributed data management engine. This system includes advantages of wide adaptability, remote and long-term monitoring capacity, high portability and flexibility. The structure of the system and its principle are introduced. Four experiments are designed to prove the feasibility of the system. The results of the experiments demonstrate the system is able to detect different actions of individuals with adequate accuracy.

***Keywords*—**accelerometer, movement monitoring, smartwatch, smartphone, wearable device.

I. Introduction

THE body movements of a human being can reflect their behavioral habits and functional activities. The ability to record and analysis these movements is essential in many areas, for example, taking care of aging people, physical therapy, athletic training, sports monitoring etc.

Several methodologies have been used to monitor the human movements, from questionnaires in early days [1] to video records [2] and motion analysis [3] later on. With the development of wireless communication and sensor technology, inertial sensors have been widely applied for this purpose [4]-[8], since they have good performance with high accuracy, good repeatability, and relatively low price [9]. Among different kinds of sensors, the tri-axial accelerometer is one of the most popular ones. Its high accuracy has been proved by many researches [10]-[14]. However, there still remain some drawbacks of these methods in practical applications. For example, the accelerometers send data directly to a computer through wireless communication with a distance limitation; some sensors are specially-made under the laboratory environment and they are inconvenient for the user to carry around. Attempts also have been made to use the accelerometers inside smartphones [15], [16]. The imperfection of such solutions also lies in the inconvenience of attaching the smartphone onto the user's body.

In recent years, the fast growth of wearable technologies provides a new option for monitoring the movements of individuals without the limitations described above. Wearable devices may be worn under, over, or in clothing, or may also be clothes themselves [17]. The improvement of various technologies creates the best environment ever for the application of wearable devices: more efficient and smaller high capacity batteries provide enough power; sensors become smaller and processors become faster without overheating or requiring active cooling systems [18]. As good examples, smart glasses, smartwatches, smart bands, smart shirts and so on are already influencing the lives of thousands of users.

The objective of this paper is to develop a human movement monitoring system that (1) can continuously collect a user's movements data and send it to a remote server in an accurate and efficient manner; (2) has wide adaptability, like waterproof capability, without distance limitation; (3) has the ability to process and analyze a large amount of data; (4) is easy to carry without causing any inconvenience to the user. The system is based on a three layer model composed by a Pebble watch (a smartwatch containing a tri-axis accelerometer), an Android smartphone and Elasticsearch (a distributed data management engine) on a remote server.

The rest of this paper is organized as follows: an overview of the method is presented in section 2. Experiments and results are described in section 3. Section 4 discusses the advantages and limitations of the system. Conclusions and future works are given in section 5.

II. Method Overview

The proposed movement monitoring system contains three parts: (1) a Pebble smartwatch for recording the user's arm movement data; (2) an Android smartphone receives data from Pebble and sends it to remote server together with data collected from its GPS sensor and accelerometer; (3) a data search and analytic engine on remote server for data storage and analysis. The overall architecture of the system is shown in Fig. 1.

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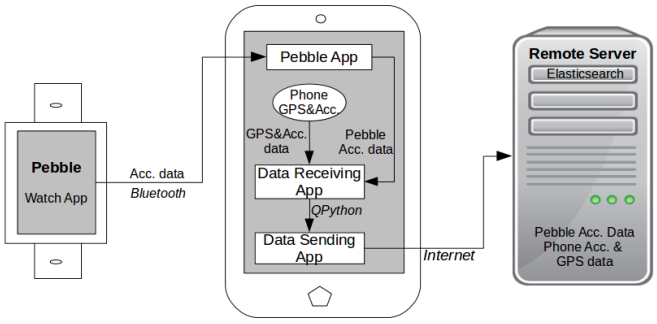

Fig.1 three-layer architecture of human movement monitoring system

A. *Data Collection with Pebble*

Pebble is a smartwatch released in early 2013, which contains a tri-axis accelerometer and Bluetooth 4.0. The accelerometer can measure acceleration caused by gravity or some type of physical movements as simple as the twist of a wrist or the flick of a finger. It is calibrated to measure a maximum acceleration from -4G to +4G, measured in milli-Gs (mG). Therefore, the range of possible values for each axis is -4000 to +4000 mG, which is enough for monitoring the normal human movements.

The application on Pebble watch is supposed to collect the raw data from the accelerometer hardware and relay it to the smartphone. To accomplish this goal, several Pebble Application Program Interfaces (APIs) are used in our application, for instance, accelerometer, data logging, UI framework and event services. The application is developed on Cloud Pebble, which is a cloud development platform provided by Pebble Technology. The interface of the watch application is shown in Fig.2.

Fig. 2 User interface of the Pebble watch application

Five values are recorded by the application: a timestamp value to identify the time when the action happens, acceleration values on the three axes and an angle value to show the angle between wearer's arm and the horizontal plane. The first 4 values are produced by the accelerometer itself and the angle is calculated from the three acceleration values according to equation 1. Fig. 3 illustrates the calculating method. The value of the angle ranges from -270° to 90°.

$$Angle = \operatorname{atan2}(acc.z, acc.a) \cdot 360° / (2\pi) - 270° \quad (1)$$

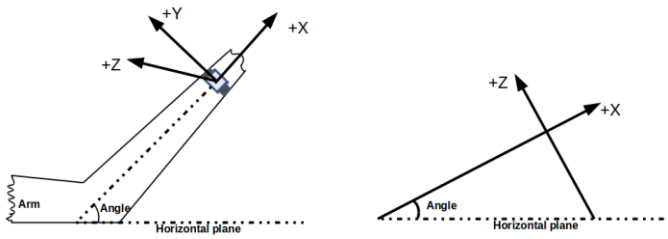

Fig. 3 Angle of the wearer's arm

These 5 values are recorded every 300 milliseconds (3.33 Hz), thus 200 records are produced in 1 minute. This frequency can be set to as high as 1000 Hz according to different scenarios. The data is stored in data logs created by the application. A new data log is created every one minute after the end of the previous one. If the Pebble watch is connected to a smartphone via Bluetooth, the data logs will be sent to the smartphone immediately, and if the smartphone is not available, the data logs will be saved in the memory of the smartwatch until the smartphone is connected. This character makes the system more flexible in real life scenario, since the users do not have to carry the smartphone with them all the time. This is especially important when doing sports like running or swimming. Fig.4 shows the data stream in the Pebble watch.

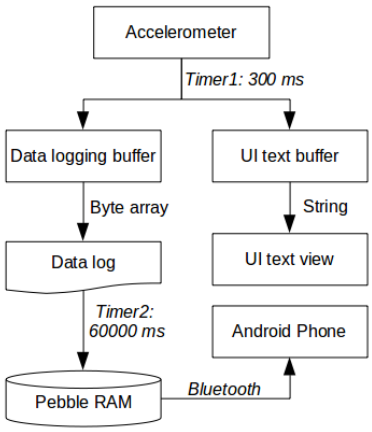

Fig. 4 Data flow inside Pebble watch

B. *Data Integration and Transfer with Android*

The smartphone in our system is responsible for collecting body posture information and transferring data to the server. It contains three components:

(1) Data reception from Pebble

The task of receiving data from Pebble watch is completed by the Pebble App on Android, which is an application provided by Pebble Technology Company. The received data logs will be saved into the App buffer space in the format of byte array. They can be exported to other Android applications for further utilization through Pebble APIs.

(2) Data extraction and integration

Every Pebble watch application possesses a Universally Unique Identifier (UUID). The Pebble API object *PebbleKit.PebbleDataLogReceiver* is able to identify a certain watch application through this UUID and extract the data logs produced by it from the Pebble App buffer space mentioned above. Based on this API, another Android application is

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developed to extract watch data and combine it with that collected from smartphone sensors.

The integrated data is then saved into a local text file every 200 records (the amount of data produced in 1 minute). The format of the data is changed from byte array to string before being saved. The text files are named with the data log timestamp to make them easier recognized. A sample record of data is presented in Fig. 5. The value of the timestamp is the number of milliseconds since the epoch time.

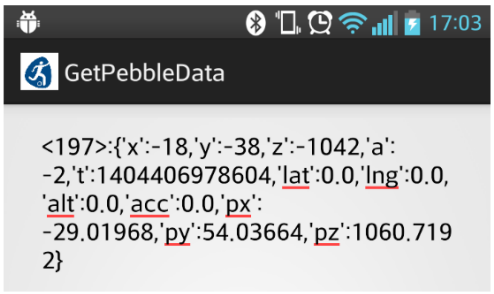

Fig. 5 Data receiving UI

Besides the 5 values collected by the Pebble watch, 7 more parameters are added to the records which represent the information collected from smartphone sensors, as shown in Fig. 5. The first 4 parameters, *'lat'*, *'lng'*, *'alt'* and *'acc'*, indicate the location information collected from GPS sensor, referring to latitude, longitude, altitude and accuracy respectively. The last 3 parameters, *'px'*, *'py'* and *'pz'*, indicate the acceleration values on the three axes of the accelerometer inside the smartphone.

Since the smartwatch can only measure the movements of the arm, the data collected from the smartphone sensors can help analyze the location of the users and their body postures.

(3) Data uploading to remote server

A mechanism composed by Scripting Layer for Android (SL4A) [19], QPython [20] and a Python script is built to upload the data from the smartphone to the remote server. SL4A brings scripting languages to Android by allowing users to edit and execute scripts and interactive interpreters directly on the Android device [19]. QPython is a script engine running on Android devices. It embeds the python interpreter, console, SL4A library for android, which can make the android device run python script or project [20].

After the above processes, the data collected from the Pebble watch and smartphone sensors is saved into text files in a local folder. A Python script file is created for sending this data to the server. When this script is running supported by QPython and SL4A, it will check if there is any .txt file in the above folder. If any text file is found, it will send the data to the remote server through Internet and delete the file after all the data inside has been sent. This process is repeated until all the text files are uploaded and deleted. Fig. 6 illustrates the working process.

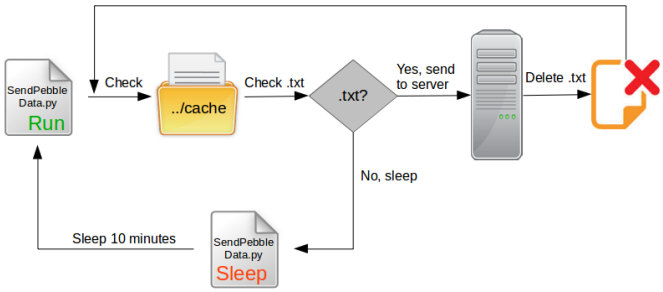

Fig. 6 Upload data from phone to remote server

C. *Data Storage with Elasticsearch*

On the remote server, Elasticsearch is used to manage the data received from the smartphone. Elasticsearch is a flexible and powerful open source, distributed, real-time search and analytic engine [21]. Each record received from smartphone is saved as a doc in Elasticsearch.

Search conditions of Elasticsearch can be defined very flexibly. We can either use the combinations offered by it or define more complicated conditions by programming. The search result can be presented in three different formats: table, JavaScript Object Notation (JSON) and Comma-Separated Values (CSV). It is convenient to export the data to different software for further studies.

III. Experiments and Results

Four experiments are designed to test the ability of the system to: (1) distinguish different actions of the user; (2) separate different movement habits of different individuals; (3) continuously monitor the movements of the user for a long time; (4) collect information from different sensors of both the smartwatch and smartphone.

A. *Experiment 1*

In the first experiment, the participant wears a Pebble watch on his left wrist and performs 4 actions sequentially: sitting and inputting on the keyboard, standing and talking with a cup in the left hand, normally walking and jogging, as shown in Fig. 7. Each action lasts for about 30 seconds.

Fig. 7 Actions of first experiment

The collected data is exported from Elasticsearch as CSV format and the analysis is finished with R, which is a language and environment for statistical computing and graphics [22]. As mentioned before, the collected data includes the acceleration values on the three axes and the angle of wearer's arm. All these parameters change with the movement of the wearer's arm. The result is plotted in Fig. 8.

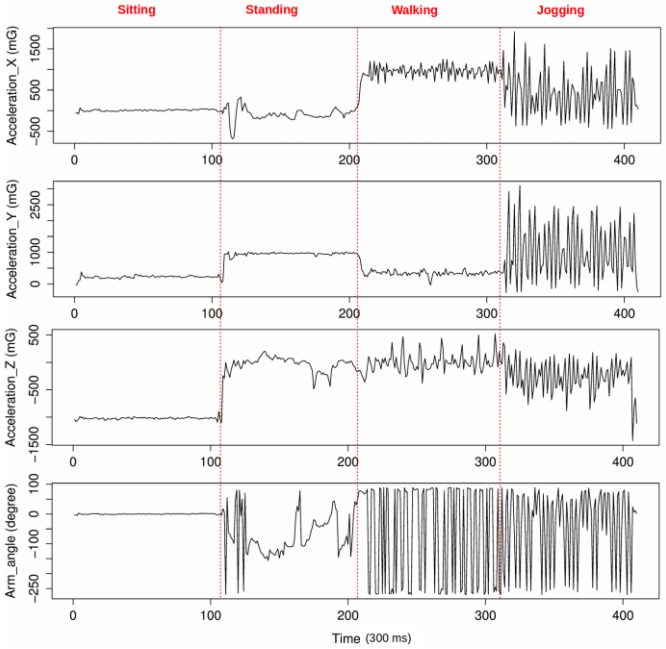

Fig. 8 Data collected during the 4 actions of first experiment

It is obvious in the figures that all the values are divided into 4 different periods and each period covers about 100 records. This experiment indicates how the system can be used to distinguish different actions of the same person at different times. We can also use it to compare the same action taken by different individuals. In other words, the system is able to figure out if the same person is wearing the Pebble watch all the time.

B. *Experiment 2*

In the second experiment, another participant (marked as Person B) is invited to perform the same actions as the one (marked as Person A) did in the first experiment. To make the result clear, we selected the acceleration values on the X axis of the walking action and plotted them together (Fig. 9).

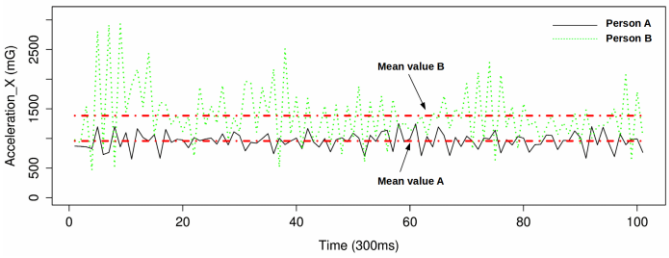

Fig. 9 Comparison results of two individuals

The difference is clear, since an obvious gap exists between the mean values of the two individuals, although their frequencies are similar. This result demonstrates that people's walking habits are not all the same. A possible application of this principle is to develop anti-theft applications for smart devices.

C. *Experiment 3*

In the third experiment, the movement data of a whole day was collected to test the system's ability to monitor the wearer's movements consistently. Part of the result is shown in Fig. 10, including the data of sleep at night and some actions in the morning.

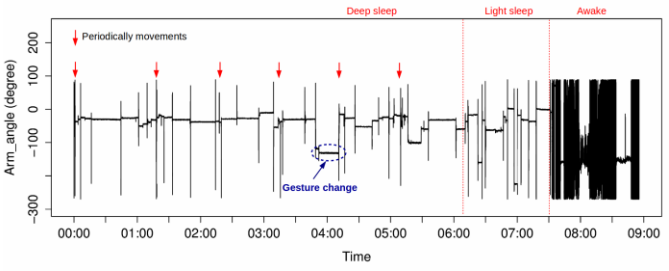

Fig. 10 Long term monitoring result

The participant begins to sleep at 00:00 and wakes up at 07:30. A sharp distinction between sleeping and waking appears in the result. The result also shows the difference between deep sleep and light sleep. During the first 6 hours, a few movements appear regularly, approximately every one hour. After 06:00, the frequency of movement increases evidently, indicating the beginning of light sleep. More details about the morning actions can be found in the following zoom-in chart (Fig. 11).

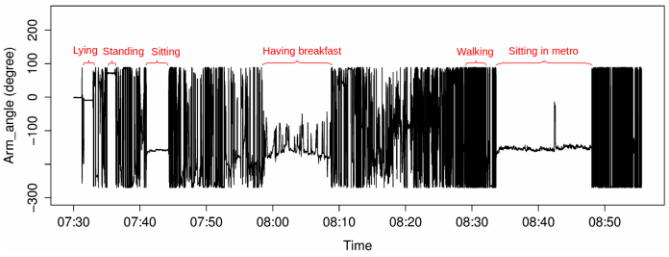

Fig. 11 Analysis of actions in the morning

A series of actions are reflected in Fig. 11: the individual wakes up at 07:30 in the morning and stays lying in bed for a few minutes after turning off the alarm, then gets up and goes to the bathroom, sits and reads news on his smartphone, sits and has breakfast, walks in the street and sits in the metro etc.

D. *Experiment 4*

A limitation of using a smartwatch to monitor human action is that it can only measure the movements of the arms. The accuracy decreases when it is necessary to identify body postures, such as monitoring sleep habits or detecting falls among aging people. Considering people usually carry smartphones in their pockets, the data produced by the sensors inside the smartphone is also collected by the system to help identify users' postures.

In this experiment, we compared the data produced by the accelerometer of the smartphone during 4 postures: standing still, sitting on a chair, lying supinely and lying prostrate. The participant carried the smartphone in his trousers pocket close to the thigh. The result is shown in Fig. 12.

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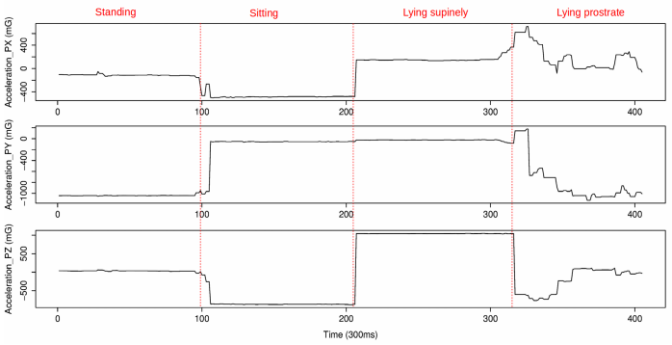

Fig. 12 Smartphone accelerometer monitoring result of different postures

The acceleration values on each axis differ distinctly between different postures. It suggests that the system is able to distinguish user's postures. After integrating both the data from Pebble watch and the smartphone, a more accurate monitoring result of human actions will be available.

The results of these 4 experiments demonstrate that the system is able to monitor the user's movements consistently with adequate accuracy. In practice, this ability is useful in many areas. For example, applications can be developed to analyze and increase the users' sleep quality, remotely monitor the movements of aging people, make better physical therapy plans for patients and so on.

IV. Discussions

The system presented above has several advantages in monitoring movements of individuals compared with similar methods proposed before. However, there are also a few limitations, which are supposed to be solved in the near future with the fast development of wearable technologies. Both the advantages and limitations of the system are discussed as follows:

A. Advantages

Wide adaptability: Instead of sending data directly from the accelerometer to the computer, this system uses a smartphone as a data transfer station. The collected data can be saved in the smartwatch or in the smartphone temporarily and sent to remote server when it is possible. This eliminates the distance limitation. Besides, the waterproof characteristic of the Pebble watch enables it to work in wet environments, like bathing, swimming or even diving.

Remote and continuous monitoring: The monitoring results can be sent to a remote server in almost real-time via the Internet. The users can have access to the result whenever they want to. This is especially useful when taking care of aging people or physically disabled people. Moreover, Pebble smartwatch is able to work for as much as 5 days supported by a battery inside, so the system can continuously monitor the user's movements for a long term.

Data analysis capability: Elasticsearch, which is a distributed, real-time search and analytic engine, is used to manage the collected data. More information can be extracted from the data with the help of machine learning and cloud computing technologies.

Faddish and convenient: Both the smartwatch and smartphone are popular elements in our society. The monitoring function can be accomplished without imposing any extra effort to the user. That makes this system easy to spread in the future.

B. Limitations

In this system, the smartphone works as a second data source to record the location and the body posture of the user in some scenarios. In order to match correctly with the data from Pebble watch, the Android application runs continuously to record the GSP and accelerometer data, which is quite power consuming. Besides, as a data transfer station, the smartphone needs to communicate with Pebble watch and remote server frequently, which also consumes much power. Consequently, the already dissatisfied battery life issue of the smartphone gets worse. This problem can be relieved by adopting other wearable devices, like smart-shirt, to detect the body movements of the user instead of the smartphone.

The immaturity of wearable technologies also creates some limitations to the system. For example, the storage capacity of the Pebble watch is only 640KB, which is not large enough to support long term monitoring without a smartphone. The old data logs will be over written by the new ones after the data pool is full. So the adaptability of the system is weakened currently in real life scenarios. This limitation is supposed to be overcome in the next version of Pebble watch.

V. Conclusions and Future Works

A human movement monitoring system based on a smartwatch, a smartphone and a remote distributed data management engine is developed. Experiment results demonstrate the feasibility of the system in performing the task of remote, long-term and continuous monitoring movements of individuals with adequate accuracy.

The work introduced in this paper focuses on the development of a data collection system. More efforts need to be made in data analysis after enough data is collected with the help of machine learning and cloud computing techniques. Possible directions include: study of movement recognition algorithms; development of practical applications, such as movement monitoring applications on smart devices for aging people; integration of the collected data with information from other sources, like social networks and intelligent household appliances, to better study the behavior of people.

Acknowledgment

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e-Psychology in Research Level Using Asynchronous e-Learning Platform in Military Environment

Nikolaos V. Karadimas, Vassia Karamanoli

***Abstract*—**The success of the e-learning platforms observed the last years has created an increasingly demand for e-learning suites in universities, academic institutions and schools, which has led to design and development of a large number of commercial and open source synchronous and asynchronous e-learning platforms. Each new e-learning platform presents its own learning model and the comparison of the e-learning platforms becomes more and more difficult to compare them. How to choose the most suitable one is not always an easy task. The main goal of this work is the investigation of the Moodle e-learning platform effectiveness during an opinion poll research in the psychology field. During the research its goal is saving money by conducting the specific research online, space by electronically storing the questionnaires, time by avoiding waste of education time and process automation by extracting and processing questionnaire data. The present work, in addition to the particular cases relating to the questionnaires distributed to students who are studying in one of the highest military educational institutions of the country, the present work describes some general points relating to the functionality and the selection of the specific platform.

***Keywords*—**e-Learning, Moodle, Self-esteem.

I. Introduction

EVERYDAY, phrases like “lifelong learning” and “e-learning” are heard more and more. This is an increasingly topical issue due to the continuous development of society and the changes brought about by new technologies. These concepts show that there must be a continued demand for learning and if someone look it professionally it is almost an obligation to looking for new knowledge on his field. So the people in a modern society needs not only to be well educated, but also to have a proper education system, which will enable autonomous learning, training, and retraining.

The education system as it was known cannot meet these new requirements and this is one reason why “lifelong learning” and “e-learning” are integral parts of these days’ education and lifestyle. The general aim of e-learning platforms is to provide information and practical opportunities for students in order to help them to increase their knowledge and skills on a particular topic.

The fact is that students may have different knowledge, needs or motives. In the past few years new e-learning platforms have been designed and developed which each one of them has almost a different solution for a new learning model. Of course there is a question has to be answered: "What are the criteria for choosing the appropriate e-learning platform?"

The selection criteria which should be analyzed and compared during the selection of an e-learning platform contain functionality aspects as well as pedagogical issues. Particularly, the platform adaptability to user demands plays a crucial role for the effectiveness and efficiency of the e-learning platform.

Second (II) section analyzes the concept of synchronous and asynchronous education and in parallel it refers to functions and characteristics of asynchronous e-learning platform Moodle, which has been selected and used in our research. Third (III) section describes the general case. Section four (IV) describes the methodology of research on the sample used and presented in section five (V). In the sixth (VI) section there is a presentation of the obtained results from the survey questionnaires. Finally in the seventh (VII) section there is an overview of useful conclusions arising from the aforementioned investigation.

II. Synchronous and Asynchronous Learning

A. Synchronous Education

The model of education that prevails nowadays is based on teaching done in classrooms between instructor with students. In synchronous education, the instructor and students are located in the same physical space, whether it is an auditorium, classroom or laboratory for experiments or an internship. The communication of the instructor with students is direct and in real-time, is a two-way relation, fully interactive and audiovisual as students see and hear their instructor and have the opportunity to address questions or have an open discussion with him. This training is based purely on the way and method chosen by each instructor in order for him to make the lecture, the necessary degree of interaction with the students and the educational material used in each lecture.

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Nowadays, in synchronous education, instructors use the board (the most traditional ones still use the blackboard) and slides with educational material which consists of text, mathematical relationships, figures and images. Of course, the introduction of the technology evolution in the education field, has led almost all speakers to mostly use electronic slides, which are presented through a PC and a projector on a projection screens. Regarding the educational material, it can be enriched and animated with three-dimensional and/or multi-colored shapes as well as other audio-visual material such as audio and video files.

Among the most important developments in synchronous education are the new features provided by the technologies of telecommunications and especially the one that Internet offers. Due to the internal network connection (intranet) and internet of auditoriums, classrooms, laboratories, offices of professors and general workplaces, offered a huge advantage in synchronous education. This feature, which did not exist before, is extended in order to cover the needs for education for students located remotely.

In order to be successful synchronous distance learning requires conferencing, audiovisual equipment and very good network infrastructures. This can be done when there is video streaming during the lecture, in order to enable students to watch in real time (on-line) the instructor from distance.

B. Asynchronous Education

Another form of distance education is the asynchronous education. Previously, communication was based on correspondence with the classic mail. Firstly, training materials, mainly books and exercise books were sending to the students, who were in another area, usually in a long distance, and then instructors remotely coordinate and monitor the whole education process. Certainly the technology evolution enriches asynchronous education with the shipment of audiovisual material stored on videotapes, CD's and DVD to the students.

The fact is that the most important evolution in both asynchronous and synchronous education, are the new features offered by technology and Internet services. Internet has improved the quality of communication between the instructors and the students. Students have easy and user friendly access to educational material from their home, fast communication via electronic mail (e-mail) or any other type of messaging each other and/or with their instructor. On the other hand, instructors organize and monitor the educational material and coordination from distance. The use of these new tools and Internet technologies for design and implementation of the asynchronous education is what is called asynchronous distance learning.

Asynchronous education, in contrast to synchronous, does not require the simultaneous participation of instructor and students. The students do not need to be found all together in a place or at the same time, because in the asynchronous e-learning none of the lectures or conversations are performed in real time.

On the contrary, each one may choose its personal training time frame to initially collect the educational material and then to study it and perform any project has been assigned to him. According to the aforementioned, asynchronous is more flexible than synchronous education. In this type of education belongs self, semi-autonomous and collaborative learning [1].

The student, in self-learning, is trained on his own by using whatever means it deems him suitable for training such as books, notes, CDs, DVDs, Internet, etc.

Semi-autonomous education is similar to self-learning, only that instructor has already determined all educational material and moreover there is a specific contact timetable with the responsible instructor either physically (meetings) or via Internet (Skype, e-mail, etc.), or via teleconference (these hours may be considered "synchronous education").

In collaborative learning, instructor and students communicate asynchronously with each other via an asynchronous learning platform. Students study in their own time, the material that has been uploaded in the platform by the instructor, but they follow a specific submission schedule of assignments, quizzes, etc. which have been initially designated.

Bagianos et al [2] have mentioned that "asynchronous distance learning" means that instructor and students do not necessarily coexist in the same physical space neither the platform requires simultaneous participation of both sides. Asynchronous e-learning platforms or virtual learning platforms are software systems that enable instructors to provide the entire course material and besides to communicate remotely and in no real-time with their students.

The majority of these platforms are designed not only to reproduce of the classical educational process in a computer environment, but at the same time the exploitation of the same computer technology in order to provide advanced education tools for instructors and students (eg, self-assessment, quizzes, forums, chat rooms, projects' depository), which implies a total education upgrading [3, 4, 5, 6, 7].

Today, there is a large number of commercial programs and applications for implementing asynchronous distance learning services. In addition a large number of systems have been designed in the majority of educational institutions and are open source programs and are freely available on internet.

Each one interested party who wishes to install such a system has the ability to customize and enrich it if desired with other applications. Of course, each group which has designed, implemented and supports a platform, periodically presents several additional applications (add-ons applications) increasing and evolving every time features on the provided platforms for the instructors and students.

C. Asynchronous e-Learning Systems

Reyes et al [8] mention that in recent years, success of various e-learning platforms has increased the demand for respective e-learning systems both at universities and other academic institutions as well as at companies. These have led to the development of a large number of commercial and open

source Learning Management Systems (LMS)..

Almost all asynchronous e-learning systems currently available, based on client-server architecture. It means that a terminal computer (client) uses a web browser to access web pages that are stored on a central server. Some of the asynchronous e-learning systems, which are used worldwide by many educational institutions and institutes are:

(a) The Eledge [9] was designed by a team of researchers at the University of Utah led by Professor Charles Wight, with the purpose of teaching the University courses on the Internet.

(b) The Future Learning Environment (FLE 3) [10] was designed by the Media Lab of the University of Art and Design Helsinki in collaboration with the Center for Research on Networked Learning and Knowledge Building, University of Helsinki. FLE3 is not designed to function as an integrated asynchronous e-learning system, but to complete the face-to-face educational process. It is designed to support the educational process in which students actively participate through the exchange of their thoughts on issues raised not only by the instructor but also by themselves.

(c) Creation of Study Environments (COSE) [11] was designed by a team of scientists at Staffordshire University within a project funded by the Joint Information Systems Committee (JISC) Technology Applications Programme (JTAP).

(d) CoMentor [12], designed focusing on teaching courses Fine Arts and Social Sciences, which in recent years does not appear to be active.

(e) Integriertes Lern, Informations und Arbeitskooperations-System (ILIAS) [13] is one of the first e-learning systems used in universities and was created at the University of Cologne.

(f) Claroline [14] is an open source software designed from the University of Louvain (UCL) in Belgium and is currently used in more than 100 countries and has been translated into more than 35 languages.

(g) Knowledge Environment for Web-based Learning (KEWL) [15] was designed in University of the Western Cape, Cape Town, Republic of South Africa, taking into serious consideration the small available bandwidth in Africa. This fact was the reason that the investigation process was particularly slow in rate using the installation on the server of this university.

(h) Modular Object-Oriented Dynamic Learning Environment (MOODLE) [16] is part of the Martin Dougiamas PhD thesis at Curtin University of Technology, Benten, Australia and has been focused on the way to make as much as easier and productive the process of asynchronous education applying the relevant theoretical educational principles. It has been translated into more than 75 languages.

(i) Manhattan [17] is a very handy asynchronous e-learning program, which was originally designed for Western New England College e-learning needs. It includes different types of newsgroups, modern communication tools (chatrooms, forums), an internal messaging system among students who participate into the same course, and tools for on-line creating and outsourcing assignments and automatic grading of the students.

(j) GUNET eClass [18] platform is a complete Course Management System that supports asynchronous e-learning services via a simple web browser. Its goal is the incorporation and constructive use of the Internet and web technologies in the teaching and learning process without restrictions and commitments. It supports the electronic management, storage and presentation of teaching materials, independently of the spatial and time limiting factors of conventional teaching and creating the necessary conditions for a dynamic teaching environment without requiring specialized technical knowledge. E-Class used the open source software "Classroom online" Claroline of adding new features.

(k) DOCEBO [19] is an open source e-learning platform, which is used in companies and higher education markets. It supports over 30 languages and can support different on-line models.

(l) DOKEOS [20] is one of the largest and most recognized companies dealing with the development of Learning Management Systems (LMS). Its main product is the learning suites creation, which are used by multinational corporations, federal administrations and universities in over 60 countries.

D. Moodle platform

The Modular Object - Oriented Dynamic Learning Environment (Moodle) [16] is an e-learning environment designed in 1999 by Martin Dugiamas, during his PhD thesis, which was developed guided by social constructionist pedagogy, Moodle is open source software and can be run on any system that supports Hypertext Preprocessor (PHP) and has the potential to be combined with many types of databases (especially MySQL). It is primarily used for asynchronous e-learning needs.

If anyone wants to analyze the specific platform, it could mention the terms that make up the name Moodle. Firstly, the entire environment of the platform composed of separate pieces of code called modules (*Modular*) that perform specific functions. Examples of modules are email, chatrooms, forums, quizzes, workshops etc. New modules are constantly made, tested and open for public use by the members of the wide community of scientists and specialists that produce code for Moodle. The environment is *Object-Oriented*, ie it is software driven by user actions (actions performed in environment objects). This feature has the effect of exempting the user from lengthy study and research to know the functions of the platform and makes the system very easy to use. It is also a *Dynamic* continuously updated environment, which allows the entry and storage of user data (personal profile, monitoring data, grades, etc.) and may present different data for each user due to the existence of an extensive database.

This means that web pages are not static, but dynamic, customized to each user and with the ability for instructors, managers and administrators to modify them through easy forms.

Fig. 1 The Asynchronous e-Learning Platform Moodle of the Hellenic Military Academy.

E. Why Moodle?

As it has been mentioned above there are many asynchronous e-platforms, which each one proposes a different solution for a new model of education. The present work has been carried out with the usage of the open source e-learning platform Moodle. The reasons that led to that choice are:

(a). Moodle is an open source content management system. Unlike other platforms, Moodle can be downloaded for free from in its official site [16]. Since it is an open source program, its development seems to be revolutionary. Programmers, developers and users in general are working for free towards the Moodle improvement. Unlike other platforms which are characterized as free programs (freeware) Moodle offers fully support via its forum.

(b). Either the user is an administrator, instructor or a student, he/she will find Moodle very easy to use because its friendly graphical user interface. For example an authorized user can insert a file in a topic by choosing from the list of activities in the specific menu or even easier by drag and drop it from any pc folder. At this point, it could be mentioned, all these icons that have been created and are part of its graphical user interface help the users to understand and use easier the capabilities that the Moodle offers during a course creation.. The eye icon can show or hide an activity or resource or even a whole topic. The cross moves an activity or resource within a course up or down. The aforementioned mean a user does not need to be a programmer in order for him to use the specific platform. Of course, everyone needs to spend some time in order for him/her to familiarize with its functions and to be able to navigate himself in the Moodle environment. Due to its ease of use, Moodle functionality is oriented toward student learning thus Moodle has been designed with educators in mind. Instructors find Moodle environment very helpful with the vast array of functions to enhance learning. It could also help the instructors to bridge the content that is taught in the class and the content of the course.

(c). Moodle almost has an endless list of activities and resources. For example, an instructor can assign an enrollment key to filter away those who are not supposed to be included in his virtual class. As for activities an instructor can create forums, quizzes wikis, workshops, feedbacks, assignments, surveys, etc. In addition, since it is not exclusive unlike commercial software, Moodle supports operating systems like Linux and Mac OS X apart from Windows. [16]

(d). Almost nobody asks what is the guide of the learning framework during the creation of an educational software. Most of the programs are oriented towards how many features they would offer to their users and do not address how will the learners learn while using it. On the other hand, Constructivism, Social Constructivism, and Constructionism are all adopted in Moodle as for its pedagogy point of view.

(e). People think that learning occurs wherein there is a classroom, an instructor and a number of students. The usual approach in the class is the instructor gives a lecture, an assignment, a quiz and then the students listen, keep notes, do their assignments, answer the quizzes. Moodle gives instructors an alternative choice for students to learn independently by giving them the opportunity to study online, from its home and during the time they want. Students learn how to use and process information and also learn to collaborate and interact with one another while using activities like forums, chats, workshops, etc. Furthermore, it offers the capability of instant feedback. Therefore students who take tests, quizzes, projects in Moodle can view their results and grades almost immediately after its submission. Of course, the instructors have to assign how students are to be assessed and have to choose an option of grading. Besides, when the instructors and the students are at the same time log in, they can write and read their comments and replies using the forums and chat rooms in Moodle in real time.

(f). Moodle is an integrated e-learning platform. The activities, resources and the other features are modular by means each one can be a stand-alone application. Of course, these are also designed and developed to complement each other.

(g). Moodle is fully interactive. Whether a user likes to work with a synchronous or an asynchronous e-learning platform, Moodle platform would never be a problem. It is designed and developed to engage users to participate and collaborate each others with activities like chat and forums which are there to highlight the value of active participation.

III. General Hypothesis

Frequently in many *paper and pencil* researches with students who are obliged to attend their classes [21] it is observed that they don't fill in the whole questionnaire that they are asked to. It is hypothesized that if people were free to choose the *where and when* of their cooperation with the research they would feel less pressure and increase their cooperation and would increase the reliability of their answers and as a result of that the reliability of the whole research.

In this paradigm the aim of the research was to investigate several variables that concern the students' attitudes towards seeking mental help in a military environment. One variable, which is involved into this situation, is self-esteem.

H1. We hypothesize that self – esteem perception increases

as increases the year of attendance.

IV. METHOD

A ten (10) item questionnaire of a Lickert scale that concern self – esteem was addressed to the students in order to examine how much they agree or disagree with the given items. Furthermore, the software IBM Statistical Package for the Social Sciences (SPSS) is used for the statistical analysis of the data according to the rules of descriptive statistical analysis.

Self – esteem was measured with Rosenberg Self-esteem Scale (RSE) [22]. Participants were asked to answer according to the degree of their agreement or disagreement in a scale from 1-5, where one (1) means "not true at all" and five (5) means "absolutely true" in a ten (10) itemed questionnaire that investigate one's perception of self – esteem. Here are some examples of the items: "*Overall, I am satisfied with myself*", "*I feel that I have a number of good qualities*", "*I feel that I'm a person of worth, at least on an equal plane with others*". However, the score of several questions have been reversed, such as "*At times I think I am no good at all*", "*I feel I do not have much to be proud of*", "*I certainly feel useless at times*", according to the instructions of the scale initiators.

V. SAMPLE

Fifty (50) questionnaires have been distributed to each of the four classes (four academic years), but only 144 over 200 questionnaires have been completed. Specifically, a random code was given to fifty (50) students of each academic year in order for those random students to have anonymous access to Moodle. Therefore, these students should logged in the platform using the given code and not their normal code and complete anonymously the particular questionnaire of the research, in a given time period. The random code gave not only the advantage of participants' anonymity but also a degree of freedom as far as the time of the questionnaire's completing up. From technical point of view, there was a restriction to prohibit the participant to move to a question if he/she had not answered the previous one. Thus, there were not any missing questions. Finally, the sample was 144 students from the four academic years. Especially 37 (25,6%) were students from the 1st academic year, 36 (24,8%) were students from the 2nd academic year, 33 (22,9%) students from the 3rd academic year and 38 (26,3%) students from the 4rth academic year.

VI. RESULTS

Over the 200 of given random codes, there was a loss of 28% of the codes that have been addressed to the students but they did not used them to answer the questionnaire. Since they were not obliged to participate, this rate is not finally a disadvantage, because at least it is not needed to cancel any questionnaires of the lots of missing items that in other cases of paper and pencil researches is observed. Additionally, the technique of the necessity of the filling up the previous question in order to go on with the questionnaire preserved the research from missing items.

The results showed that the reliability cronbach's *a* was ,824. According to descriptive statistics the results (frequency and percentage) for the perceived self – esteem were given from Moodle (fig.2, fig.3, fig.4, fig.5) as the following example to the question "*Overall, I am satisfied with myself".* One (1) means "not true at all" and five (5) means "absolutely true".

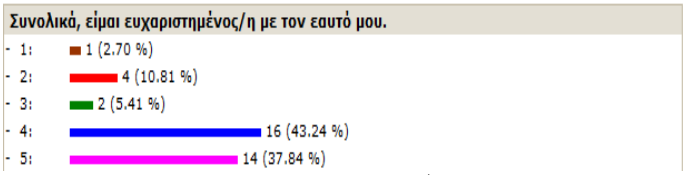

Fig. 2 Graphical result from the 1st academic year.

Fig. 3 Graphical result from the 2nd academic year.

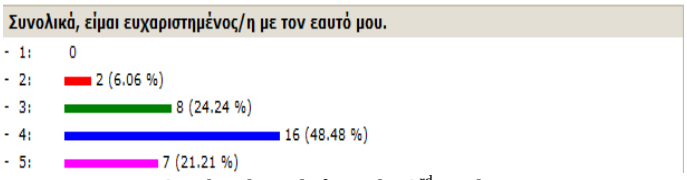

Fig. 4 Graphical result from the 3rd academic year.

Fig. 5 Graphical result from the 4th academic year.

VII. CONCLUSIONS

Moodle utilization in conducting an opinion poll research in psychology field can offer a large number of benefits in time, place, money, effort and reliability although there is a small loss rate due to the degree of freedom given to the subjects.

On the other hand, it is not observed at all the effect of random questionnaire completion (e.g. creating symmetrical shapes based on the number of response selections or similar questionnaire responses), which it happens quite often in opinion polls with *paper and pencil* and drive researchers to eliminate many completed questionnaires.

Furthermore, as for saving time, Moodle, except for data automatic insertion, allows the researchers to take automatically descriptive statistics results immediately after the questionnaire completion. The last one confirms the general hypothesis during the selection of the suitability of this particular e-learning platform.

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Moreover, this work partially confirms another aforementioned hypothesis about self-esteem feeling which increases as increases the year of studies, as shown by the presented results. However, lower rates are observed in the 2nd year of studies (Fig.3) where education becomes more demanding, alibi adaptation in the academy ceases to be valid and there are another two years to the final completion of the training and obtaining their diploma.

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Automatic Learning Path Design: development and implementation

Agostino Marengo, Alessandro Pagano, Giulio Monopoli

***Abstract*—** This paper will describe the development and implementation of an Adaptive System Prototype with the aim to manage an automated and customized learning experience.

After the first in-depth study on the usefulness and effectiveness of personalized learning approach, the research team intended to fill the gap between the theory of personalized learning environments and its practice trough the development of an adaptive learning plugin implemented on mostly used, Open Source, Learning Management Systems.

The developed technology, follow the goal to identify any end user of the LMS, create a customized user profile with their starting skills and learning preferences in order to automatically tailor a personalized learning path. The main purpose is to maximize student's performance.

This paper describes the main steps for the implementation of the prototype of this Adaptive Learning System named **iO3** (intelligent Open Cube), as it will be an *intelligent, Open Source, Open Knowledge, Open Plugin* system.

***Keywords*—** Adaptive learning, Automatic Learning Path design, e-learning, Personalized Learning Environments.

I. Introduction

Considering the state of the art of most common e-learning environments, many researchers believe that adaptive learning is a critical requirement to enhance the teaching quality and the user performance throughout the learning process. The adaptive learning feature improves the starting skills of a user, providing specific content related to his learning style.

The road to follow in order to build an effective learning and teaching performance cannot overlook the aspect of personalized learning environments.

Generating a *customized learning path* for any learner provides a challenging work for researchers involved, both, in informatics and education fields. Learning Path is a collection of different learning items that are combined to achieve a specific learning goal. Furthermore, the development of an customized (*adaptive*) learning path means that learner's starting skills should be evaluated for providing a tailored learning path suitable for each student.

Different learners may have different characteristics, prior knowledge, starting skills, motivation or needs. This variety of "distinguishing marks" commonly requires the management of different information to different learners in a different format. Taking this in count, our research group believes that it is fundamental to develop adaptive educational systems which consider the several individualities of each student when presenting information, learning objects and/or practice opportunities, in order to make the learning process as effective, efficient, and motivating as possible. [1] This is not a way to rethink education, but a way to reinforce opportunities of professional and educational growth.

The purpose of this research study is to identify a process to deliver the right contents according to the student's learning style and to develop/implement it in a software module.

The goal of this research is to develop **iO3** (intelligent Open Cube) system, an adaptive technology, based on an Open Source LMS that automatically build suitable learning path for each user/student considering his own assessed profile.

iO3 will be:

- **Intelligent (i)** as it will project an innovative Intelligent Agent to support e-learning and develop such an approach, evaluating the impact on the speed and success of learning given specific learning outcomes;
- **OpenSource (O^1)** as it will only use Open Source software verifying its quality standards. Open Source technology will be used and analyzed considering the efficiency and efficacy of services and the design of tools to ease interactive and collaborative processes;
- **OpenLearning (O^2)** as it will deliver constructive knowledge functional proficiency and to all people who want to approach it. This academic environment will become a landmark for university students, high school students, adult or senior learners, professionals and whoever wants to access to the high level knowledge without necessarily pay for it.
- **OpenPlugin (O^3)** as it will define a plugin prototype and deliver it on the Open Source Community using GNU Licence;

On the methodological point of view, the main questions that this research project aims to answer are:

- Which learning objects should be picked to build a learning path suitable for each user?
- How could adaptive learning be implemented in Open Source LMS (Learning Management System)?

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To answer these questions the research team investigates the adaptive technology and, in this paper, describes the implementation of an adaptive "strategy" in the mostly used Open Source Learning Management System (LMS): Moodle.

The first step in building an adaptive learning tool is to identify the student's profile with his own learning style and starting skills in order to determine the appropriate learning content that corresponds to the individual students learning style and learning needs. [2]

In the development approach proposed, user profile is assessed and evolved using Case Based Reasoning. The Adaptive Learning Path is generated using the learner's behaviour patterns, which are modelled as the learner's characteristics like learning styles, goals and performance.

This paper shows the development of a plug-in for Open Source LMS that helps to select the suitable learning object each student.

In this personalized learning environment, the student's performance will be enhanced and the expected result is to reach higher motivation to finish the course, avoid situation in which the student has to study un-useful or unsuitable contents. [3]

II. Methodology

The steps needed to achieve the research objectives of the whole research project in which this paper is placed, are to be identified in the technological innovation process.

First of all, the research team performed a deep study of the state of the art.

At the end of this phase, the research team proceeded to the code development of the software and all the technical works needed to meet the functional requirements.

After development, a phase of tests and experiments conducted in vitro and in vivo will be launched. This step will ensure the compliance with the objectives of the project and measure the degree of goals achievement, through statistical surveys and satisfaction questionnaires on teachers and the learners.

During this phase it will be possible to take action to make changes and functional maintenance/bug-fix. Finally, the collection and organization of results phase will take place in order to proceed to the scientific dissemination.

III. Moodle LMS Adaptive Features

The merely delivering of Learning Objects inside a learning path is not enough. Repositories of Learning Objects are built with specific user interfaces and architectures that make them easy to use and permits various levels of interactivity including search, submissions, comments/reviews, and creating personal collections. The prospect of these personal high-educational paths may be the way to empower people, in particular during the Life Long Learning of an employee (developing acquired work positions or developing skills in case of mobility). Furthermore any academic network could benefit of this repository, sharing best practices in the different fields of research.

Moodle is the mostly used open source LMS. It can be used to deliver online learning in a huge variety of scenarios.

These scenarios are mainly virtual schools, K12 [4], higher education, corporate universities, charter schools, and commercial training, to name but a few. Moodle is used primarily as an asynchronous learning tool, where learners study at different times. However, it also includes synchronous tools. Moodle is used both as the primary delivery vehicle for courses as well as a supplemental tool for face-to-face learning. To put it simply, Moodle is a teacher's toolkit to help improve learning, is designed in a community with teachers interacting directly with programmers. Moodle's intuitive and simple interface is the result of this collaboration.

Moodle originally stood for Modular Object-Oriented Dynamic Learning Environment. From a programmer's perspective, the "M" in Moodle is a very important concept. Modularity is designed throughout Moodle. This lets a developer make significant modifications to Moodle without having to modify its code. This is a very important capability in terms of reducing the amount of time taken to make modifications when new versions of Moodle are released [5].

Moodle lacks of student classification, so the research team focus the work providing a student modelling process to add a brand new feature: tailored learning paths.

Once information about the learners is available from the student model, the adaptive procedure can be provided.

Different aspects have to be considered when aiming at providing students with adapted courses. One dimension refers to what can be adapted in a system.

Different methods exist for providing students with adapted courses. These methods determine which features of the system are different for different learners.

Existing adaptation features can be classified regarding their aim into two groups, namely for adaptive navigation support and adaptive presentation.

Adaptive navigation support is based on links and includes features such as direct guidance, map adaptation, as well as adaptive sorting, hiding, annotating and generating of links.

Adaptive presentation includes adaptation features based on content such as adaptive multimedia presentation, adaptive text presentation, and adaptation of modality.

An example of existing tool for adaptive navigation support in Moodle is the Activity locking.

The basic concept locks a student out of a specific activity until the student meets a score, a time or a view criterion matrix for one or more specific activities or re-sources in a course. In Moodle LMS, there are options to hide the locked activity, or hide a complete section of activities and resources. Other options include showing a progress icon next to

completed activities. Some specialized conditional activities locks are based on an overall course criterion matrix (http://docs.moodle.org/dev/Adding_activity_lock).

With this tool, the teacher is the only one who can change or hide/unhide activities and resources depending on his assessment of the individual differences of his students. So, teachers or instructors, who are creating a course, should prepare some alternative version of the course for better or weaker students.

The proposed, and much more effective approach, is an adaptive sequencing of learning courses/activities for each particular learner based on a student model updated after each interaction with the learner

IV. Adaptive Software Analysis

To better understand the concepts expressed in the rest of the paper it is necessary to clarify some terms:

- **course**: a set of one or more 'learning objectives'
  course = $(lb_1, lb_2, \ldots, lb_n)$ $n > 0$

- **learning object** (**lo**): a set of one or more 'assets'
  lo = $(as_1, as_2, \ldots, as_n)$ $n > 0$

- **tag**: a string representing the content of the Moodle's resource/activity

- **asset (as)**: a Moodle's resource or activity (Assignment, Chat, Choice, Database, External Tool, Forum, Glossary, Lesson, Quiz, SCORM package, Survey, Wiki, Workshop, Book, File, Folder, Page, URL) with one or more tag.

  asset = $(M, tag_1, \ldots, tag_n)$ $n > 0$

  M = {Moodle's resource | Moodle's activity}

- **vis(as)**: the visibility of a generic asset as. It can only be 'VISIBLE' or 'NOT VISIBLE'

  vis(as) = {VISIBLE | NOT VISIBLE}

- **pre-test**: a specific quiz submitted to the user at the beginning of the course to evaluate his preparedness.

  pre-test = $(q_1, q_2, \ldots, q_n)$ $n \geq m$
  m = number of total assets in the course

- **quiz**: a set of 'tagQuestions'

  quiz = $(q_1, q_2, \ldots, q_n)$ $n > 0$

- **tagQuestion (q)**: a set composed by the text of the question, one or more correct answer, one or more wrong answer, one or more reference to an asset and a rate.

  question = (t, CA, WA, AS, r)

  -t = text of the question
  -CA = $\{ca_1, ca_2, \ldots, ca_n\}$ $n > 0$ a set of correct answers
  -WA = $\{wa_1, wa_2, \ldots, wa_n\}$ $n > 0$ a set of wrong answers
  -AS = $\{as_1, as_2, \ldots, as_k\}$ $k > 0$ a set of linked assets
  -r = the rate of the question (0-100%)

- **answ(q)**: the final user's answer to a generic tagQuestion q. It can only be 'CORRECT' or 'INCORRECT'

  answ(q) = {CORRECT | INCORRECT}

Following the guidelines expressed by Ian Sommerville, Pete Sawyer [6] and Gerarld Kotonya [7] the research team identified the following functional requirements:

Teacher will be able to:

FR1, FR2, FR3 – Create, Modify, and Delete a tag.
FR4, FR5 – Create and delete an asset.
FR6, FR7 – Create and delete a tagQuestion.
FR8 - The plugin must hide or display the assets of the course based on the profile obtained for the user.

V. Use Case Diagram

These use case diagrams (Fig. 1,2,3) were made accordingly to M. Fowler [8], I. Jacobson [9], D. Booch [10] and S. Cook [11].

The use cases approach helps the research team to deeply profile the teacher/editor role inside the described scenario.

As shown in the Functional requirements list, below the teacher's use case is described for tags, assets and tagQuestions.

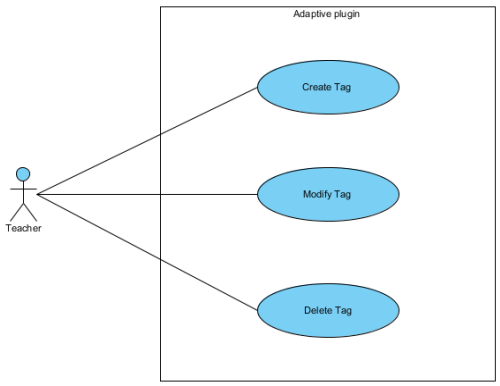

Fig. 1 manage tags

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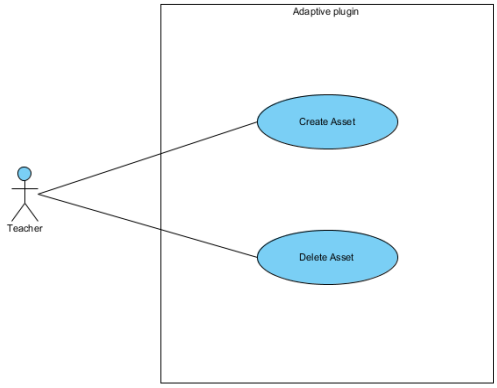

Fig. 2 assets

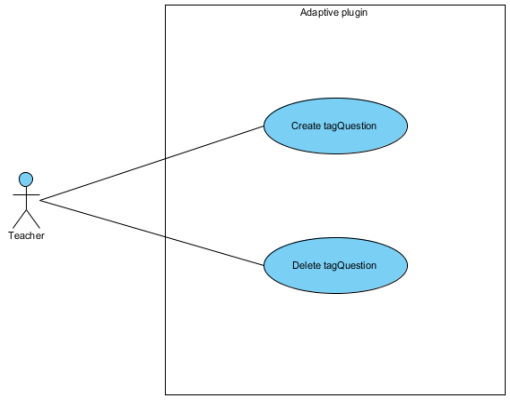

Fig. 3 tagQuestions

VI. Plugin Development

Two parts compose the developed plugin: the first part, which allows teachers to manage assets and tagQuestions, the second part which is a Moodle's availability condition plugin.

The concept flow for this adaptive plugin that design suitable learning paths for each user, works work as follow:

- ❖ When registered to a new course, the user is forced to answer to a pre-test
- ❖ The plugin makes available only some assets, based on the answers given by the user during the pre-test.
- ❖ To complete the course, the user must study the available assets
- ❖ After the user studied all the available assets, the plugin present him a new pre-test
- ❖ If the user pass this pre-test, he complete the course, otherwise the plugin shows him other assets to study.

The teacher has only to create the assets and the tag questions linking to each other Moodle's resources or activities-tags and questions-Moodle's resources or activities using the tools provided by the plugin.

To achieve these goals the team created ad hoc HTML pages through what it's possible for the teacher to create these links.

The research team involved in the development process, also analysed the database scheme proposed previously and founded trough state of the art analysis [12] but decided to create a new one in order to better satisfy the new identified requirements.

The image shown below (Fig. 4) highlights the implementation of the plugin at database level.

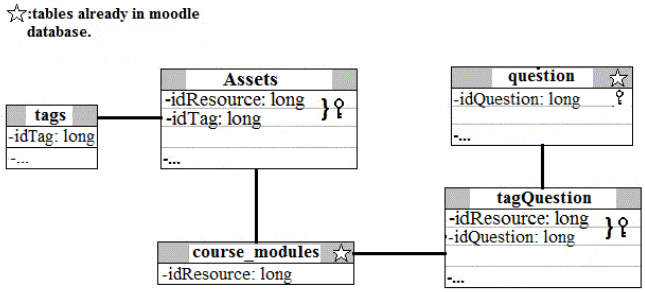

Fig.4 added database tables

The starred tables are already in Moodle LMS existing database, the new ones are:

- Assets: This table saves links between tags and a Moodle's resource or activities. The primary key is composed by idResource and idTag. This allows to link one or more tag to a single resource.
- tags: This table saves new tags and their respective name and description.
- tagQuestion: This table saves links between questions and a Moodle's resource or activities. The primary key is composed by idResource and idQuestion. This allows to link one or more question to a single resource and vice versa.

VII. Algorithm

The core of this adaptive plugin is the "Control Algorithm". The logic behind should be described briefly with some sentences.

Suppose that Q is a pre-Test, then:

$\forall q_i \in Q$, $0<i<n$ where $Q = \{q_1, \ldots\ldots, q_n\} \wedge$
$q_i = \{T, CA, WA, A, r\}$ where

- T = text of the tagQuestion
- CA = $\{ca_1, \ldots.., ca_h\}$ $h>0$ is a set of correct answers
- WA = $\{wa_1, \ldots\ldots., wa_l\}$ $l>0$ is a set of wrong answers
- A = $\{as_1, \ldots.., as_m\}$ is a set of linked assets
- r = the rate of the question

if $answ(q_i)$ = 'INCORRECT' then $\rightarrow$ $\forall as_j \in A$, $0<j<m$ $vis(ass_j)$ = VISIBLE

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VIII. TESTS

At the moment of writing this paper, several tests have been conducted "in vitro". In these tests the team tried to note in the plugin could actually indicate for each user under test, the asset to well study in order to fill the own weaknesses identified during the initial pre-test.

The developed plugin is well integrated inside the Moodle LMS architecture and is respecting the functional requirements identified in the analysis stage.

No problems or lacks discovered in performances of the software in relation of the web server or the user experience.

To perform the "in vitro" test the research team create a sample class of 50 (fake) students and 10 teachers of different subjects. Each user, in relation of his role and permissions, tries to perform the actions planned.

Further tests are being analysed in different scenarios: academic blended course, corporate training course, face to face traditional learning.

IX. CONCLUSION AND FUTURE WORK

The objectives planned for this part of the research work are successfully achieved.

The "Adaptive plugin" developed picks the suitable learning objects building a tailored learning path suitable for each student.

In vitro tests demonstrate that the software is working and is consistent with the identified functional requirements.

The future works after this stage, concern the "in vivo tests" to prove the efficiency and the effectiveness of this approach in real cases.

Other future works, related to software development are related to an early upgrade of the developed plugin in order to extend its functionalities. According to this, has already been included the Tag feature. The Tag feature is not actually used but represents a future development's feature whose purpose is to better adapt the user's course content.

The research team also plans to improve the user experience thanks to the design of HTML5 interfaces that helps to become more intuitive and accessible on multiple devices.

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High Dynamic Range Video Eye Tracking Dataset

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***Abstract*—**High Dynamic Range (HDR) imaging has been gaining widespread acceptance and the technology is maturing rapidly. Although visual attention for Low Dynamic Range (LDR) image and video content has been well explored by the research community, few efforts have been made to study the visual attention model of HDR content. To fill this gap and help developing visual attention models for HDR, we present a HDR video eye tracking dataset, *DML-iTrack-HDR*, in this paper. The eye tracking data was collected from naïve participants viewing HDR videos in a free viewing task. This paper describes the dataset in details, including the experiment procedure, video stimuli, HDR display, eye tracker, and the fixation density maps.

***Keywords*—**Dataset, Eye Tracking, HDR, Visual Attention Model.

I. Introduction

HIGH Dynamic Range (HDR) content has recently received significant recognition in several multimedia application areas. HDR delivers dynamic range that is close to what is perceived by the Human Visual System (HVS) in real life. The HVS can accept a huge range of scene intensities (from about 10^{-6} to 10^{8} cd/m^2, or 14 units). The human eye can accommodate a range of 10^5:1 in a single view [1]. Presently, the vast majority of existing consumer cameras and display devices are able to support Low Dynamic Range (LDR) video content with contrast ratio of approximately 10^2:1 to 10^3:1.

In real life human eyes selectively attend to some interesting regions while ignore other parts of the scene. Computational visual attention models simulate this selective behavior and provide predictions about the most visually important areas in images and videos. Understanding HDR visual attention is essential to several different components of an end-to-end HDR content delivery pipeline such as HDR content capturing, compression, and transmission, as well as in designing HDR quality metrics for cameras and displays.

Eye tracking is a very well-established method of capturing an individual's looking behavior and visual attention. Data collected from an eye tracking experiment are necessary for the development, assessment and optimization of visual attention models. However, to the best of our knowledge, there are no publicly available HDR eye-tracking datasets. In order to fill this need in the research community, we created such an HDR video eye tracking dataset called *DML-iTrack-HDR* [2]. Ten HDR video sequences were displayed on a Dolby prototype HDR TV, and the eye movements of the viewers were recorded by a SensoMotoric Instruments (SMI) eye tracker. These videos were watched by 18 individuals, and fixation density maps (FDM) were obtained for each frame. The *DML-iTrack-HDR* dataset is available at [2].

The rest of this paper is organized as follows: Section II provides details on the experiment settings for eye-tracking, the process of creating fixation maps using the recorded fixation points is explained in Section III, and conclusions are provided in Section IV.

II. Experiment Settings

In this section, we provide details about the properties of the HDR dataset, the specifications of the prototype HDR display system used in our study, and our experiment procedure. Table 1 summarizes important parameters and details of our experiment.

A. Stimuli

Ten HDR video sequences are selected from three different datasets in our study: a) Technicolor [3], b) Froehlich et al. [4], and c) DML-HDR [5]. Table 2 provides details about the videos used in the experiments. The Technicolor HDR dataset videos were captured by a rig of two Sony F3 or F56 cameras with simultaneous low and high exposure settings [3]. The HDR dataset provided by Froehlich et al. [4], were captured by an Alexa camera, a CMOS sensor based motion picture camera made by Arri. The DML-HDR dataset was captured at the University of British Columbia with RED Scarlet-X cameras, which can capture dynamic range up to 18 stops.

B. Prototype HDR Display

Experiments were performed using a Dolby prototype HDR TV display that consists of a projector with the resolution of 1024×768 at the back and a 40-inch full HD LCD placed in the front (see Fig. 1). The contrast range of the projector is

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Table 1. Summary of eye tracking experiments.

	Details	Specification
Participants	Number(M/F)	18(8/10)
	Age Range	21 - 30
	Test	Snellen chart, Ishihara chart
HDR display	Model	Dolby prototype
	Resolution	1024 x 768
	Peak luminance	2700 cd/m^2
	Screen size	66.5 x 49 cm
Eye tracker	Manufacturer	SMI
	Model	iView X RED
	Sampling frequency	250Hz
	Resolution accuracy	0.4 ± 0.03°
	Setup mode	Stands alone; mounted on tripod
Presentation	Repetition	1
	Gray frame with dot	2s
	Stimuli duration	115s
	Dummy stimuli	Two HDR images in the very beginning
Viewing condition	Task	Free viewing
	Ambient light	dim
	Environment	laboratory
Setup	Floor to eyes	110-130cm
	Floor to screen	94cm
	Floor to eye tracker	98cm
	Eye tracker to screen	67cm

20000:1 and is capable of emitting 15000 ANSI lumens. To deliver HDR viewing experience, the HDR video is processed to generate two calibrated streams, which are sent to the projector and the LDR respectively, according to the procedure described in [6]. The LCD screen is fed by a color stream, while a calibrated luminance stream is sent to the projector. The maximum brightness level achieved by this HDR display system prototype is 2700 cd/m^2.

C. Procedure

Before each participant viewed the stimuli, a calibration was run which allows the eye tracker to determine where individuals' fixating is on the screen, and ensures accuracy of the eye tracking data. The calibration stage was repeated if the quality of the calibration was not satisfactory. Each participant was asked to 'free-view' all videos in the stimuli. Videos were played at their native frame rate. Before each video sequence was displayed, participants were asked to fixate on a dot presented at one of the four corners of a neutral gray

Fig.1. HDR display system.

background. Note that by requiring participants to start each sequence at one of the corners of the screen, we ensured that they were free to choose where to first begin looking at the material presented on the display, thereby avoiding any influence from the previous sequence and minimizing center bias for viewing videos [7]. The corner fixation dot was presented for 2s before each video starts, and the corner location of the dot was randomized from one trial to the next.

III. Fixation Density Maps

The eye tracker automatically records three types of eye behavior: fixations, saccades and blinks. The summary of fixations for different HDR test videos is provided in Table 3. Fixations and information associated with each fixation are used to generate fixation density maps. The FDMs represent subjects' region of interest (RoI) and serve as ground truth for assessing the performance of visual attention models. To generate FDMs for the video clips, spatial distribution of human fixations for every frame is computed per subject. If the duration of a given fixation is longer than the time-length of one frame (1/frame-rate), this fixation hit appears in more than one frame. Then, the fixations from all the subjects are combined together and filtered by a 2D-Gaussian filter with standard deviation of 1 degree of visual angle (which corresponds to σ= 20 pixels in our setup). The Gaussian filtering is applied to compensate for the eye-tracking errors and visual sensitivity reduction due to the distance from the fovea [8]. Fig. 2 depicts a few frames from one of the video clips, *playground* and the last column in Table 2 shows FDMs correspond to the provided snapshots for each HDR video.

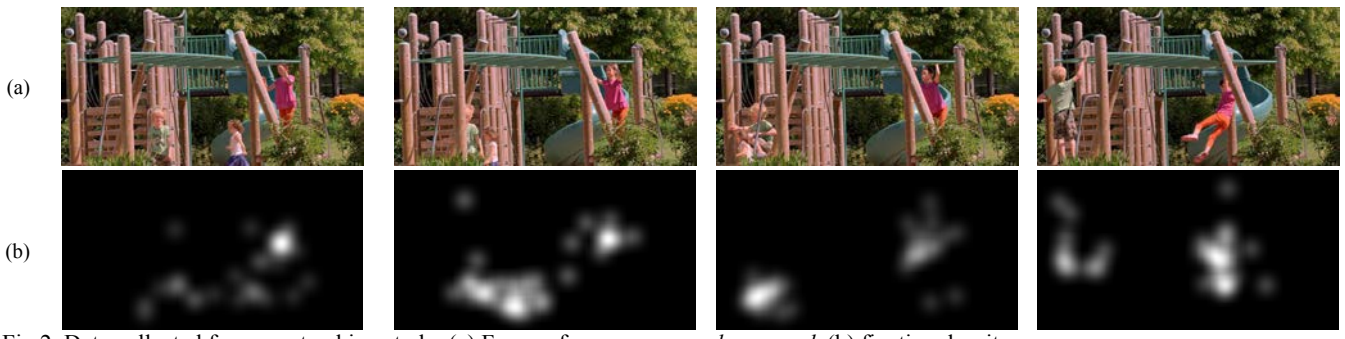

Fig.2. Data collected from eye tracking study. (a) Frames from sequence *playground*, (b) fixation density maps.

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Table 2. Video sequences used in eye tracking experiments.

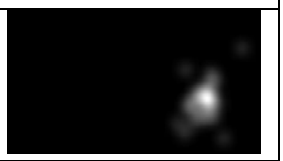
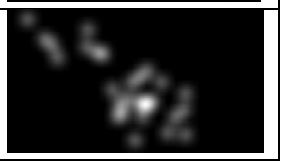
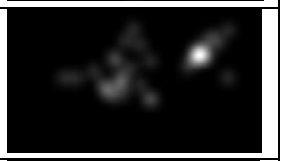
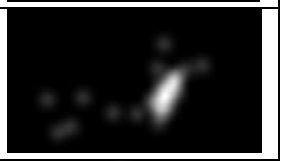
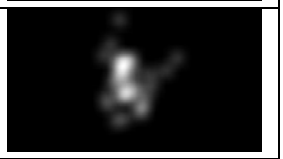
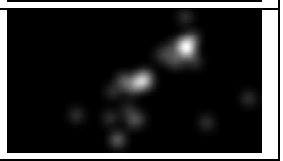
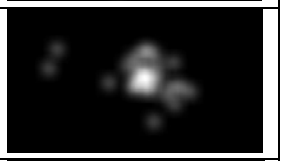
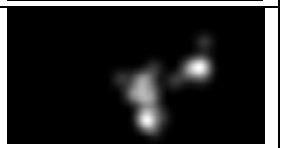
HDR Video Clip	Video Specification	Source Database	Description	Clip Snapshot	Fixation Density Map Snapshot
Balloon	200 frames 30 fps 1920 * 1080	Technicolor [3]	Exterior Medium color spectrum Slow global and local motion		
Market	400 frames 50 fps 1920 * 1080	Technicolor [3]	Exterior High illumination High color spectrum Static scene with slow motion		
Bistro 01	151 frames 30 fps 1920 * 1080	Froehlich et al. [4]	Interior High contract with local bright sunlight at the window Single moving object and slow motion		
Bistro 02	300 frames 25 fps 1920 * 1080	Froehlich et al. [4]	Interior High contract scenery with local bright sunlight at the window		
Bistro 03	170 frames 30 fps 1920 * 1080	Froehlich et al. [4]	Interior Medium illumination		
Carousel	339 frames 30 fps 1920 * 1080	Froehlich et al. [4]	Exterior scene at night Fast moving colorful objects Light sources with changing color		
Park	439 frames 30 fps 1920 * 1080	Froehlich et al. [4]	Exterior scene at night Wide color spectrum Fast motion		
Fishing	371 frames 30 fps 1920 * 1080	Froehlich et al. [4]	Sunlight scene Sunlight reflection on water surface		
Playground	222 frames 30 fps 2048*1080	DML-HDR [5]	Sunlight exterior scene High illumination High color spectrum Fast motion		
Mainmall	241 frames 30 fps 2048*1080	DML-HDR [5]	Medium illumination Slow local motion		

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Table 3. Summary of fixations.

Sequence	No. of fixations	Fixation duration (ms)	No. of fixations per second per subject
bistro01	252	339	2.78
fishing	512	387	2.30
park	713	325	2.71
mainmall	383	326	2.65
market	410	304	2.85
bistro03	239	405	2.34
balloon	252	312	2.80
carousel	651	274	3.20
playground	376	313	2.82
bistro02	938	332	2.61
average	472.6	331.7	2.71

The number of fixations for each clip is the number of fixations from all observers; fixation duration of each clip is the average duration across all fixations.

IV. Conclusion

In this paper we present an HDR video eye tracking dataset called *DML-iTrack-HDR*. This dataset provides insight in human viewing behavior when watching HDR videos. The FDMs generated from human fixations can be used to evaluate the accuracy of HDR visual attention models, and optimize their performance.

Acknowledgment

The authors would like to thank Dolby Canada for donating the prototype HDR display used in our subjective tests. Also special thanks to Prof. Stefan Grandinetti and his team members for giving us access to their HDR dataset.

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The Analysis of the Physiological Similarities Human

Hana Talandová, Lukáš Králík, Milan Adámek

***Abstract*—** This paper deals with the similarity of fingerprints of humans. The paper is divided into two parts, the first part introduces of the oldest, the best known and most widely spread biometric identification method, which are fingerprints. The second part describes the experiment, which compared the similarity of fingerprints of different people and the subsequent evaluation of the results obtained during the experiment.

***Keywords*—**Fingerprint; biometric method; experiment

I. FINGERPRINT

The development of biometric systems brings with it a certain amount of comfort and security of use. Therefore, biometric identification has become dynamically expanding field. On the market are many methods of identification. Among the most extended method still belong to the identification by fingerprint. This is due to the best ratio price: power. Fingerprint scanning device is at a much more affordable price, while maintaining the same precision than scanning device at other biometric methods.

With using previously created reference sample in the database it should relatively quickly identify the authorized person and allow access to the system, the entrance to the protected area. This method of biometric identification categorized into the group of daktyloskopic identification. The Daktyloskopic identification is based on the images of the papillary lines, which is located on the inner side of the phalanges, palms and soles. [1]

Dactyloscopy is based on three rules:

- Around the world are not two people with same papillary ridges image;
- Throughout a man's life papillary ridges image remain relatively constant;
- Papillary ridges cannot be removed if is not removed a germ layer of the skin.

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The Papillary lines are formed against the skin. They are created by growing up of dermis in to the skin. „ the capillaries"– therefore the papillary lines. The image of papillary line is created during embryonic development. The Papillary line reaches a height of 0,1-0,4 mm and width of 0.2 – 0.7 mm. [1]

For identification by fingerprint, we focus on the fingerprint minutiae (Fig. 1). Minutiae are distinguished by using their geometric of shapes, frequency and distribution of the patterns of papillary lines. They are irregular and a specific shapes of minutiae that show the differences. [1]

The advantage of the identification by using fingerprint is user friendliness. On the market, we can find a large offer of sensors, which have against other biometric devices smaller size and energy costingness. The disadvantage of the fingerprint device is the possibility of easily by-passing, because they are not checked liveness of the applied object. It's easy to get fingerprints without the user's awareness and for people with skin problems is the identification very difficult or sometimes impossible. [2] [3] [4]

Fingerprint Minutiae	Name	Fingerprint Minutiae	Name
	Dot		Ridge
	Eye		Start and End Ridge
	Island		Hook
			Fork
	Enclosed Ridge		Crossing Ridge
	Enclosed loop		Duplication
	Specialties		
	Trifurcation		Displacement
			Bifurcation

Fig. 1 Fingerprint minutiae [3]

II. MEASUREMENT OF FINGERPRINTS COMPLIANCE

For this measurement was used terminal MorphoSmart

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Finger VP of Morpho manufacturer. The terminal is connected to PC via USB and individual images were obtained by using a SW MorphoEnroll.

The measurement was attended by 16 people including 7 women and 9 men. All participating persons are not referred to their names, but are referred as a Subject plus number (the used abbreviations in the tables are S1, S2, ... to S16). Women should be found under S1, S3, S4, S5, S6, S8, S15 and men under S2, S7, S9, S10, S11, S12, S13, S14, and S16.

From each subject were taken 3 images of index finger of her/his right hand. During the entire measurement were created and compared up to 48 images.

The images were converted from RAW14 into BMP format. After this operation images were subsequently adjusted and compared by using eFinger SW that allows comparison of two images to detecting compliance.

For comparison in eFinger were selected only the best and most similar two samples where was clearly visible the entire finger and the most possible minutiae ridge and loop the middle of finger.

Sequentially for each fingerprint, were extracted points and fingerprint was saved to a database. After converting, all fingerprint was selected MIN DISTANCE as a matching method. This is the fastest and most conclusive method.

III. THE RESULT OF COMPARING OF FINGERPRINT OF THE INDEX FINGER

Compliance for used method (MIN DISTANCE) is evaluated from 0 to 1000 when 1000 is the maximum compliance - 100%. The values above 250 are taken as a suitable with the minimum number of matching minutiae, which is sufficient for minimum basic match that is accepted. In the tables, the values are given in percent.

For the index finger of the right hand of each subject were taken two images that were compared among themselves and with the image of index finger of the right hand of other subjects.

In table 1 are compared image1 and image2 of the same subject and for different subjects were compared all images1. In table 2 are compared in reverse order: image2 and image1 of the same subject and for different subjects were compared all images2. In table 3 are compared image1 and image1 of the same subject and for different subject were compared image1 and image2. In table 4 are compared image2 and image2 of the same subject and for different subject were compared image2 and image1.

TABLE I. Compliance of comparing the fingerprint of the right index finger in the order of 1-2; 1-1

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
S1	45,6	22,2	23,6	23,4	20,5	22,6	21,3	18,4	24,2	18	19,3	18,6	18,7	22,5	20,3	16,9
S2	21,2	46,3	23,4	20,7	18,7	23,8	19,5	18,2	24,3	16,2	19,1	18,6	19,2	20,5	17,4	18
S3	23,6	24,9	45,1	20,6	19,5	21,2	19,1	18,9	22,3	16,4	18,7	18,9	17,1	20,6	15,4	18,4
S4	22,8	24	23,7	45,2	21,2	21,6	23,9	20,1	25,4	20,2	17,8	19,3	18,7	24,1	19	16,8
S5	25,9	23,9	24,1	23,8	45,3	24,7	23,5	22,7	24,8	20,5	16,5	16,5	19,5	18,8	16,6	16,5
S6	21,9	23,2	20,8	18,7	20,8	45,1	20,6	18,6	23	17,4	18,5	19,2	15,8	20,2	14,1	17,6
S7	24	22,2	21,1	24,1	21,3	24,6	43,6	23	25,8	23,2	17,2	17,7	19,1	21,1	14,4	16,1
S8	22,5	22,4	23,5	23,8	24,2	23,1	21,4	45,5	24	21,7	16,5	17,5	18,3	18,9	17,2	17,9
S9	21,6	24,3	22,2	21,5	19,7	23,5	22,2	19,6	74,4	19,1	17,7	17,3	19,7	23,5	18,9	16
S10	22,6	20,2	19,9	25,4	23	21,3	31,9	22,9	24,9	47,8	15,6	18,3	23,3	20,6	20,1	15
S11	14,8	14,6	14,2	14,1	13,8	14,5	13,7	14,2	13,6	13,6	44,9	14,9	13,2	12,9	12,1	23,5
S12	15,8	15,8	16,3	16,8	14,9	16,5	15,5	16,1	14,7	17,1	19,2	45	16,8	15,1	15,7	21,8
S13	22,5	22,7	20,4	23,2	22,8	18,5	22,3	20,3	23,5	24,6	14,6	17,7	46,3	21,7	24	14,2
S14	20	18,4	18,4	19,2	15,3	18,6	17,2	15,2	21	16,9	16,1	18,6	18,4	56	21	14,5
S15	23,4	22,8	20,1	24,5	20,5	18,7	20,1	20	22,4	20	14,1	17,1	23,4	21,7	48,7	139
S16	14,8	15,9	16,1	15,3	15,3	15,6	14,7	16,9	14,1	14,2	18,5	18,4	13,7	12,4	12,9	44,4

When comparing the image 1 and image 2 of one finger for the same subject, the compliance value is between 43.6% - 74.4%. The highest value of compliance had subject S9 (77.4%). On the other hand, the value of compliance between other subjects is in range of 16.1% - 31.9%. When the highest value of compliance had subject S10 with the subject S5 (31.9%).

TABLE II. Compliance of comparing the fingerprint of the right index finger in the order of 2-1; 2-2

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
S1	46	23,5	21,7	21,7	19,5	19	23,1	22,8	21,1	23,2	20	20,2	14,5	19,5	18,1	19,9
S2	20,7	45	23,9	22,8	18,6	17,7	23	24	21,3	20,8	18,7	20,6	18,5	21,9	19,4	20,3
S3	24,6	25,9	45,5	23,3	20,1	19,3	24,1	24,7	22,2	21,3	18,6	19,5	16,5	20	21,4	19,5
S4	21,8	25,5	20,7	45,6	19,4	18,4	24,1	22,2	24,1	21,7	17,9	19,9	16,4	20,2	18,9	18,9
S5	24,3	23,1	24	24,3	46,1	24,2	24,2	23	23,4	23,7	16,3	17,6	16,9	15,2	23	18,6
S6	22,9	21,9	23,5	22,5	24,5	46,2	24	21,6	22,4	23,3	16,3	16,6	17	12,6	20,8	18
S7	21,4	23,7	20	21,5	19,3	19,1	45,9	21,9	21,4	21,6	19,3	20,4	16,3	19	17,1	21,1
S8	22,6	26	23,1	21,8	19,1	18,3	22,8	45,6	25,4	22,5	17,8	20,9	17,4	21,6	19	19,4
S9	21,1	16,9	25,3	23,9	19,1	18,2	22,9	23,8	77,9	22,1	18	19,9	20,6	23,8	21	20,1
S10	23,6	24,3	23,5	22,4	21,7	20,1	24	23,3	23	45,4	19,1	19,9	15,9	17,7	19,5	19
S11	15,2	14,3	14,9	14,1	13,7	13,8	14,8	14	13,8	14,7	46,3	22,7	12,7	14,5	13,2	24
S12	16,9	16,7	16,9	16,8	15,9	15	17	17,5	16,6	17,1	19,1	47,4	19,5	14,1	16,7	23,5
S13	16,7	21,4	20	19,3	20,3	19,7	18,5	20,2	24,4	18,2	13,6	20,4	45,2	24,4	25	18,5
S14	15,6	18,5	15,9	15,8	12,3	10,3	15,7	17,2	19	13,7	16,9	18,6	21,9	50,8	23	18,8
S15	20	22,9	22	21,3	20,1	17,8	19,6	22,4	23,4	20,8	16,2	19,1	20,2	30	45,1	19,6
S16	17,6	17,7	17,6	16,8	17,2	16,7	18,5	17,3	17,7	16,8	18,6	19,3	17,9	14,7	17,9	44,6

For the second method of comparison between image1 and image2 of single finger for the same subject was the value of compliance ranged in 44.6% - 77.9%. Again, the highest value of compliance had subject S9.

In this table, the values of compliance compared with other subjects were in a similar range as in the previous table 19.3% - 26%.In this case; the highest value of compliance had subject S2 and subject S8 (26%).

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TABLE III. Compliance of comparing the fingerprint of the right index finger in the order of 1-1; 1-2

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
S1	100	30,5	23,7	24,8	19,9	18	23,7	22,8	25,8	21,9	18,6	21	20	22,8	20,8	19,7
S2	21,8	100	21,8	26,1	19,7	18,8	24,6	23,5	24	20,5	18,9	21,2	19,1	20,5	18,1	18,9
S3	21	24,6	100	24,4	19,1	18,2	23,1	21,8	22,6	20,3	18,1	20,7	18,3	20,1	18,1	19
S4	24,7	24,2	24,5	100	21,5	20,1	23,9	24,6	22,5	24,8	18,3	19,3	19,7	22,2	22,8	19,1
S5	24,1	24,8	24,2	24,4	100	22,4	24,8	22,6	23,5	23,3	16,6	17,9	17,1	15,2	22,9	19,3
S6	20,7	24	19,7	21,7	18,7	100	24,4	24,5	23	20,8	18,9	19,8	15,5	19,8	18,2	19,4
S7	23,5	24,9	24,7	23	21,6	21	100	24,7	24,5	22,3	17	18,8	16,9	16,4	20,9	17,7
S8	22,9	25,1	24,6	24,3	24	21,5	23,8	100	23,6	22,9	16,2	18,5	15,7	15,7	23	18,4
S9	20,6	17,7	24,5	23,7	18,4	17,6	22,7	25,7	100	21,6	18,1	19,8	20,2	24,8	21,1	19,8
S10	22,9	24,5	22,7	20	21,9	22,2	22,2	23,6	23,9	100	15,8	18,6	19,9	17,6	23,6	18,4
S11	15,2	14,4	14,4	14,2	14,4	14,1	14,5	13,9	13,5	14,7	100	24,4	13,1	14,1	12,5	24,1
S12	17,5	15,1	16,9	14,9	15,6	14,8	16,3	16,2	14,7	16,2	19,6	100	17,5	14,1	15,8	24,1
S13	19,8	23,6	22	24,2	20,8	22,5	19,1	23,3	24,8	21,8	14,1	18,3	100	21	27,6	17,6
S14	18	20,7	17,9	17,9	14,6	13,8	18,4	19,4	20,5	18	16,9	18,7	21,8	100	23,8	17,3
S15	18,1	23,8	21,8	20,8	20,8	19	18,8	21,4	25	19,4	14,5	20	26,7	27,9	100	18,1
S16	15,2	14,9	15,2	15,8	16,3	15	16,5	15,3	14,4	15,4	18,6	18,5	15,4	12,3	13,8	100

When comparing two identical images for a single subject than compliance, always reach to 100% for all subjects. The value of compliance between both images for two different subjects is compliance again between 18.6% - 30.5%. In this case, the highest value of compliance had subjects S1 and S2 (30.5%).

TABLE IV. Compliance of comparing the fingerprint of the right index finger in the order of 2-2; 2-1

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
S1	100	22,3	21,7	21,7	20,2	21,8	21,4	18,8	21,1	18,2	19,8	20,7	16,5	20,6	14	17,2
S2	24,3	100	22,4	21,2	20	22,9	20,5	20,3	21,8	19,3	18,2	18,1	19,6	21	18,2	17,1
S3	24,1	25	100	22,5	25,6	20,9	23,4	24,6	20,7	18,8	19,9	18,1	19,1	17,4	22,4	16,5
S4	25	27,3	24,9	100	19,4	23,4	20,6	19,3	24,3	16,1	18,5	17,4	19,3	20,7	16,5	18,1
S5	24,7	25,3	24,7	25	100	22,5	24,3	23,5	23	20,2	17,2	17,1	18,2	18,1	16,6	17,5
S6	22,6	23,1	23,3	23,8	23,6	100	236,	21,2	21,5	20,9	16,9	16,3	19,5	16,5	15,4	16,1
S7	22	22,9	21,5	20	19,8	24,1	100	18,8	21,4	18,1	18,7	19,5	16,1	19,3	14,6	18,9
S8	22,9	23,7	22	21,3	19,2	23,5	22,9	100	19,6	24,8	19,2	17,9	18,8	19,6	22	16,4
S9	24,9	24,7	22,6	21,8	20,5	24	22,4	20,2	100	19,2	17,5	17,2	20,3	23,3	19,2	16,3
S10	23,2	21,4	21,3	22,9	20,3	21,9	29,1	22,9	22,9	100	19	19	18,6	21,1	13,7	17,4
S11	14,2	14,4	14,3	14,7	13,9	15	13,7	14,1	13,8	13,7	100	23,3	24,4	12,8	13,5	12,7
S12	17,4	17,8	17,4	16,6	15,9	16,6	16,3	16,9	16,4	17	18,9	100	27,4	17,2	14,9	18,2
S13	23,5	22,2	21,2	24,3	20,1	17,8	19,1	18,4	24	22,2	14,1	18,3	100	25,1	21,8	15,7
S14	17,9	16,4	15,9	17,5	12,2	16,1	13,1	13,1	20,1	14,6	16,1	18,5	18,2	100	23,6	15,3
S15	23,4	21,1	20,8	23,1	20,7	20	21,3	19,3	23,6	19,6	15,5	17,8	21,2	20,2	100	15,2
S16	17,1	16,7	16,9	17,1	17,7	17,2	16,1	17,3	17,3	17,3	19	20,1	16,8	14,6	16,7	100

In the last table are again compared the same two images of single finger. So the value of compliance reached to100%. When comparing two different images for different subjects, the value is in the range of 20.1% - 27.4%.

Low values in comparison of two different images of the same finger for a single subject (about 45%) in Table 1 and 2 are result of the fact that during taking a fingerprint the finger cannot be rotated, lifted, pushed strong or weak, etc. The finger should be centred and not moving in order to capture as much as possible loops and minutiae on the fingertip. In Tables 3 and 4 were compared a single image for a single subject and therefore we get compliance value of 100% .

IV. Conclusion

The Identification by fingerprint is one of the oldest, the best known and most widely spread biometric method. It is the most widely used method of identifying not only in the criminalistics, but also in various the security systems, the banks, and the security services.

The main objective of this experiment was discovering compliance of fingerprints between different people and if there is any compliance then how much. In all cases of measurement, the rate of compliance was approximately 25%. Only for subject S16, the rate of compliance was always lower than all the others. How show the tables 1 and 2, which compared different images of the one finger from various subjects, we are find that the difference was not as distinctive as in Tables 3 and 4. Where the picture the fingerprints of one subjects was compared and subsequently it was compared with other subjects.

This experiment shows that the level of compliance of fingerprints is not large for the different people. If we talk about the security than the using of the fingerprint, it is not too safe. Because when we are re-scanning of the finger we are able to acquire around 50% of the compliance and this affect the setting of the device for fingerprint.

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The role of expressive full-body avatars and earcons and auditory icons in e-assessment interfaces

D. Rigas, and A. Algahtani

***Abstract*—** This paper investigates the role and effectiveness of multimodal metaphors in e-assessment interfaces. It evaluates usability of specific combinations of multimodal metaphors on their own or in combination with other. The parameters of the evaluated usability included efficiency, effectiveness and user satisfaction. The empirical research described in this study consisted of three experiments of 30 participants each to evaluate the effect of visual text, avatars and images individually, avatars, visual text and recorded speech in combination with images.

The use of full body expressive avatars with earcons and auditory icons were evaluated with 30 users. This investigation assessed the role of an avatar as a tutor in e-assessment interfaces. The results demonstrated encouraging usability results. The effectiveness and applicability of avatars in e-assessment interfaces were observed and discussed.

***Keywords*—**e-assessment, multimodality, avatars, earcons, auditory icons.

I. Introduction

Learning and assessment are complementary to each other. Developments in user interfaces and the way that information is communicated continues to influence e-learning or e-assessment systems. Computer-mediated assessment, computer-aided assessment, online assessment and e-assessment are interconnected terms and often used in relation to the utilisation of information technology [1]. Assessments are generally conducted to assess students' progress and to assist on-line student learning. The design of the assessment is widely recognised as a challenge for e-learning systems. It is often an integral part of the learning software [2]. The enhancing of the quality of the learning experience is an important factor. Several pedagogical principles have been suggested to enhance the learning experience including assessment [3].

Several definitions have been introduced for e-assessment but in essence is the use of computers to elicit that a particular level in education has been achieved [4-7]. Usability is an important evaluating parameter in the development of interfaces for e-assessment. Usability examines the effectiveness, efficiency and user satisfaction of a user interface [8 and 9].

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II. Literature Review

A. Multimodality

In overall terms, the literal sense of mode is the technique through which a certain work is accomplished. The term "multimodal" refers to accomplishing a task via the use of a number of methods all combined together. Multimodal is in effect the coexistence of more than one communication metaphors [10]. In some cases, multimodality may prevent information overload to the user [11].

The term involves the use of multiple communication metaphors that are mapped to the human senses (hearing, touch, olfaction and taste) but several researchers distinguish between computing modalities and the sensory modalities of psychology. Sharon Oviatt suggest that multimodalities (e.g. speech, touch, hand gestures, eye gaze and head and body movement) are multimedia schemes of output" [12] and [13]. Generally, a multimodal interface is a human-machine interface that uses multiple channels of communication between user and the machine [14].

In this study, the term multimodal metaphor is used to indicate the use of auditory and visual metaphors to represent the information to be used in e-assessment methods. When designing multimodal user interfaces, the following must be considered [15]:

1) Selection of appropriate modalities to communicate the required information.
2) Combining and synchronising the presentation of the modalities.

A speech modal is a channel that is used to represent particular information to users using voice [16]. Natural speech involves the use of recorded speech that is recorded, stored and played back [13].

The presentation of information using sound assists to decrease the amount of text and graphic required in the interface [16]. Also, this will utilise other senses such as hearing and sight. Non-speech sound metaphors in auditory channels are non-verbal cues that transmit information around

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objects in the computer interface. These can be made of digitally recorded or synthesised musical instruments, everyday sound effects, or electronically produced pure tones [17-19].

There is a growing demand for research that recommends merging non-speech sounds (earcons and auditory icons) with graphical interfaces to decrease the visual workload which impact the users' performance [20]. According to [21] auditory icons are defined as "everyday sounds mapped to computer events by analogy with everyday sound producing events". They provide a method that sounds natural in representing data that is dimensional and also the represents the objects that are conceptual in specific computer schemes. The auditory icons allow the data to be categorised into different sets using a single sound [22]. One of the most important advantages of using these is that the sounds used in them are those which people hear in their daily lives, and link them with a specific action [23]. An example of this can be found in the virtual world where we would hear the sound of an object crashing into a wastebasket when the file is deleted, or marked for deletion. This category of auditory icons is like the sound effects which complement the visual events with an appropriate sound in a computer scheme. Yet, their purpose is not just simply to serve as entertainment tools but also to convey very important information regarding the events taking place in a computer scheme – this allows the user to listen to the sounds from a computer as he does from the everyday world.

Systems like EAR (Environmental Audio Reminders) play a variety of the non speech audio cues for offices and the common areas within EuroPARC in order to keep us up to date regarding the various events taking place around its building; Share Mon utilises background sounds in order to spread awareness; Sound Shark, the sonic finder, is useful when incorporating the auditory icons in an interface that is well known and used often – the simplicity of it leads people to underestimate the functions that auditory icons are capable of. For this reason, Gaver and Smith [24] demonstrated auditory icons used in a large-scale, multiprocessing, collaborative system called SharedARK, and called the resulting auditory interface SoundShark [25]. However [26] said the analysis of both source and sound are not usually significant although that [26] has introduced an ad-hoc synthesis to let users recognise sound instead of the analysis of source and sound. These systems display the extensive range of functions performed by the auditory icons. These include provision of information regarding the user's actions, the possibility of new actions and also the object's attributes that are not visible in the system. They also provide the background information regarding the modes as well as processes in a system that is more complex.

Earcons are short, non-speech, musical sounds that are used in the interaction processes between computers and users [27 and 28]. Earcons are associated with either objects or actions presented in a computer interface. As earcons require abstract associations with data, users must learn them in an initial training process [29].

Avatars are classified as naturalistic, abstract or realistic. It simulates a person as a graphical image of a user [30]. The avatar can be either the head of a man or woman, or a whole body. The idea behind the avatar is to simulate a real life person who naturally interacts with the user. For example, in e-learning, it can be used as a virtual lecturer [31 and 32]. Avatars often simulate body-gestures in order to better mimic human behavior. Body gestures are part of non-verbal messages. Non-verbal messages communicate a significant amount of information [33, 34]. Although body gestures are culture-dependent, strong messages of emotion and attitudes are communicated [35]. Body gestures in avatars are used to enhance speech and add emphasis [33, 36]. By using our hands, heads and feet, we can represent a very wide range of signs, signals and movements [35]. Avatars also help to "humanise" user interfaces. Humanisation has two objectives; to make the interfaces easier and more enjoyable to use and to make the interface more similar to humans [37]. The process of anthropomorphism offers interfaces to computer schemes via the provision of some human-like characteristics [38].

III. Aims and Objectives

The research question of this study is whether the use of avatars have a positive effect on users' learning achievements in an e-assessment interface. The objectives were:

3) To examine the impact on the usabilirty of e-assessment interfaces that utilise full-body expressive avatars with earcons and auditory icons.
4) To investigate the most effective metaphors for specific types of e-assessment.
5) To evaluate the user interaction in terms of efficiency (time taken to complete tasks), effectiveness (successfully completed tasks) and user satisfaction.
6) To measure the performance of recall and recognition tasks of use in the presence of expressive avatars with full body gestures, earcons and auditory icons.
7) To investigate the user performance during the execution of simple, moderate and complex interaction tasks and identify the implications to usability.
8) Determine the combined effect of the multimodal metaphors to e-assessment.

IV. Experimental Condition

The use of expressive avatars with body gestures together combined with earcons and auditory icons provides an investigation platform in e-assessment interfaces. The research assumptions are:

1) The provision of a realistic interaction with the user that resembles a face-to-face interaction.
2) Making the learning process easier and increase the user's interest, motivation, and learnability.

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V. Assessment Types and Multimodality

There are six types of assessment that communicate information to users in the e-assessment interface. These are error, comment, thinking, explain questions, suggestions and mark. Earcons communicated the correct answer to the question when spoken by the avatar. The aforementioned six types of assessment were grouped in three levels in terms of their ability to help; high, medium and low. Each of these levels was represented by a rank as follows: 1 for low, 2 for medium and 3 for high. This ranking refers to the potential of each metaphor (earcons and auditory icons) to assist in communicating the correct answer. For example, the first earcon consisted of only one note to communicate low ability, the second earcon consisted of two notes to show a medium rank.

Auditory icons were also used. The sound of "glass breaking" communicated an error, "opening a bottle lid" communicated that a comment is about to start, a "honking horn" indicated that the thinking has started, "a closing window" the explanation of questions, "door opening" that a suggestion is about to start, and a "hand clapping" that a mark is about to be communicated. Earcons and auditory icons were presented during the pause intervals so that they do not interfere with the spoken messages of the avatar.

VI. Sample and Experimental Procedure

A group of users (n=30) assessed the experimental interface in order to obtain an overall viewpoint of the suitability of the metaphors used. The procedure followed during the experiment is presented below:

1) Anonymous gathering of the sample profile (e.g. educational level).
2) Recording previous knowledge in relation to e-assessment interfaces, expressive avatars, earcons and auditory icons.
3) A short demonstration video introducing the e-assessment interface.
4) Presentation of example instances of the e-assessment interface with particular emphasis upon the multimodal metaphors used. The object of this training was to ensure the user's ability to understand and interpret each of these multimodal metaphors.
5) User performed the experimental tasks and all relevant user data was recorded. Each user was asked to answer 6 questions connected to the delivered assessment type. The questions were of two types; recall and recognition.
6) Post-experimental user questionnaire that gathered their views regarding the various multimodal metaphors used. Users also had the opportunity to provide suggestions or comments for improvement.

The independent variables were:

1) Multimodal metaphors. These were earcons, auditory icons and expressive avatars with body gestures.
2) Types of assessment. These were error, comments, thinking, explain question, suggestions and mark.
3) Assessment questions. These questions included recall and recognition in order to evaluate the users' learning achievement attained from the information presented by the tested e-assessment interface.

The dependent variables were:

1) Completion level (correct answers): This is the number of successfully completed tasks. It was measured by the frequency of correct answers to the recall and recognition questions linked to the communicated assessment.
2) Involvement of users with the type of assessment: This was measured by the number of users who correctly indicated these features after being communicated by the non-speech sounds.
3) Users' recognition of earcons and auditory icons: This was measured via the number of users who successfully interpreted the auditory stimuli in the context of being communicated in the experimental interface.
4) User Satisfaction: It was measured using questionnaires to gather the views of users.

VII. Sample profile

The test sample consisted of 30 users who took part in the experiment individually. The age profile of the sample consisted of 18 – 24 (13%), 25-30 (26%) and 31- 41 (60%). The gender ratio was 60% male and 40% female.

The educational profile of the sample consisted of 14 users (43%) at a postgraduate level and 17 users (56%) at an undergraduate level. 26% of users used computers for between 1 and 5 hours per week, 20% for 6 to 10 hours and 53% for more than 10 hours and 76% of the sample had knowledge about multimodality and e-learning applications. 66% of the sample used internet for surfing and 23% for education. At a pre-experimental level, only 26% of the sample thought that e-assessment would enhance on-line e-learning applications.

VIII. Results and analysis

The following provide descriptive and statistical analysis of the results obtained from the experiment in terms of achievement level, involving (in terms of correct and incorrect users' answers) in addition user satisfaction, and users' views regarding the non-speech sounds that accompanied the avatar body gestures as assist. This was the results of the experimental group consisting of 30 volunteers who took part in the study. In addition, the levels of significance in students responses was examined using the nonparametric Chi-square statistical test at $\alpha = 0.05$ indicating significant difference when p-value was found less than 0.5.

IX. User achievement

The frequencies of correct answers to the assessment questions were used to assess the users' achievement. Each user answered nine questions using recall and recognition methods. The total number of questions was 180 (30 users x 6 questions per user) equally distributed over the two types.

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Fig. 1 shows the percentage of successfully completed tasks (correct answers were provided by users) by users grouped according to assessment and question types. The percentage of successfully completed tasks with correct answers was 78%. This statistically significant with chi-square value at 0.200, cv = 3.84, $p<0.05$. For recall tasks or questions, the successful rates were higher than that for the recognition tasks or questions.

The response to the 90 questions was 78.8% for recall and 87.7%. The difference between correct and incorrect answers was significant in both assessment question types; recall chi-square value at 16.8, cv = .200 $p<.05$ and recognition 7.4, cv=0.200, $p<0.05$. The percentage of the sample who correctly answered questions linked to "involved thinking" was 86.7% and for "error" 83.3%. The other results were 73.7% for "more suggestion", 70% for "explain question", 60% for "mark" and 53.3% for "comment".

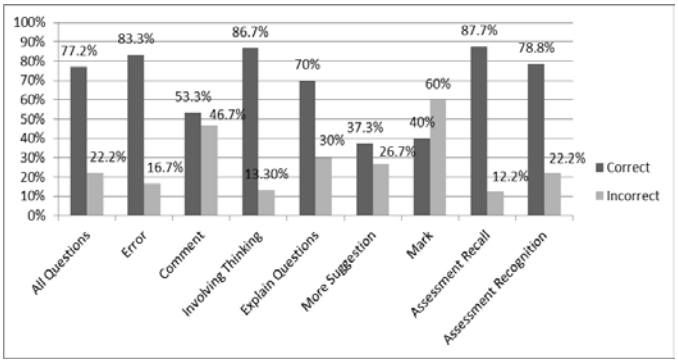

Fig. 1 Correct and incorrect percentages of answers achieved by users for all questions, assessment types and assessment question types

Table. I Chi-square values and significance levels relating to the achievement level

Variable	Chi-square value	Asymp. Sig.	Significance
All assessment question	.200a	.905	No
Assistance Type			
Error	13.333[a]	.000	Yes
Comment	.133[a]	.715	No
Involving Thinking	16.133	.000	Yes
Explain Questions	4.800a	.028	Yes
More Suggestion	6.533a	.011	Yes
Mark	1.200a	.273	No
Assessment questions			
Recall	16.800[b]	.000	Yes
Recognition	7.400[b]	.025	Yes

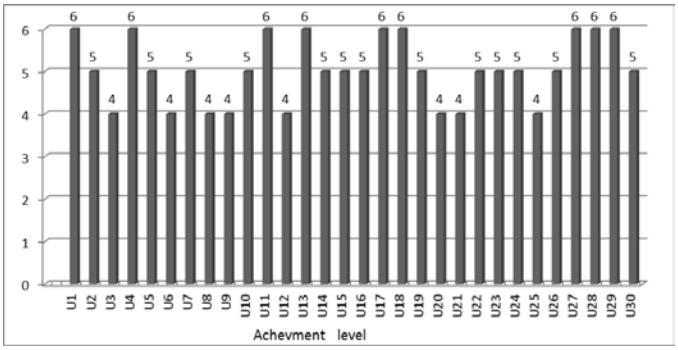

Fig. 2 the number of correct answers provided per user

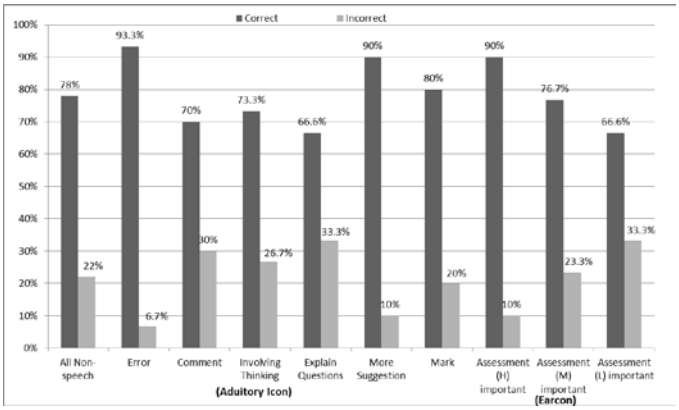

Fig. 3 correct recognition of users of the assessment types that were communicated by non-speech sounds, earcons and auditory icons

Table I shows that the outcomes were significantly dissimilar for correct and incorrect answers for error, thinking, explain question and more suggestion but there was no significance for comment and mark. Fig. 2 shows the correct answers per user in the sample. Nine users (1,4,11,13,17,18,27,28, and 29) answered each question successfully.

The multimodal metaphors used (expressive avatars with full body gestures, auditory icons and earcons) improved the delivery of the assessment content in the e-assessment interface. The auditory messages increased the volume of information communicated by the avatars but did not cause an information overload to users.

X. User Involvement

On completion of the achievement tasks, users were asked to do two more "involving" tests. Users were provided with six different assistance messages using auditory stimuli and they were requested to indicate the type of non-speech sound that was the most effective. The total number of questions was 180 (30 user x 6 questions per user). Fig. 3 shows the correct responses of users to this task related to all non-speech sounds, earcons and auditory icons.

The results ware statistically significant ((1)=15.6, cv=3.84, $p<0.05$). The majority of the users recognised correctly the assessment types communicated via auditory icons. More specifically, 93.3% of the sample (28 users) correctly recognised "error" message using an auditory icon similar to a "broken glass", 90% (27 students) accurately determined the "suggestion" message using a sound similar to a "bottle opening" and 80% (24 users) recognised the "mark" message using a "hands clapping" sound. This percentage decreased to 73.3% and until 66.6% for the remaining assessment types.

Users were requested to perform three tasks with questions that were communicated using non-speech stimuli in order to determine the high, medium or low level of the provided assistance. 90% of the sample (27 users) correctly identified the "high importance" message type compared to 76.7% (23 users) for the "medium importance" and 66.6% (20 users) for the "low importance". In a subsequent evaluation, three types of auditory stimuli were played for each of the assessment types and the importance level of the assistant type. Users had

to distinguish the sound that linked each of the assessment types and its level of importance. The obtained results for the non-speech sounds, earcons and auditory icons were encouraging. In total, 84% of the tested sounds were correctly recognised by users. This outcome was highly significant ((1) = 15.6, cv = 3.84, $p<0.05$). 100% (30 users) of the sample correctly recognised the auditory icon that sounded like a "broken glass" to communicate an error and 93.3% for the sound that resembled "opening a bottle" to communicate a suggestion. However, the percentages for the other auditory icons used were 76.6% and 70%.

The earcons used to communicate high, medium and low importance of a message were correctly recognised by all users. These results suggest that the tested auditory icons and earcons were successfully interpreted and more easily remembered by users when utilised in e-assessment condition to signal the importance of particular content delivered by a body gesture. The responses of users were positive (see Fig. 4) with respect to their views and feelings about earcons and auditory icons used interactively. However, 70% of the users felt irritated when they heard the sounds through the experiment. It is noteworthy that there was some difference in user frustration. There was a small difference between agreement and disagreement of 53.3% and 46.7% respectively. For usefulness, 86.6% of users found these sounds to be helpful and 76.6% of users felt that the presentation of sound assisted them to concentrate with the presented content.

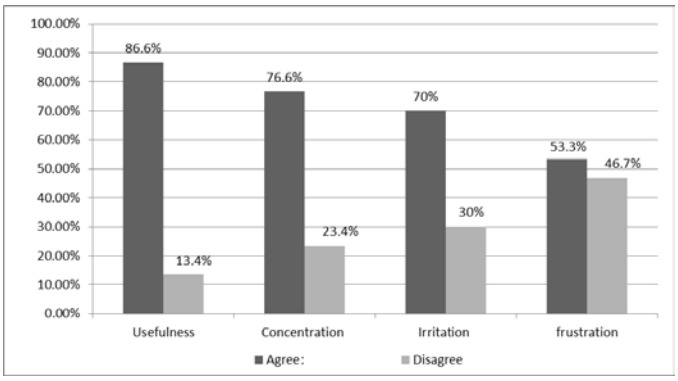

Fig. 4 Results of the user evaluation toward the non-speech sound

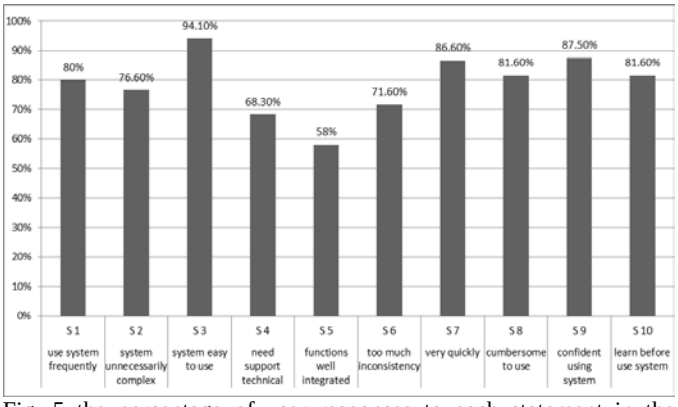

Fig. 5 the percentage of user responses to each statement in the satisfaction questionnaire

XI. User Satisfaction

User satisfaction was measured using a questionnaire composed of 10 statements. Users provided an answer using a 5-point Likert scale [39, 40] ranging from strong disagreement to strong agreement. These findings provided an overall viewpoint of the users' attitude towards the different aspects of the Auditory Avatar Body Gestures condition.

Fig. 5 shows the user views on their satisfaction for particular aspects of the experimental platform. The mean score for user satisfaction was 81%. The parameters expressed in statements S1, S3, S5, S7, and S9 were the most agreed by users. 85% of the users agreed that the system functions were well integrated (S5) and that most users are likely to learn quickly (S7). 78.5% of users welcomed the use of the auditory icons and expressive avatars (S9). 94.1% of users would use the e-assessment interface again and 80% thought that the interface was simple to use.

Some users disagreed with statements S2, S4, S6, S8, and S10 with rates fluctuating between 68.2% and 81.5%. 81.5% of users needed training to use the e-assessment interface (S10) and 68.2%, disagreed that using the interface requires the need for technical support (S4). Overall, users welcomed the use of the expressive avatars with spoken messages, auditory icons and earcons. On balance, the user satisfaction results were more positive than negative. This demonstrates, from the user satisfaction prospective, that there is a clear prima facie for the inclusion of multimodal metaphors in e-assessment and e-learning applications.

XII. Discussion

This experiment showed that the users had an increased level of concentration on the delivered assessment content. This increased concentration was due to the inclusion of interaction metaphors of diverse modalities in the tested condition. The textual metaphors combined in the condition with body gestures of the assistant avatar contributed to capturing the user's visual attention towards the provided information. At the same time, additional auditory explanations about this information were presented by the voice of the full body gesture avatar. Non-speech sounds did not appear to influence concentration as users were engaged with the assessment content communicated via auditory stimuli. Consequently, users were able to present the correct answer. The results of this experiment showed that user achievement levels were significantly assisted by the addition of earcons and auditory icons that aided the contribution of the body animated virtual instructor to achieve both types of the required evaluation tasks.

Auditory icons significantly assisted users to successfully complete recall and recognition questions. However, earcons were more effective in recall questions than in recognition questions. The earcons used in this experiment were less helpful compared to auditory icons. The outcomes of the experiment indicated that users were satisfied significantly with the inclusion of auditory icons and earcons in evaluating the e-assessment interface (see Fig. 4). Most users stated that these sounds assisted their involvement and did not divert their concentration. Moreover, the auditory icons were chosen

because they were the closest environmental sound mapping for the communicated information. Additionally, each of these sounds indicated one meaning at a time and they were used consistently throughout the auditory body gestures avatar interface. This multimodal approach to the e-Assessment interface generated a generally improved user satisfaction and performance. Finally, the obtained results suggest that utilising non-speech sound with body gestures in the form of avatars enhances, to a large extent, the usability and user involvement within the delivery of information in e-Assessment learning interfaces.

XIII. Conclusion

The experiment presented in this paper investigated the achievement level and user involvement with the use of earcons and auditory icons used as complementary auditory signals to indicate the dissimilar assessment types as presented by a virtual instructor. The experiment also investigated users' satisfaction. A total of 30 students took part in the experiment to assess the e- Assessment interface as an extension to the interface tested in the previous experiment by adding of Non-Speech sounds. The results showed that these sounds were effective in directing the users' attention to important parts of the Assessment, and contributed positively to enhance user achievement levels in different learning activities. Furthermore, these sounds were memorable, understood, and increased user satisfaction and enjoyment. Consequently, the use of these metaphors was discovered to be significantly useful to enhance the usability of an e- Assessment interface. Ultimately, this study showed the addition of auditory non-speech metaphors to an Avatar Body Gestures condition to allow the user to engage with diverse types of Assessment and questions. Three types of multimodal metaphors were presented which were included in the interface: visual-only metaphors (text which is Assessment type content), audio-visual metaphors (speaking avatar with body gestures) and auditory metaphors (earcons and auditory icons). The collection of experimental data was mostly focused on observations and questionnaires and contributed to the valuation of user's involvement and enhanced user ability performance, such as achievement level and user satisfaction. The results indicated that the users were satisfied, significantly with the inclusion of auditory icons and earcons. Mostly of students stated that these sounds were neither irritating nor frustrating, helped their involvement and did not divert their concentration.

The results of this study highlight the significance of the multimodal metaphors in enhancing learnability performance, as well as the usability of e-Assessment interfaces, in terms of achievement level and user satisfaction.

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Collaborative Decisions within Business Intelligence Context: A GDSS prototype

George A. Rigopoulos, Nikolaos V. Karadimas

***Abstract*—**In this work we present a prototype for a web based Group Decision Support System, which can be integrated within a firm's Business Intelligence (BI) architecture to support decisions in small collaborating teams. It is based on web technology and can be used in asynchronous mode from group members. It implements a multicriteria methodology for classification decisions where aggregation of members' preferences is performed at the parameter level. Initially, a set of parameters defined by stakeholders is proposed to the group by group facilitator. Next, each group member evaluates the proposed parameter set and expresses her preferences in numeric or linguistic format. Individual preferences are aggregated by appropriate operators, and a group parameter set is produced which is used as input for the classification algorithm. NeXClass multicriteria classification algorithm is used for the classification of alternatives, initially at a training set of alternatives and later at the entire set. Finally, group members evaluate results, and consensus as well as satisfaction metrics are calculated. In case of low acceptance level, problem parameters are redefined by group members and aggregation phase is repeated. The system has been utilized to solve real world group classification problems, especially within the BI environment of a commercial bank, supporting mainly financial decisions. Empirical findings from the GDSS application have been evaluated and enhancements have already been incorporated in order to improve existing functionality and provide additional features. Regarding the overall approach, findings provide evidence that it is appropriate for similar decision problems in numerous business environments, and the GDSS can be a valuable tool for enhancing a BI framework with advanced decision capabilities.

***Keywords*—**Business intelligence, Group decision support, multicriteria decisions.

I. Introduction

Following advances in Information Technology the majority of processes and decisions in large firms and organizations can be characterized today as data driven. The ability of acquisition and organization as well as development and diffusion of knowledge has become a critical factor for market performance and firm viability. Moreover, the amount of information gathered from traditional and novel sources such as customers, Internet and information systems, is excessively increasing requiring additional organizational effort. As a consequence, increasing complexity at the knowledge level has led to additional needs for advanced decision support. Provision thus of appropriate decision support tools at managerial as well as at operational level is critical for efficient performance, and moreover it offers firms a strong advantage against the rest of the competitors within the domain [1], [2], [3].

One of the Information Technology directions that aims to support firms handle the above complexity is Business Intelligence (BI). BI provides a set of methods, processes and tools to support firms' decisions through intelligent exploration, integration, aggregation and analysis of data from various resources. In brief, the origins of BI tools can be traced at the early developments of Decision Support Systems (DSS), while current needs for advanced intelligent decisions due to information complexity has led to a massive development of BI systems with DSSs' being a subset of BI domain. Within a BI architecture, a DSS stands on top of BI tools, utilizing aggregated information provided though them, to assist decision makers optimize their decisions. Additionally, since most of the decisions within firms today require the participation of a group of decision makers, it is critical to provide tools to assist them within the context of a BI framework [4], [5], [6].

Group decision support has received significant attention from researchers due to its potential application to various business domains. Research in decision support systems targets towards supplying decision makers with appropriate tools to assist them in optimizing their decisions. Since a decision support system has to reflect decision makers' preferences or decision model, building an appropriate Group Decision Support System (GDSS) is not a straightforward process. Moreover, a number of issues have to be considered such as individuals' preference modeling, negotiation protocols and coordination, to mention a few.

Several methodologies and tools have been developed in order to support groups, ranging from collaborative techniques to negotiation ones, depending on whether group members share a common goal or support individual goals. Technologies acquired for developing a GDSS tend to follow advances in Information Technology, resulting in recent advanced systems. Incorporation of web technologies nowadays, for example, can support collaboration features which could not be implemented in the very early GDSSs. However, from literature analysis there are very few approaches that combine BI concepts and Group Decision

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Support Systems (GDSS), which is the main contribution of our work [7], [8], [9].

Following the above, we developed a structured methodology which is based on multicriteria analysis and supports group classification decisions and a GDSS which implements it. In this paper we present the methodology and architecture along with a prototype.

The overall architecture and development of the GDSS was based on web technology in order to be easily integrated within an existing BI infrastructure. We followed a layered approach, implementing concepts from Service Oriented Architecture (SOA), aiming to provide a subset of the functionality of the GDSS in terms of Web Services. The proposed GDSS can be part of an existing BI architecture within a firm or an organization, gathering input from several BI subsystems to integrate them into a decision support framework.

The GDSS has been deployed in real business environment supporting mainly financial decisions. Regarding the overall methodology, findings provide evidence that it is a valid approach for similar decision problems in numerous business environments within a BI architecture.

The structure of the paper is as follows. Following the introduction, relevant background information in BI and decision support as well as group decisions is presented. Next, we present the integrated group decision multicriteria methodology implemented by the GDSS. Section 4 presents the architecture of the developed GDSS mentioning key features of the system. Finally, the conclusion summarizes the work.

II. Background and Relevant Work

A. BI and decision support

BI is generally defined as "a term to describe leveraging the organization's information assets for making better business decisions" [10]. Intelligence in BI is often defined as the discovery and explanation of hidden, inherent and decision-relevant contexts in large amounts of business and economic data. BI consists today one of the fastest developing domains in Information Technology. It is widely assumed that in the near future BI systems integration with CRM (Customer Relationships Management) and ERP systems (Enterprise Resource Planning) will provide firms a strong competitive advantage, enhancing quality of managerial decisions [11], [5].

In general, BI systems combine data from internal information systems of a firm and integrate with data coming from the environment such as. statistics and financial databases, to provide adequate and reliable up-to-date information on different aspects of firms' activities [5]. The use of BI tools is popular in industry [12], [13], indicating the firms' growing needs to handle the vast aggregation of information orienting from business documents and data, including business forms, databases, spreadsheets, e-mails, articles, technical journals and reports, contracts, and web documents. Distinction between knowledge management and BI is not always clear [14], although knowledge and content management technologies search, organize and extract value from information sources, while BI focuses on the same purpose, but from a different scope.

BI is mainly targeting in advancing decision making utilizing data warehousing and online analytical processing techniques (OLAP), collecting relevant data into repositories, where organized and validated can be further available for decision making. In general, business data are extracted, transformed and loaded from various transactional systems into a data warehouse after data cleansing processes and multidimensional models are created to support drill down and roll up analyses. A number of vendors provide tools and platforms for such operations and advanced end user functionality to support large amount of data [15].

From the above, the linkage between BI and decision support within firms is evident. Moreover, BI origins can be traced back at the early data-driven DSS approaches [6]. Later, BI term was promoted and used as an umbrella term "to describe a set of concepts and methods to improve business decision making by using fact-based support systems". Although BI is sometimes used instead of the term of executive information systems (EIS), in general BI systems can be defined as data-driven DSSs. With the advent of Internet, BI vendors shifted their BI solutions towards web technologies and enterprise BI portals emerged [16].

B. Group decisions

Group decision making has become an essential component of both strategic planning and everyday operations for the majority of today's organizations and enterprises. Since complexity of business environment requires sufficient knowledge from a wide range of domains, contribution of a team of experts with key skills is the only way to achieve efficiency in decisions. In order to support groups' needs, various researchers work on developing tools and methodologies, ranging from collaboration technologies to decision support systems [7], [8].

However, group decisions are quite more complex compared to single decision making, since a number of contradicting factors are involved such as individuals' personal opinions, goals and stakes resulting in a social procedure, where negotiation and strategy plays a critical role.

Group decision making in real business environments raises also some issues such as:

- Conflicting individual goals,
- Not efficient knowledge,
- Validity of information,
- Individuals' motivation.

Despite the inherent complexity, within a group decision making setting, a member is able to express personal opinions and suggest solutions from a personal perspective. In addition, negotiation and voting advance efficiency of decisions and increment acceptability and adoption since all participants have contributed to the result, smoothening thus any disputes.

In general, group members can be motivated by individual

perceptions to work within the group either towards collaboration or towards competition. While in the first case, members express similar opinions and goals, in the second one they state opposite opinions. Although collaborative teams work towards a common goal contradictions may also occur.

Some key techniques that have been acquired in order to facilitate group work and decision include:

- Brainstorming,
- Nominal group technique,
- Delphi method,
- Voting,
- Multicriteria analysis.

C. Group decisions and multicriteria analysis

Group decision support is a subset of the more extended research area of group support and negotiation. Group decision support is an active research topic and existing literature is quite extensive covering business as well as social issues. Limiting the scope of relevant literature to integration of multicriteria analysis within group decisions, we performed a detailed survey focusing on relevant approaches, and especially on developed Group decision support systems. An extensive review of multicriteria analysis integration within GDSSs is presented by Rigopoulos [7], [8], [9].

In general, multicriteria analysis can be incorporated as a method to model preferences and facilitate decision making within a group of decision makers. Modeling under a multicriteria setting can be formulated under two major directions:

1) In the first approach, individual multicriteria models are developed, which capture individuals' preferences. Each group member formulates a multicriteria problem defining the parameters according to her preferences and solves the problem getting an individual solution set. Next, the separate solutions are aggregated by aggregation operators providing thus the group solution.
2) In the second approach, one multicriteria model is developed for the entire team. Each group member provides a set of parameters which are aggregated by appropriate operators, providing finally a group parameter set. Upon this set the muticriteria method is applied and the solution expresses the group preference.

Each approach poses both positive and negative aspects depending on the aggregation operation, which is followed.

III. Proposed Group Decision Methodology

The main objective of our work is to provide support to a group of decision makers in classification problems. The problem refers to the assignment of a set of alternatives in a number of predefined non-ordered categories, according to their performance on a set of evaluation criteria. For this reason, we have developed a structured group decision methodology, which is based on the following principles:

1) The decision group is a small homogeneous team of collaborating decision makers. Although the methodology can be extended to large decision teams, our approach is based on collaborative teams, which target towards maximizing consensus. Non-collaborative teams require a negotiation-based approach, which is out of scope of the present methodology.
2) A facilitator coordinates the entire decision process. The entire group decision process is coordinated by a Facilitator. Usually, in group decision making a negotiation phase takes place at the preliminary steps of the decision problem formation. During this negotiation, which can be structured or not, basic parameters are defined. Since our methodology is not focusing on group formation procedure and initial negotiations, we consider that a preliminary negotiation step has already been executed, possibly by utilizing brainstorming technique, between stakeholders, and the outcome of this process is an initial proposal of parameters. This set is expressed from Facilitator as the initial proposal upon which group members will express their preferences. Facilitator guides the entire process in order to produce efficient and timely results.
3) Decision problem is structured or semi structured. The team solves a structured classification problem contributing their preferences. Non structured problems are out of scope.
4) Multicriteria analysis is utilized for the classification. For the classification problem we utilize multicriteria analysis which provides appropriate support to similar problems.

Following the above principles, we developed a group decision methodology which is separated in the following major phases:

A. Problem initiation

. In this phase Facilitator initiates the decision problem, defining all appropriate parameters. The parameters are related to the specific multicriteria methodology, and refer to criteria, alternatives and categories. In details:

1) Basic parameters. Initially, Facilitator defines a number of basic parameters, related to classification problem such as the number of group members, the number of categories, the number of criteria, and to results assessment such as the consensus, satisfaction and acceptance levels. These levels define minimum required levels for the group decision. In case they are not satisfied, a second round is executed with modification of individual preferences.
2) Members. Facilitator defines the group members assigning all necessary contact details.
3) Categories. Facilitator defines the set of categories for the classification of alternatives.
4) Evaluation criteria. Facilitator defines the set of evaluation criteria according to problem requirements.
5) Criteria weights. Facilitator defines the criteria weights.
6) Alternatives. Facilitator defines the set of alternatives for classification, and defines their performance on the evaluation criteria.
7) Entrance thresholds. Facilitator defines appropriate entrance thresholds for each category.

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8) For each threshold Facilitator defines preference, indifference and veto thresholds similar to ELECTRE TRI method.
9) Training set. Facilitator defines a subset of alternatives as training set, in order to evaluate parameters' accuracy.

After the initiation of the parameters, Facilitator communicates through the GDSS with group members informing them about the problem and asking them to submit their preferences.

B. Aggregation of individual parameters

In this phase group members express their preferences on the proposed parameter set. Member preferences are expressed in numeric values and linguistic preferences. For the aggregation of numeric values we utilize the Social Judgment Scheme (SJS), while linguistic terms are aggregated in terms of an Ordered Weighted Averaging Operator (OWA) [18], [19].

Aggregation of member preferences is executed for the following parameters

1) Criteria. Group members express their acceptance on each proposed criterion in a five point linguistic scale and their preferred weight in numeric value.
2) Alternatives. Group members express their acceptance on alternatives' performance or submit their preference in numeric value.
3) Categories. Group members express their acceptance on each category definition, and submit their preferences on category thresholds in numeric value. .

Facilitator proceeds with validation of members' input and aggregates the values. Parameters with low acceptance level are marked and are subject to review if final results are not acceptable by group members.

C. Application of multicriteria classification algorithm

After the aggregation of individual members' parameters a group parameter set is created and NeXClass algorithm for multicriteria classification is applied on this group parameter set [17]. NeXClass algorithm classifies an alternative to a specific category with respect to alternative's performance to the evaluation criteria, considering a set of alternatives, a set of predefined non-ordered categories and a set of evaluation criteria. In more details the algorithm works as follows:

1) For each category decision maker defines an entrance threshold using available information. This threshold represents the minimum requirements for an alternative in terms of performance on the evaluation criteria in order to be included in this category.
2) Decision maker defines alternatives' performance on the evaluation criteria.
3) For each alternative an excluding degree is calculated for every category threshold, based on outranking relations, following a similar approach to ELECTRE TRI method.
4) Next, the fuzzy excluding degree of an alternative over a category is calculated.
5) Assignment to a category is based on the rule which states that alternative is assigned to the category for which the excluding degree over the entrance threshold is minimum.

Application of NeXClass classification algorithm is executed through the following steps

1) Training set classification. Classification algorithm is initially applied to the training set initially, as it has been defined by group members. Classification is executed by Facilitator, and group members are informed to assess the results.
2) Evaluation of results. Each member expresses her preference on the results in a five point linguistic scale, and in case of low acceptance level, Facilitaror executes a second round of parameter definition from members in order to calibrate the model. When training set classification is acceptable, Facilitator proceeds with the classification of the entire set of alternatives. In case of low acceptance level after the second round, Facilitator terminates the process in order to revise the problem with stakeholders.
3) Training set classification. Classification algorithm is finally applied to the entire set by Facilitator, and group members are informed to assess the results.

D. Results assessment

Group members assess the results expressing their preference in a five point linguistic scale. In case of low acceptance level, Facilitator reruns the model, requesting modifications from members.

IV. Group Decision Support System

A. Overview

A prototype GDSS was developed to implement the aforementioned methodology. The design of the GDSS was based on the following requirements:

1) Collaboration. The GDSS should promote collaboration between group members by appropriate functions. Group members for similar decision problems, can be selected ad hoc without any prior collaboration. The GDSS should thus promote the feeling of a common goal to members minimizing thus individual goals.
2) Communication. Since business operations may span over several locations, members can be located separately. Communication thus between facilitator and group members should be efficient enough in order to provide results in a timely way. The GDSS should thus provide appropriate communication tools.
3) Anonymity. Although anonymity poses some negative issues, it encourages members express their preferences without restrictions or external influence. For this reason, the GDSS should support anonymity at presentation level.
4) Asynchronous operation. Different time zones and locations of today's business operations require asynchronous operation and decision making. The GDSS should thus provide asynchronous operation efficiently.

Considering the above requirements, a layered approach

which can be easily deployed in an existing BI infrastructure was selected for the GDSS architecture (Fig. 1). BI architecture components such as transactional data source systems and data warehouses can be easily connected and integrated with the GDSS, being the sources of input data. In the same way, GDSS output can be deployed in firm's BI systems advancing firm's knowledge. Regarding the technology utilized, GDSS modules have been entirely developed in Java language using JCharts library for chart preparation. Apache web server is used to host the entire site with Tomcat as servlet container and Tomcat Axis used for the deployment of web services. Data layer has been implemented in MySQL database, but can be hosted in any relational database.

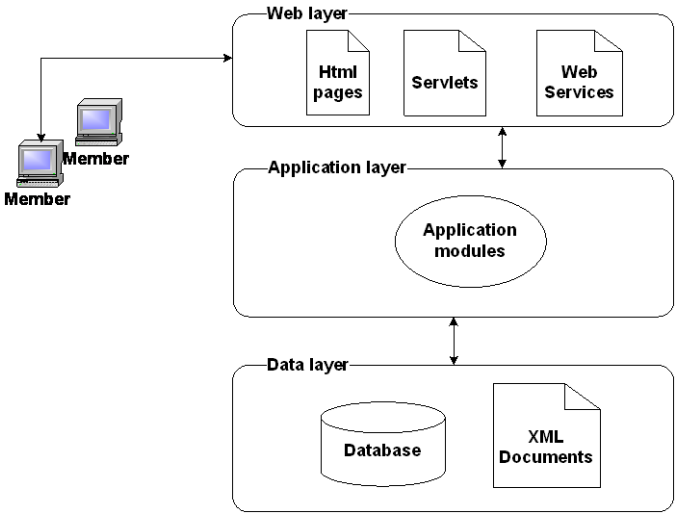

Fig. 1 Overall GDSS architecture within a BI framework

B. Architecture

The GDSS comprises of the Data, Application and Web layers as described in the following:

1) Application layer hosts all the functional modules which implement the methodology. The layers comprises of the following major functional modules, which have been developed in Java language:
   - Group facilitation module. It is the core module of GDSS, which is responsible for the coordination of group decision process.
   - Communication module. This module implements all the necessary functionality, which is required for the communication between group members and Facilitator.
   - Multicriteria algorithm module. This module implements the NeXClass multicriteria classification algorithm [17].
   - Aggregation module. This module implements all the aggregation processes following the methodology. SJS and OWA aggregation are implemented on individual members' preferences [18], [19].
   - Presentation module. This module is responsible for the presentation formatting, in both simple numeric and graphical formats. Utilization of graphs for result visualization, increases familiarization and understanding from group members. For the development of graphs JChart library has been utilized.
2) Data layer, stores all the necessary data for decision problems. It is one of the core components of GDSS architecture, and is responsible for storing all the necessary data for each classification problem. Since the orientation of GDSS is to operate into business environment, the data model was designed to meet relevant demands. It can store problem parameters from multiple simultaneous decision problems and can handle any combination of group members and parameters without conflicts. It can also store previous problems or demonstration ones for educational purposes, with specific consideration to privacy issues. In order to meet the above needs, we have implemented a relational model distinguishing three major virtual groups of entities: Problem parameters, Preferences and Results. Each one consists of a number of Database tables which along with the relations satisfy the needs of the GDSS.
   - Problem parameters group stores all necessary data related to a group problem. Parameters include all necessary data for a decision problem referring to criteria, categories, alternatives and members.
   - Preferences group stores all the data representing group members' preferences. Preferences group is separated into two sub groups, which store individuals' and aggregated preferences accordingly. Aggregated preferences data is the input for the multicriteria classification methodology.
   - Results group stores all the data related to the results of the problem.
   - The model can reside in any relational database available at business environment. In addition, there is the option to import data in the form of XML documents for decision problems with large number of alternatives, when the data are already present into another system. Data can be originated from several sources of a firm's BI infrastructure and further the entire Data layer can be itself a part of the BI infrastructure.
3) Web layer, provides all the user interface functionality. User interface has been designed in order to guide users through the steps of the methodology and has been implemented using web technology. Servlets and html pages offer GDSS functionality to group members in a user friendly way. In addition, an XML interface has been developed for importing data for large scale problems which are already stored in existing systems. Finally, a subset of GDSS functionality can be provided as a web service.

GDSS is accessed through a main login page, where users

have to provide appropriate password. The system recognizes two roles: Facilitator and Member. Facilitator works on a full functional mode of the system, while group Members work on a mode presenting a subset of functionality. Facilitator initiates a new problem or selects to process an existing one. For a new problem, he defines the proposed parameters and informs group Members. For an existing problem, he can validate Members' input, and proceed to aggregation of preferences and classification of the training set.

Members, after logging into the GDSS, can select a problem and insert their preferences upon the proposed parameter set. Several graphs provide visualizations over the numeric parameters helping members' understanding on them.

After validation of members' input and aggregation of preferences, facilitator executes the classification algorithm using the appropriate functions from his menu, and informs members for the classification results for the final assessment phase (Fig. 2, Fig. 3, Fig.4).

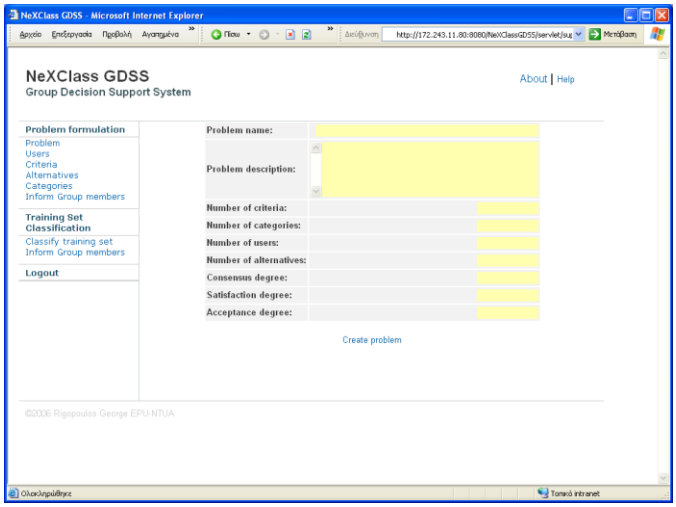

Fig. 2 Facilitator's mode for problem initiation

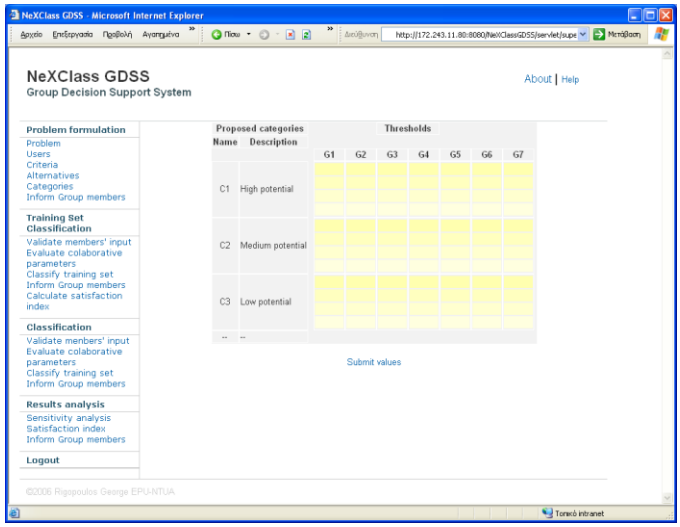

Fig. 3 Facilitator's mode for category thresholds definition

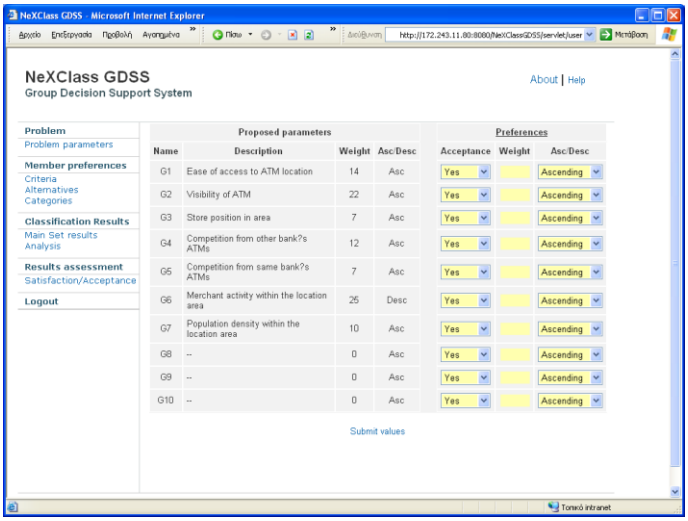

Fig. 4 Member's mode for parameter definition on criteria

V. Conclusion

In this paper we presented the prototype for a web based Group Decision Support System for small collaborating teams based on web technology highlighting the methodology and the overall GDSS architecture and functionality. The GDSS is based on web technology in order to be easily integrated within existing business infrastructure. A layered approach was followed, implementing Service Oriented Architecture and a subset of the functionality of the GDSS is provided in terms of Web Services. The system has been tested and evaluated within banking environment, where it operates supporting mainly financial decisions. Empirical findings from GDSS application provide evidence that the methodology and the GDSS provide a valid approach for similar decision problems in business environment. We believe that this methodology and GDSS can be easily deployed to support group decisions in similar environments.

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Proposal of Model for Security Management Integrated System

Lukas Kralik, Roman Senkerik

***Abstract*—**Security passes through all management levels of the organization and must cover all areas of the organization activities and must affect the operation of security mechanisms. Currently the requirements for security are increasing and within large amounts of these requirements and their security-related obligations individual links and relations are fading. A number of activities are unnecessarily multiplied and repeated. Thus this issue makes (already expensive) security to be more expensive. The way out of this situation is the integration of security activities in order to eliminate duplication and create a comprehensive integrated security system.

***Keywords*—**security, security management, organizational structure, integrated security system.

I. Introduction

THE main purpose of the security system is to ensure the safety organization in all possible aspects. This system is characterized by dynamic and constant influence of a large amount of variable factors on the processes of this system. Basic and simultaneously the weakest elements of the security system is people (own or other employees), technology in the form of material resources, a network of organizational relationships in the form of regime measures and last but not least information.

In practice, we usually understand under the concept of company's security system correctly created security policies that are implemented into the daily running of the organization which making it as a foundation of functional safety and security management system of the company. Sufficiently secured organization's assets against damage or destruction are an essential element of security management. With regard to the increasing number of attacks on the organization's assets, it was necessary to establish a security system for the organization [1].

Such a system is designed to help faster and more efficiently to focus on individual sectors of safety and security with regard to safety and security aspects, which are essential for the organization. Underestimating security system leads to serious disruption of the daily operations of the company. The consequences can be serious for the company and its management. The company's security management system given by means of the set of objectives, strategies and policies hierarchically allocates the area of security solutions from the corporate level to the individual protected areas (for example human resources, information security, etc...). An extension of security system represents the security policy. Two parts create the security system. The first part consists of operational and technological security and the second part is the classic security [2].

The security measures of information, physical and human resource security pass through both of these parts. Security of human resources represents the basis of the security system of the organization, since it includes the human factor issues and the process of security consciousness, which means accountability and shared responsibility for security. The problem at present is how to rationally and effectively manage elements of the security system.

Currently the usage of modern approaches, decision support systems (for example based on ITIL framework) [3] - [6] are the main open tasks in the integrated company security systems, together with the development of more robust and effective systems dealing with the information security [7], [8].

II. Evaluation of the Current Organization's Approach to Security Management

The quantity and diversity of laws, regulations, technical standards and methodologies together with the extension of the security field causes lose relations and links between individual areas of security. Security takes many forms for different protected systems. As a result, it leads to the fact that there are fragmented objectives, resources, and practices in the field of security, which lowers the security standard. Duplicity, disunited terminology and uncovered spaces are result of the low integration of security processes within their companies. Activities associated with the security management of the company are carried out separately within each functional department, which leads to inefficiency. Various experts ensure lot of activities, which are similar or identical. This fact causes that expensive security is even more expensive than it is necessary (See Fig.1).

Security sectors that in the opinion of company management pass through the entire company and require

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unified management are entrusted to the security department. Other security areas are entrusted to the individual organizational units. In many companies, this disunity affects the main (top) management from the perspective of the organizational integration of individual departments dealing with security issues, and also from the perspective of communication and cooperation between these departments and their managers. This approach to security management brings another problem, which is disunity of used terminology.

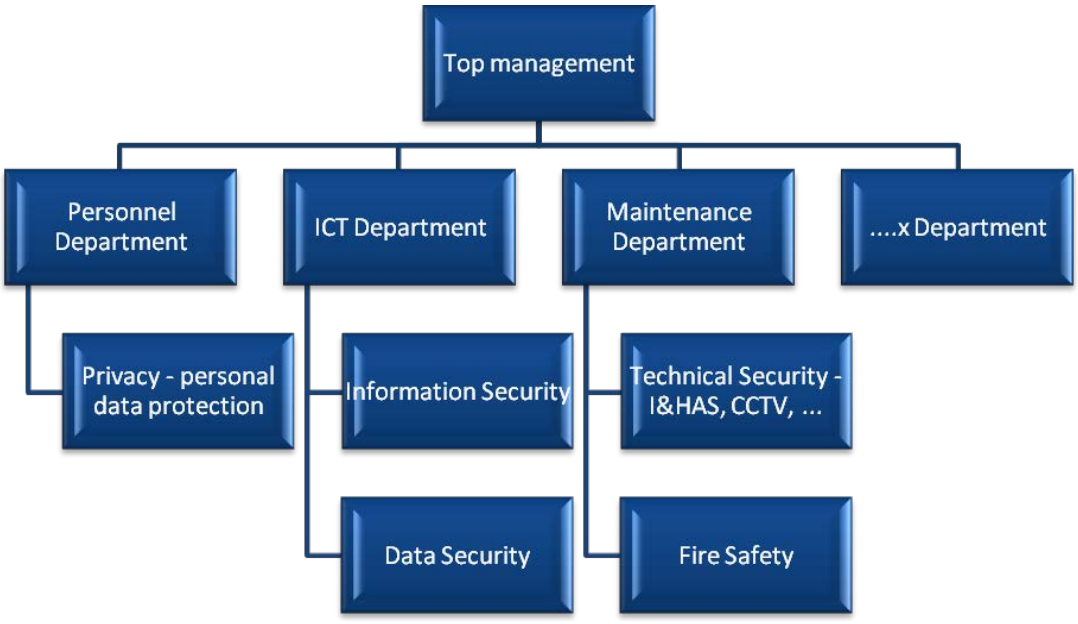

Fig. 1 Separate security management in company

Fundamental flaws in companies' approach to security management are:

- Separate management of individual security areas, which entails:
  - Fragmentation of objectives, resources, procedures that are related to security.
  - Duplication of activities.
  - Inconsistencies within terminology.
  - Inconsistent methodology.
  - Insufficient coordination and cooperation of management associated with the low integration of management processes in security areas.
  - Fragmentation in security management.
  - Decreased ability to respond to security abnormal situations.
  - Higher security costs.
- Absence of comprehensive legislation, which clearly define the individual security areas.
- Absence of legislation defining the type and method of maintaining security documentation for all security areas.

III. A Comprehensive Approach to the Process of Establishing Security

The objective of the comprehensive approach to the process of establishing security is not to have the best possible security. But to have set a combination of security measures, which cover the main threats and reduce risks to an acceptable minimum. A comprehensive approach to the process of establishing security is a way to minimize mentioned consequences of separate solutions, especially of separate security management for individual security areas [3] - [6].

It is very important for this procedure not to place too much emphasis on one element of security solution that would be at the expense of other security elements. For a comprehensive approach to the process of establishing security it is necessary to ensure that the solution is always balanced and solid. At the same time, security costs must be proportionate to the value of the protected assets or the level of risk. This is because investments in security are rightfully increasing, and therefore they need to be properly, functionally and efficiently spent.

Security passes through whole company and must be correctly managed. Its underestimation may cause serious damage to the company's functionality. Therefore, it is necessary that the decision to establishing security are based on the decision of the top management that wants to deal with security and mainly on the decision about correct approaches. Top management of company must make decision what they expect from security, how will be the security management implemented, how to evaluate current level of security in company and how will be formulated the future development of security management in company. This activity does not provide at first sight concrete results. There is no immediate visible result and usually does not noticeable any significant improvement in company's performance. Vice versa, often in

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establishing security, for example the risk analysis, so the disorders in company are shown. In addition, some steps in establishing security may work of company rather slow down.

The expected benefits of a comprehensive approach to the process of establishing security of company are:

- Consistency of management and security processes;
- Consistency of control, security and crisis documents;
- Lower the cost of implementing security in comparison with individual solutions,
- Creation of united methodological environment,
- Integrated documentation system of company's processes.

A. Integrated Security Management System

The result of a comprehensive approach to establishing security is an integrated security management system. Integrated security management system is a set of leadership skills, organizational structures and processes which objective is security of company. The main prerequisite for the success of organizational structures and processes is effective communication between all stakeholders and based on constructive relationships, united terminology and shared support of defined objectives. Top management of company must make decision what they expect from security how will be security management implemented, how evaluate current level of security in company and how will be formulated future development of security management in company. Company must establish responsibility for security as a separate part of management. Security should not be part of other roles that lack the powers, responsibilities and resources to enforce it. Integrated security management system organization must implement the basic relationships between the different areas of security. Process of security management must be perceived as a solution of complex problem in which it is necessary to manage not only the security of company as a complex, but also its each aspect.

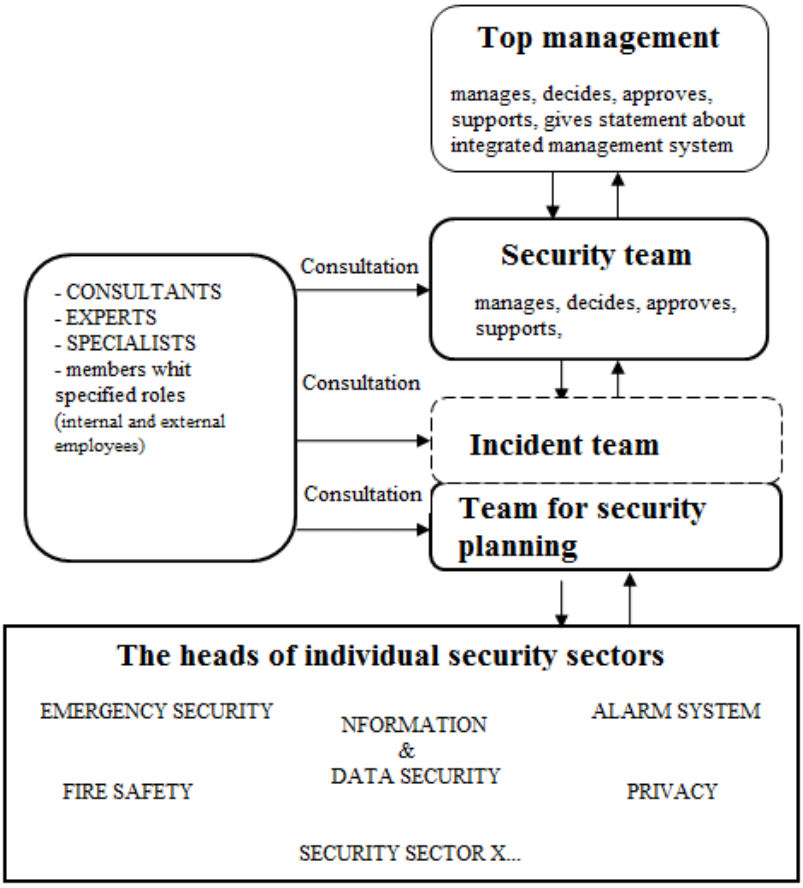

Fig. 2 Relations and responsibility in the organizational structure

B. Model of integrated security management system from the perspective of the organizational structure

The mostly utilized current approach for security management, which is characterized by separate management of individual securities, does not allow implementing the model of integrated security management system. Figure 2 shows a proposal of model that demonstrate the basic components of an integrated security management system from the perspective of organizational structure, including the

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responsibility for their implementation and mutual relations. In the context of establishing of an integrated security management system in the company, there must appear new units in the organizational structure. Names of organizational structures and departments are not essential. What are important: their job; responsibilities and competence in design, implementation and operation of an integrated security management system.

Security team is responsible for managing the assets of the company. A condition would be that members should have sufficient experiences in the security management area and be able to issue and manage tasks and some of them have to directly perform. It would be a top unit of the company in issues of security management, which should provide conditions for:

- Risk analysis.
- To develop a plan for the creation and approval of documents in connection with the security management system.
- Be responsible for the content of the documents and provide their approval by top management.
- To solve problems, which arise in the context of an integrated security management system and has crossed the framework of competencies for security planning team.

The team should be build by internal employees. And the head of this team should be known as a security manager. Team size would depend on the size of company and the nature of the production program.

The team for security planning should be a specialized team that would be responsible for the provision and implementation of security management system in company. Its members must have qualified information and knowledge about the company's assets and their protection. The task of this team is assessing different aspects regarding the protection of assets and resolve conflicts that might arise between organizational units of the different security sectors. The head of this team is the same person as for security team - the security manager. The main condition for the functioning of team for security planning is fact that all the heads of each security sector must be on the same management level to promptly and competently respond to arising problems.

Incident team is only temporary team that will be used only for solving of security incident. Team members must be experienced employees in security sectors and there must be represented all security sectors. One of team member must be the head of department, where the incident occurred. Afterwards, depending on the nature of the incident, another team member will be an expert on specific problem. And last but not least, members of the team will be heads of departments that are affected by incident. Such an incident team will be appointed by main (top) security team. The head of this team can become a person of top management however it is depending on the nature of the incident. Furthermore for the direct solving of the incident, an external specialist or consultant should be used. Nevertheless such procedure should be realized only in cases, when the incident danger grows or has already arisen into a crisis situation.

IV. Conclusion

This paper represents the complex overview current mostly used approach for company's security systems. Furthermore it presents the proposal of complex integrated security model. Model of integrated security management system from the perspective of organizational structure is based on:

- Classification of responsibility for security to the level of top management of company.
- Allocation of responsibility for the security and secure its support.
- To ensure the effectiveness of integrated security management system in the form of its control and approval.
- To create a new organizational unit - security department.

Model of integrated security management system from the perspective of organizational structure will allow interaction between the individual security sectors as well as risks management based on indicators for reducing the impact of any threats to an acceptable level and optimize investment in security.

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Computer based BIA method in preschool education

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Abstract—The study was conducted on a sample of 110 preschool children divided into two subgroups: 60 boys and 50 girls aged 6.23 years. Morphological characteristics and body composition were measured of. Ex post facto research draft was applied. By applying multivariate (MANOVA) and univariate (ANOVA) analyzes of variance statistically significant differences between respondents' groups were found. Individual differences manifested in variables: *Body Height, Intracellular Water Mass, Extracellular Water Mass, Protein Mass* in favor of the boys, and variables *Mineral Mass* in favor of the girls. Linear regression analysis found no significant correlation of the predictor system with the BMI (body mass index) criteria in both sexes. The results suggest that there are no major changes in the structure of body composition in either of sexes; however, it is different in comparison to a previous year. Children are of a similar nutritional status and no significant changes in the assessment of body fat were noted, while larger differences and variability can be expected in the pre-pubertal period. Continuous monitoring of body composition and mass at this age is proposed.

Key words—Anthropomenria, body composition, methods of BIA, preschool children.

I. Introduction

Lack of movement (hypokinesias) in children continues to occupy attention of scientific community, due to which intense need for monitoring of obesity and the inclusion of a large number of children in different forms of kinesiology activity has appeared [1]. Today, the movement of humans is studied in all its forms and mutual relations as well as relations with all other forms of human existence and activity [2]. Kinesiology stimuli in children caused by a variety of influences trigger changes in parts or whole anthropology status, which is consistent with the theory of integral development in kinesiology [3], starting with the initial transit through to the final state.

There are different approaches to defining and comparing body composition in children, as well as the structure of a morphological status. New technologies in the field of kinesiology are used to find more efficient and faster means to solve the existing problems [4]. Recent research shows that the standard anthropometric methods to define the morphological types are still used with some 33%, and the method of *BIA* (Bioelectrical impedance) with 25% of the total methods used [6]. It was found that anthropometric methods by Mateigka and *BIA* methods do not make a significant difference in the assessment of adipose tissue. It is in most cases justified the older sample of subjects. The best indicators of the physical condition of the population, and to some extent the child growth and development are height / weight ratios used to calculate BMI (body weight (kg) / body height (m^2)). It was found that the assessment of *BMI* (Body mass index) in children showed good results with high accuracy when used on a large sample of subjects [9]. Accumulation of adipose tissue in humans depends on hormones and demonstrates the role of gender. In females, relatively more fat is built up than in males. The ratio of fat and muscle in women is 28: 39% and in men 18: 42% [10].

Age characteristics of preschool children are (plastic) skeleton subjected to various distortions. This is another reason why the assessment and measurement, as well as planning kinesiology activities should be treated by professionals in preschool institutions. Children's muscles when compared to muscles of adult humans develop poorly and are small in weight as compared to the overall weight of the body, and also in relation to the internal organs. It was found to be 27% of total body weight while among adult men it was 42-44%. Muscle fibers in children are thin and the percentage of water content in them is higher than in adults, they develop poorly and gradually. Firstly the muscles of the major muscle groups are being develop and, later, the smaller ones. By the character the muscular work can be dynamically characterized by alternating flexion and extension, which is accompanied by changes in the joints and static which is characterized by a more or less continuous muscle groups effort. Knowledge of the respiratory system in children is undeniably needed for organizational modeling of kinesiology activities. Compared to adults, children have a reduced respiratory frequency of 22-24 times per minute, and adults 16-18 times a minute. The heart and blood vessels of a healthy child are in a favorable affiliation towards the body. Heart is not burdened by hard work or difficult excitement, and saved from harmful influences (smoking, alcohol, etc..), it operates without any difficulty and precisely. Bone mass acquired during childhood is a key determinant of bone health in later life. Physical activity, especially one that is focused and well monitored, represents an important anabolic stimulus. The greatest load, in relation to the skeleton, is created by muscle contractions. Bone adapts to the referred load to maintain their structural and functional roles [7].

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Body composition and constitution represents the clearest characteristic of a man. In adults, it represents an environmental behavior, sports, success but also illness. Defining the physical constitution of children is quite a heavy problem, because they do not yet have a stable reference features, especially girls. When attempting to define the physical constitution of children special attention should be paid to gender differences in the distribution of body constitution, changes in somatic type, as well as the stability of individual's body constitution during the growth and development of children [8]. Besides the differences that accompany the individual systems, there are also differences in the intensity of growth during childhood and adolescence. The fastest growing age is between 1 and 3, and at the beginning of puberty. Adipose tissue is increased by cell proliferation in IX-XII months, and from the age of 12 until adolescence and beyond this period, the fat tissue is increased only by increasing the mass of adipose tissue cells. Therefore, these periods are critical for the subsequent development of obesity in adult men.

Morphological characteristics of children are increased with the growth and development of the body. Boys and girls at the age of 3.5, 5 and 6.5 years differ in height, and the boys are slightly higher [7]. Similar accounts stated by indicate that boys of preschool age in addition to being taller, have larger volumes of the upper arm and forearm. There was no statistically significant difference in terms of semi-annual increment of height between boys and girls. In terms of body weight differences between boys and girls have been found at the pre-school age where boys have a slightly higher body mass [9]. No statistically significant differences in constitution of body composition were noted in pre-school children born prematurely. Recent research on the territory of Belgrade indicates high levels of underweight children in kindergartens as many as 31.76%, while the percentage of obese children in kindergarten was about 13.54%. The classification was based on the distribution of *BMI* in both sexes [10].

Given that contemporary lifestyle is extremely fast changing and a subject to various alterations emerging from external environment, the aim of the study was to find, by application of the *BIA* (Bioelectrical impedance) methods a statistically significant differences in the body structure in preschool children of different sex from Belgrade and to determine the relationship between the structure of body composition and their nutritional status. This would provide an important purpose for new and distinctly faster methods of assessment of body composition and facilitate monitoring and programming of special forms of kinesiology treatments aimed primarily at reducing the value of *BMI*.

II. RESEARCH DESIG

The sample consisted of 110 children aged 6.23 years, divided into two homogeneous subsamples of 60 boys and 50 girls who, at the time of measuring the structure of body composition, were attending The 11th of April Preschool in Novi Beograd. The sample was derived from a population of preschool children random method of sampling, i.e. *Quota sample*. This type of sampling is professionally and scientifically justified when investigating a mass phenomenon. Prior to measuring commencement the homogenization of groups (samples) was performed, therefore, the planned quota sample survey can provide very good results and external validity of the study (generalization) 7]. In the study we used the Non-experimental research design i.e. *ex post facto draft*, given that for the research purpose it was necessary to analyze the connection between the independent and dependent variables, and the direct control over them was not provided. Before carrying out the survey parents of children were given the questionnaire containing the plan and course of the study, and they were also asked for written consent to conduct research on their children (Declaration of Helsinki for Biomedical Research, 1975). The measuring was conducted in May 2013.

Basic anthropometric measures were selected as a sample of measuring instruments:

I Longitudinal dimensionality of the skeleton:

1) *Body height* (0.1 cm)

II Volume and body mass

1) *Body weight* (0.1 kg)

Based on the values of body height and weight variables *BMI* (Body Mass Index) was calculated by the following formula:

$$\mathrm{BMI} = \frac{\mathrm{BW(kg)}}{\mathrm{BH(m^2)}}$$

Sample of measuring instruments for the assessment of body composition consisted of the following variables:

III Body composition:

1) *Total Muscle Mass* (0.1 kg),
2) *Total Fat Mass* (0.1 kg),
3) *Total Body Water* (0.1 kg),
4) *Intracellular Water Mass* (0.1 kg),
5) *Extracellular Water Mass* (0.1 kg),
6) *Protein Mass* (0.1 kg),
7) *Mineral Mass* (0.1 kg), and
8) *Fat Free Mass* (0.1 kg).

In measuring longitudinal dimensionality of the skeleton, we adhere to certain standards (the IBP standards):

1) The standard standing position of respondents (barefoot in their underwear, head to Frankfort horizontal position)
2) Defined parameter,
3) Measuring instrument (Anthropometer by Martin)
4) Accuracy (0,1 cm),
5) Measurement techniques.

In accordance with the research tasks technical conditions and setting for achieving precise and accurate results were to be achieved as part of the organization of measuring of morphological features.

1) measurement of anthropometric measures performed in the morning (7 am to 13 pm);

2) instrument was standard and calibrated daily before the commencement and during the measurement process after its application on 10 individual subjects;

3) subjects were measured in the halls where participants perform physical education activities. Room was spacious

enough and well lit, and the air temperature allowed the subjects to feel comfortable (17 ° C to 22 ° C);

4) before the start of measuring it was necessary to set two measuring posts. The distance between the posts had to be at least 5 meters;

5) all measurements were performed by four Recording administrators, each of whom always carried out the same task;

6) subjects who were measured had to be minimally dressed, barefoot and wearing only the sports shorts;

7) for the purpose of control the measuring results were read out loud and repeated by the person recording the data before entering the details in a subject's card while the measuring instrument was being used on a subject.

Determination of the structure of body composition was performed by the Inbody 230 apparatus, which operates on the basis of bioelectrical impedance (BIA). The BIA analysis is a quick, non-invasive method for the evaluation of body composition in both field and clinical settings. This method estimates the structure of the composition of the body issuing low, safe doses of current (800 micro amps) through the human body. The stream passes through the body without resistance through the muscles, while adipose tissue producing resistance when the current passes through such type of tissue. This resistance is called bioelectrical impedance and is measured by devices that assess body composition. A double-energy X-ray absorptiometry (Eng. Dual Energy X-ray Absortptiometry-DEXA) operates in such a way that the X-rays of different energies are directed towards the body. The differences in the absorption of various energy X-rays are used to calculate the presence of minerals in the bone, as well as to calculate the composition of the soft tissue that surrounds it. It has become the reference method in body composition research studies. When compared to DEXA In Body (Biospace Co., Ltd., Seoul, Korea) has proved to provide very accurate (r = 0.974) results.

Statistical analysis included the calculation of basic descriptive statistics: the arithmetic mean as a measure of central tendency (M), and the standard deviation as a measure of variability (SD). For determining statistically significant differences in the overall status of body composition between groups of respondents the multivariate (MANOVA) analysis of variance was used, a single statistically significant difference was tested by univariate (ANOVA) analysis of variance. linear regression analyses was applied to analyze relationships between sets of variables for assessing body composition system as a predictor variable and variables for assessing the nutritional status as a criteria variable.

III. INTERPRETING THE RESULTS

Table 1 shows the values of descriptive statistics of the tested variables, and multivariate and univariate differences for both sexes, all at the conclusion p> 0.001. Based on Wilks F test in Table 1 it can be concluded that there exists statistically significant difference between boys and girls in the entire tested area of body composition. Individual differences were found in the variables: *Body Height*, *Intracellular Water Mass*, *Extracellular Water Mass* in variables *Protein Mass* in favor of the boys, while girls achieved higher and statistically significant values in variables *Mineral Mass*. No significant deviations with respect to the normality of data distribution were found, as evidenced by values of means and standard deviations.

Table 1. DESCRIPTIVE STATISTICS AND DIFFERENCES

	Boys N(60)		Girls N(50)			
Variable	M	SD	M	SD	f	p
BH	1233.6	41.98	1196.5	50.83	17.59	**0.000**
BW	245.20	26.66	254.46	39.47	2.13	0.147
BMI	19.87	2.01	20.86	2.59	5.05	0.027
TMM	11.85	2.04	11.17	2,309	2.65	0.106
TFM	5.81	2.43	4.90	2.35	1.41	0.236
TBW	17.28	2.50	16.27	2.77	4.04	0.047
IWM	10.11	1.36	9.31	1.16	10.64	**0.001**
EWM	6.30	0.85	5.74	0.76	12.96	**0.000**
PM	4.39	0.58	3.99	0.55	13.79	**0.000**
MM	1.53	0.23	1.71	0.21	17.68	**0.000**
FFM	22.32	2.98	22.64	2.33	0.36	0.545
F=27,882; P=**0,000**						

Legend: M – arithmetic mean; S – standard deviation; f – univariate f test; p – level of the f test statistical significance; F – multivariate Wilks F test; P –multivariate F test statistical significance.

Table 2 and 3 show the values of the linear regression analysis of body composition with body mass index (BMI) in both sexes at the conclusion p> 0.001.

Table 2. REGRESSION ANALYSIS OF BOYS *Body mass index*

Variable	rpart.	t	Beta	pbeta
Total Muscle Mass	-0.055	-0.508	-0.592	0.614
Total Fat Mass	-0.302	-2.549	-0.406	**0.014**
Total Body Water	-0.066	0.609	0.726	0.545
Intracellular Water Mass	0.240	0.662	3.565	0.511
Extracellular Water Mass	0.236	1.180	3.202	0.244
Protein Mass	0.183	-0.503	-0.189	0.617
Mineral Mass	0.169	0.184	0.153	0.855
Fat Free Mass	0.234	-0.796	-6.466	0.429
	R=0.440; R^2=0.194			
	F=1.533; P=0.169			

Key: rpart. - partial correlation coefficient; t - value of t -test; Beta - standardized regression coefficients; pbeta - the level of statistical significance of the regression Beta coefficient; R - coefficient of multiple correlation; R^2 - determination coefficient; F - value of F ratio ; P - multiple correlation coefficient statistical significance.

Table 3. REGRESSION ANALYSIS OF GIRLS *Body mass index*

Variable	rpart.	t	Beta	pbeta
Total Muscle Mass	0.046	0.019	0.004	0.985

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Total Fat Mass	-0.252	-2.741	-0.569	**0.009**
Total Body Water	0.035	1.954	0.520	0.058
Intracellular Water Mass	-0.011	0.621	0.211	0.538
Extracellular Water Mass	-0.124	-0.463	-0.136	0.646
Protein Mass	0.139	0.574	0.091	0.569
Mineral Mass	-0.114	-0.392	-0.158	0.697
Fat Free Mass	-0.149	-1.797	-0.278	0.080
		R=0.498;	R^2=0.248	
		F=1.694;	P=0.129	

Key: rpart. - partial correlation coefficient; t - value of t -test; Beta - standardized regression coefficients; pbeta - the level of statistical significance of the regression Beta coefficient; R - coefficient of multiple correlation; R^2 - determination coefficient; F - value of F ratio ; P - multiple correlation coefficient statistical significance.

Based on the results of linear regression analysis of body composition with the criterion (BMI), it can be concluded that the system of predictors in both girls and in boys did not achieve a statistically significant correlation with the results of the *Body Mass Index* variable. the low value of the coefficient of multiple correlation in both sexes were achieved, and adjusted coefficient of determination in boys is also generally small and explains for only 19.4%, while in girls it is almost 30% of the common variance. It can be assumed that this occured because the predictors system is composed of only eight variables for assessing body composition, and responsible for the remaining variability are other features and capabilities of the anthropological status in girls and boys. Based on the standardized regression coefficient Beta and their statistical significance, the negative correlation of *Total Fat Mass* variable on the results achieved in the BMI variables in both sexes may be noted. It can also be verified by inspecting the partial correlation coefficient, which, after splitting the influence of other variables, has achieved the highest negative correlation in both sexes. Since the whole predictor system in both sexes had a statistically significant effect on the criterion, these findings can not be perceived as justified.

IV. CONCLUSIONS

Analyzing the results of the preschool age boys and girls body composition a certain differences can be noted, a differences generated in the longitudinal dimensionality of the skeleton and the variables assessing the total amount of water in and out of the body cells in favor of the boys. To obtain individual reference values laboratory and clinical research are needed. Under no circumstances reduced values in girls can be ascertain, but it is necessary to indicate the importance of these fluids in children. The reduced values in the extracellular fluid generate higher osmosis of intracellular fluid, and water to enter the cell and restore the balance. This phenomenon in children may result in a variety of conditions of the CNS manifested by anorexia, vomiting, drowsiness, confusion, headache. Boys in comparison with their counterparts, have higher values of the total amount of protein mass in the body. Some experts believe that proper diet regime should contain a large amount of protein. However, the proposed daily amount of protein in the last decade has been reduced. Twenty or thirty years ago 1 gram of protein per day per kilogram of body weight was advised to adults, with many recommending 1.2 and even 1.5 g / kg of weight per day. According to facts from the World Health Organization Diet study, 0.75 g / kg of weight per day is enough for an adult (56 g for a man or woman of 70 kg). Today we know that excessive amounts of protein in children is closely associated with rheumatic diseases, osteoporosis, elevated uric acid in the later period. Accordingly, the diet quality is not dependent, as is taught, and on the protein amount and origin, but the use of a variety of healthy ingredients. Given that, until recently, proteins were a parameter used to assess the quality of diet which was thought to be much better if it encouraged more growth. Foods rich in protein and calories, given to children in developed countries that affect increased rapid growth may lead to serious consequences in adolescence and later in life: obesity, increased risk of getting diabetes and atherosclerosis. The USA experience shows that parallel with the increase of overweight prevalence the overweight children tend to face more difficult levels of obesity [11]. It is obvious that the girls at this age have not yet entered the phase of rapid growth, but higher value of the total amount of body minerals in girls and reduced value of extra-and intracellular fluid may indicate differences in hormonal status between sexes. The organism has eight main endocrine glands which secrete chemicals referred to as hormone, and they are transferred by the extracellular fluid into all parts of the body and thus help regulation of body functions. Minerals are integral parts of many enzymes important for regulating mechanisms. Their role may be as essential as the role of other essential ingredients: amino acids, fatty acids, vitamins. They play a major role in the contraction of muscle cells, bones and teeth in children (e.g. Calcium). They are also important elements for the formation of the normal muscle (phosphorus), and if not present in the diet may lead to the loss of muscle mass. Decreased amounts of magnesium may result in an increase in the neuromuscular irritability, and enhance mental disorders. The outcome of the study regarding the sex differences in body composition are consistent with the findings of Martinovića (Martinović) et al. [12] conducted in the same age-sample. Differences were recorded in the same variables indicating the presence of influence of various external factors, lifestyle, nutritional status and quality, the impact of parents' socioeconomic status, other dimensions of anthropological space for children, but also, particularly stressed by the authors, the importance of monitoring. When it comes to body weight, and body mass index no major discrepancies have been noted. The research results indicate that level of nutrition in both boys and girls is satisfactory and the essential differences between them were not observed. These findings are consistent with quantitative research on preschool children conducted by Bala (Bala) [7]. Recent research of Stem (Stamm) et al. [13] indicate that there are gender differences in the height/weight ratio, that trend is

growing trend and more common in high school children then in younger children. Although preschool in terms of growth and development can be defined as a very heterogeneous with uneven levels of development authors Kosinac et al. obtained opposite findings.

Results obtained by relations of body composition and nutritional status (*BMI*) in boys and girls were not significantly related. The only negative correlation was found in variable *Total Amount of Body Fat* in both sexes, as might be expected, but since body composition predictor variables system was not significantly associated with the criterion it remains to be assumed that the other features and capabilities of the anthropological status had a greater impact. Authors Šević et al. suggest that Body Mass Index as a measure of nutritional status in terms of the share of fat and muscle component is the one that determines the overall health risk, but it also means that in addition to *BMI* it is necessary to involve other methods for assessing body composition [14]. On the other side authors Zenić et al. [15] recommended a nonlinear regression model for determining the relation with the criteria and they find it more efficient for identifying possible breakpoints in the line of regression.

The authors suggest that continual monitoring of anthropological dimension state of preschool children is needed, and that body composition should be monitored using Bioelectrical impedance methods to enable planning and changing of programmed transformation process in kinesiology activities according to the needs and requirements.

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A Study on Ontologies and their Classification

Thabet Slimani

Abstract— During the last decade, the use of ontology in distributed environments (Web) is useful to enable semantic management of information and knowledge sharing. Given that the objective of an ontology is to capture generic and formal knowledge, used and shared across applications and by groups of people, it is important to know their classes or families which help their content understanding. In this paper, after a general introduction about the basis of ontologies and its modularization, we present ontology classes which represent an important issue in semantic web.

***Keywords*—**Ontologies, ontology classes, ontology families, ontology languages, ontology modularization, semantic web.

I. Introduction

RECENTLY, the word ‘‘ontology’’ has become a stylish word within the Knowledge Engineering discipline. Several definitions about ontology have been presented in many papers. Also, we have seen how such definitions have modified and evolved over the time. At least, an ontology allows a machine-understandable semantics of data, and make easy the search, exchange, and integration of knowledge. Which facilitate the use of e-technology.

The following section presents two different definitions of Ontologies:

- In computer science, an ontology is an attempt to make a complete and rigorous conceptual schema within a specified domain. Typically, an ontology is a hierarchical data structure including all the significant elements and their relationships and regulations within the domain [1].
- In AI field, an ontology is an explicit specification of a conceptualization [2, 3]. In such an ontology, the universe of discourse is concept names (e.g. classes, relations, axioms) accompanied with a description of what the concepts mean, and their formal axioms.

Although the use of ontologies suggests a concrete approach to build sharable knowledge bases, it also raises questions that need answers, such as:

- Which are the different ontology families?
- What is the objective for using an ontology in an application?
- Which approach can be used to build an ontology?

Several types of ontologies have been enumerated in academia. Depending on context, the word “ontology” can designate different computer science objects. For example, an ontology has a distinguished naming which depends on the domain:

- in the field information retrieval is named thesaurus
- in the field of linked data is a model represented by OWL format
- in the field of databases is an XML schema
- etc.

However, to perform a study clarifying the different forms of ontologies to help their content understanding is an important issue. Additionally, it is important to define precisely the vocabulary derived from the word ontology. For example, what is the difference between a domain ontology and a task ontology?

First, we introduce the modularization of ontologies. Second, we present the different types or families of ontologies.

II. Ontologies: definitions and Modularization

The word ontology is employed in the field of AI research, as it is useful to make the conceptualizations of a domain explicit which enables their comparison and analyzes. Gruber [2] defines an *ontology* as an explicit specification of a conceptualization. An ontology is a description of knowledge-level [4] where the representational formalism is independent [5]. Additionally, ontology is a representation of the entities type, their relations, and their constraints [4]. It consists of a set of classes, relations, instances, functions and axioms ordered hierarchically. Formally, ontology is a description of data that remains constant over various data/knowledge bases in a certain domain [6].

The differentiation between Ontologies based on their generality level can be presented in the classification presented by Guarino in [7] and showed in Figure 3. Ontologies can be classified according to the conceptualization subject (content). Very general things such as time, space, insubstantial or concrete objects, and so on can be covered by the *top-level Ontologies*, independent to the domain usage. The construction of either *domain* or *task* Ontologies can be done based on these top-level Ontologies. The first category includes Ontologies dedicated to cover a given domain (medical or university, for example) independently to the task that uses the ontology. The second category includes Ontologies specified for a generic mission (content annotation or situation recognition, for example) irrelevant of usage domain. In conclusion, the development of

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application Ontologies helps particular tasks to be solved within particular domains, and consequently often requires both domain and task Ontologies for reusability.

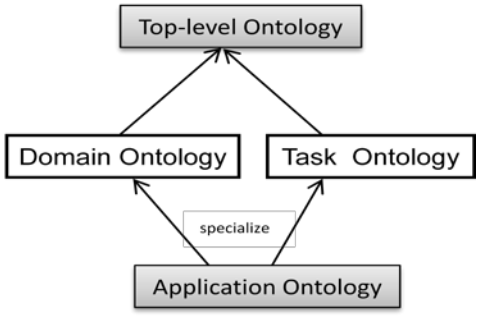

Figure 1. Guarino's ontology classification [7].

Ontology may be classified as follows, based on the scope of the ontology (see also Figure 1):

- Upper/top-level ontology: it describes general knowledge (i.e. what time is and what space is).
- Domain ontology: it describes the domain (medical domain, personal computer domain or electrical engineering domain).
- Task ontology: it is suitable for a specific task (assembling parts together).
- Application ontology: it is developed for a specific application (assembling personal computers).

Modularization can be used at each level. For instance, upper ontology could includes modules for real numbers, time, and space (parts of upper ontology, generally are called generic Ontologies). Upper levels Ontologies could be imported by Ontologies at lower levels and adding them specific knowledge. Domain and task Ontologies may be independent and are combined to be used for application ontology.

III. Ontology Families

The classification of Ontologies depends on several criteria. It is possible to make classification based on the ontology expressivity (language of representation) or the ontology components (concepts, instances, properties, axioms, etc. See Figure 2). Ontology components can be represented by specific Ontologies. For example, if we focus on concepts, as a key component of Ontologies, they can be represented by an ontology based on different behaviors:

- **Textual Definitions:** As instance it defines concept by a sentence ("University", "Person"….)
- **Properties set:** As instance the concept "University" has the property "name", "address" and "creation date".
- **Logical definition:** Constituted by several formula. For example, in Quran ontology, the Earth , Sun, and Moon are classified under "***Astronomical Body***":
- **Instance Set:** Constitutes a set of instance that belongs to a concept. For example, "firdous paradise" is an instance of "afterlife-location" concept of Quran ontology.

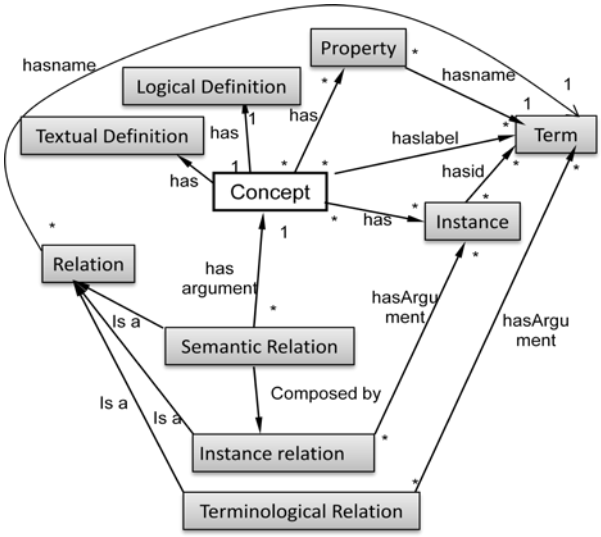

Figure 2. Ontology Depicting Ontology Components with their relationships.

Ontology components such as concepts (things, events…), instances and properties are represented by one or more symbols denoting terms rapidly understood and readable by humans. The connection between all these ontology components is realized through relations. Semantic relation is a connection that link only concepts together: for instance the location relationship indicates that student concept is enrolled in a university concept. The link that connects only instances is denoted by instance relations which are in turn instances of semantic relations. It is difficult to generalize the relation between all instances of their concept, because some relations between instances are contextual. As example of instance relation the student instance named "john" is enrolled in the university instance named "Stanford". An example of contextual instance relation can be that the professor instance named "Jeffry" is localized in the university instance named "Stanford". The relationship that terms can have is expressed by the terminological relations. For example the term "university" is synonym to the term "education".

According the type of structure and the amount of their use, Sowa [8] distinguishes two main categories: terminological (lexical) and axiomatized (formal).

The following sections present four categories of Ontologies (including the two categories presented in Sowa) corresponding to the usage of the previously described components. Each section describes the type of language used to define the ontology.

A. Informational Ontology

Informational Ontologies is a composition of diagrams and sketches utilized for the clarification and organization of collaborators project development ideas. These Ontologies can

be used only by humans can use these Ontologies. Informational Ontologies are characterized by the following behavior:

- Simply adjustable and scalable
- Artificial and schematic
- In general, they can be used at some point in the design process of a project: for instance, informational ontology can be employed during the information system conception phase of development project.

As shown in Figure 3, Bouattour et al. (2005) [9] propose a new set of concepts describing informational Ontologies used for architectural design. The constitution of the used information ontology is a set of objects, actors, activities and documents. During the cooperative process of design building, all these components are related and the architectural design state of the components presented in the informational ontology is guided by the decision process of each actor concerning this component.

Additionally, another example of informational ontology is described by Lee and McMeel [10] which concerns project construction.The informational Ontology is developed in order to facilitate the communication between the groups (including different actors) involved in the project construction. These proposed information Ontologies are accompanied by some general patterns that should be modified aiming to resolve the specific problem of project construction.

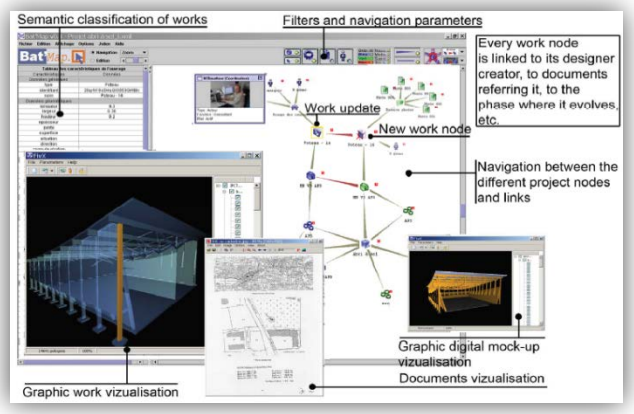

Figure 3. Informational ontology concerning architectural project ([10]).

The understanding of the language convention of each actor using the ontology element is the first step of problem solving. The second step includes negotiation and collaborative works preserved to find the appropriate solution of the project construction. The modification and the adaptability of this type of ontology have to be significant.

B. Terminological/Lexical Ontologies

If a specific ontology contains concepts and relations that are not fully accompanied by axioms and definitions determining the necessary and sufficient conditions of their use, this ontology is called lexical or terminological ontology. Linguistic Ontologies can be glossaries, taxonomies, dictionaries, folksonomies, controlled vocabularies, thesaurus, or lexical databases. A linguistic ontology concept can be referenced by different terms (computer, IT and computing are synonyms) determining the relative positions of the concepts with respect to one another and partially specified by relations (whole/ part or supertype/ subtype).

Linguistic Ontologies have double roles: Firstly, it aims to present and define the used vocabulary based on dictionary (for example including all the terms actually used in language). Secondly, linguistic ontology uses vocabulary normalization as a terminology agreement between a communities users defining the term used to represent a concept in order to prevent ambiguity. For instance, the normalization process selects one of those to be convenient label of the concept when a concept could be described by two synonym terms.

Three basic relationships among terms which characterizes thesaurus: specialization, hierarchical and associative. A “specialization” relation between two concepts is represented by relations like “part of” relation, for example. In hierarchical relation between terms the “instance of” relation between a concept and one of its instances can be hided. And finally, associative relation between two terms means the existence of a semantic link occurring between concepts labeled by these terms but this semantic link is not provided with any information.

The following section describes two languages used to describe this type of ontology: The first language named RDF is used for defining metadata, and the second language named SKOS is used to define thesaurus.

- **RDF:** short for “Resource Description Framework”. It is a graph model used to formally describe the Web resources and their metadata, to allow automatic processing of such descriptions. Additionally, RDF is a recommendation from the W3C intended for meta-data structures creating that defines data on the Web. RDF is implemented in XML and composed by Triples: (1) the subject representing a web page (a subject is a resource or anything that can have a Unique Resource Identifier (URI)) , (2) the property or predicate representing an attribute name (for example, the name “dc:enrolled” is used to represent the student property) and (3) the object representing the actual value of the web page attribute (an object can be a URI, a literal, a date, a noun etc. or a blank node).
- **SKOS:** short for Simple Knowledge Organization System. It is a Semantic Web initiative proposed by W3C with the aim to develop specifications and standards based on XML supporting the use of knowledge organization systems (KOS) (thesaurus, subject heading, classification schemes, and taxonomies, for more clarification see http://www.w3.org/2004/02/skos/intro).

Several examples of Thesaurus using SKOS and/or RDF are described in the following section:

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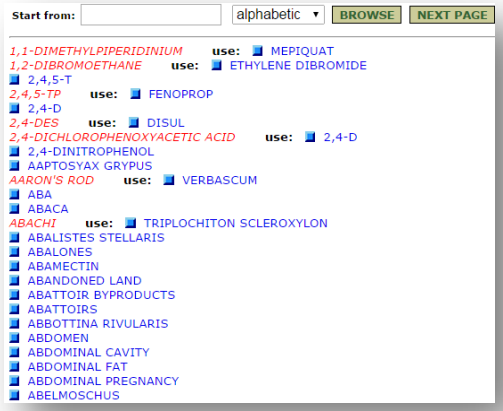

Figure 4. The theme list of AGROVOC - Multilingual Agricultural Thesaurus.

- **AGROVOC Thesaurus:** AGROVOC is a multilingual agricultural thesaurus designed to cover the terminology of all subject fields in agriculture and several other environmental domains (forestry, fisheries, environmental quality, pollution, etc.). The AGROVOC thesaurus is used to develop the Agricultural Ontology Service (AOS). As presented in (AGROVOC), it consists of descriptors (indexing terms consisting of one or more words) and numerous (10,758 in English) non-descriptors (synonyms or terms helping the user to find the appropriate descriptor(s)), available in different languages and controlled by relationships, used to identify or search resources. Fig.4 schematizes an example of theme list presented by AGROVOC.
- **HEREIN Thesaurus:** The HEREIN project is a European Heritage Network information system which focuses on cultural heritage, especially on architectural and on archaeological heritage. HEREIN is intended to gather governmental services in charge of heritage protection within Europe Council. The multilingual thesaurus related to the HEREIN project aims to offer a terminological standard for national policies that deals with architectural and archaeological heritage (for more clarification see http://www.european-heritage.net/sdx/herein/index.xsp).
- **GEMET Thesaurus:** short for General Multilingual Environmental Thesaurus and developed as an indexing, retrieval and control tool for the EEA. GEMET is the reference vocabulary of the European Environment Agency (EEA) and its Network (Eionet). Additionally, GEMET was designed as a "general" thesaurus, aiming to define a common general language, a foundation of environment general terminology. Several languages are used in GEMET (for more clarification see http://www.eionet.europa.eu/gemet).

Figure 5. The search interface of URBAMET.

- **URBAMET Thesaurus:** URBAMET is a bibliographic data bank designed for the French library. It covers thematic fields on urban development, housing and accommodation, town planning, public facilities, architecture, transport, local authorities etc. This data bank is created in 1986, and since this date the hierarchical organization of all these topics gave place to the construction of URBAMET thesaurus. The thesaurus is available in French, Spanish and English. The URBAMET application allows the search, display and circulation of these topics through the different tables. Regularly updated and revamped in 2001, today this thesaurus contains 4250 descriptors divided into 24 tables. Each descriptor belongs to a single semantic table and its acceptation arises from the position which he has been assigned in this organization. Fig.5 shows the interface presented by URBAMET thesaurus.

C. Axiomatized/Formal ontology

Guarine (1998)[11] proposes a classification dividing Ontologies into three classes: information, terminological, and knowledge modeling. Based on this classification, information Ontologies do the same with the databases structure (e.g., database schema), terminological Ontologies indicate the terms that are used for knowledge representation in the domain of discourse; and knowledge modeling Ontologies are adopted for knowledge conceptualizations specification. In a similar manner to this classification with the one proposed by Sowa [8], knowledge modeling Ontologies would fit into the axiomatized class, but information Ontologies would be positioned in the middle of knowledge and terminological Ontologies since they have a lot of of the features of the formal ones but they lack some central elements such as clearly defined is-a relationships.

However, formal Ontologies whose concepts and relations have associated axioms require a clear semantics for the language used to define the concept. The definitions in formal Ontologies are stated in logic or in some computer-oriented language, but require clear motivations of how to distinct

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between concepts and how to define strict rules of concepts and relationships. This is obtained by using first order logic or Description Logic (formal logic) where the meaning of the concept is ensured by formal semantics [12].

Different formal languages used to describe formal ontology can be enumerated: First Order Logic (FOL), Description Logics (DL), Conceptual Graphs (CG), etc. OWL is a standard language recommended by W3C. The following sections give two examples of OWL presentation of formal Ontologies belonging to architecture domain and pervasive environment.

OWL short for Web Ontology Language is a recommendation for W3C designed to be used by content information processing applications, instead of information presenting to human. OWL makes easy the interpretability of Web content by machines than that supported by RDF, XML, and RDF Schema (RDF-S) by offering additional vocabulary providing along with a formal semantics. OWL includes three increasingly-expressive sublanguages (See Fig.6):

- **OWL Lite:** is a simple sub-language of Owl intended for quick reasoning and programming simplicity that supports those users that need a classification hierarchy and simple constraint features. The expressiveness of OWL Lite is limited to classification hierarchy and a simple constraints functionalities 0 or 1 (functional relations) providing a quick migration path for thesauri and other taxonomies. For instance, a person has a single address, but may have one or more names; OWL Lite does not allow its representation.
- **OWL DL:** DL short fort for description logic. OWL DL has an increased expressiveness and supports those users who want the maximum expressiveness without to lose computational completeness (all inferences will be taken into account) and decidability (all calculations will be completed in a finite time) of reasoning systems. OWL DL includes all the constructs of OWL language with some restrictions such as type separation (a class cannot be an individual or a property, and a property cannot be an individual or class).

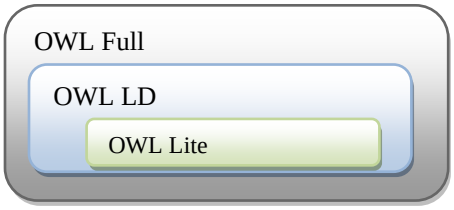

Figure 6. Expressivity of OWL Sub-languages (OWL Lite ⊆OWL DL⊆OWL Full).

- **OWL Full:** OWL Full is intended for users who want to increase expressiveness and the syntactic autonomy of RDF with no computational guarantees. OWL Full includes a full compatibility with RDF/RDFS. Additionally, in OWL Full the reasoning is often complex, slow, incomplete and unsolvable. For instance, OWL Full treat a class simultaneously as a collection of individuals and as an individual in its own right. An additional significant difference from OWL DL is that a owl:DatatypeProperty may be an owl:InverseFunctionalProperty. OWL Full permits an ontology to expand the meaning of the pre-defined (RDF or OWL) vocabulary.

The following section gives examples for some formal Ontologies:

- **Korean Architectural Domain Formal Ontology:** Kim (2005) [13] has initiated a Korean research project describing a formal ontology based in OWL and Protégé. To realize this project, the authors have been developed a prototype to help learn the History of the main Korean historical buildings.
- **CoBra Formal Ontology:** short for "Standard Ontology for Ubiquitous and Pervasive Applications". CoBra ontology is designed to facilitate the pervasive computing [14]. The ontology has been modeled in OWL to enable exchange and reasoning about knowledge. As application, an intelligent meeting room system on the campus of an university has been implemented by the authors. The ontology includes 17 classes and 32 properties definitions aiming to define some of the ordinary relationships and attributes associated with people, places and activities in an intelligent space. While a person enters into a conference room, he/she is marked as present by the system and his situational information (from heterogeneous sources such as the Web, corporate databases, etc.) is acquired by the system.
- **SOUPA Formal Ontology:** Short "for Standard Ontology for Ubiquitous and Pervasive Applications". The SOUPA ontology [Chen at al. 2004] is expressed using OWL language and presents a shared ontology combining many helpful vocabularies from different consensus Ontologies.

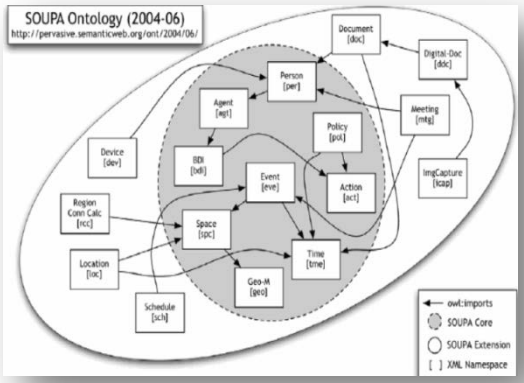

Figure 7. SOUPA Formal Ontology [14].

SOUPA includes intelligent agents represented by modular component vocabularies. Those agents are associated with beliefs, intentions, desire, time, space, events, actions, user profiles, and policies for security and privacy. SOUPA

contains two distinctive related set of Ontologies: SOUPA Core and SOUPA Extension. The SOUPA Core Ontologies set attempts to define generic vocabularies, while the SOUPA Extension Ontologies set define additional vocabularies that support specific types of applications and supply examples for defining new extensions of ontology (see Fig. 7).

- **CHIL Formal Ontology:** short for Computers in the Human Interaction Loop, CHIL Ontology [15] provides general-purpose vocabularies including a multi-sensor smart spaces and context-aware applications. In CHIL ontology, the inference is based on the notion of a network of situation states. According to this approach, the entities and their properties used to describe the environment defining a situation is considered as environment state description. Modifications to individual or relative properties of particular entities correspond to events that indicate a modification in the situation.
- **CONON Formal Ontology:** short for Context Ontology [16], CONON is based on ontology for reasoning and contexts representation. CONON is an ontology based OWL encoded context designed for context modeling in pervasive computing environments, and for logic-based context reasoning supporting. CONON includes an upper context ontology that captures general concepts about basic context (the context in each domain shares common concepts encouraging the reuse of general concepts), and also provides extensibility for domain-specific ontology adding in a hierarchical manner. Also, the defined upper ontology provides flexible interface helping the definition of application-specific knowledge (See Fig.8 representing a partial definition of CONON upper ontology).

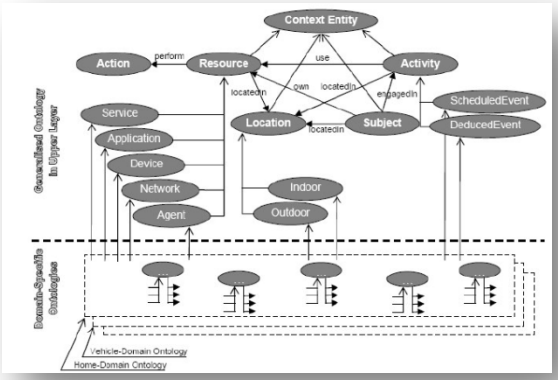

Figure 8. Partial definition of CONON upper ontology [16].

D. Software Ontologies

We denote by Software Ontologies a software implementation driven Ontologies designed to provide conceptual representation focusing on data storage and data manipulation, and that can be adopted for software development activities (guaranteeing data consistency). In software ontology, a concept contains a set of properties and concepts are related between them by the relations or properties they have. Some constraints are associated with these relations. Thus, data stored in the object properties (instance of concept) could be processed in various behavior (called methods). However, software Ontologies goal is not the particular description of instances during execution time, but, usually it is defined with conceptual modeling languages adopted in software and database engineering. These languages are used in software design stage: for instance Entity-Relationship Model language or Object Model Language. The following section presents the most recognized design language which called UML.

- **UML:** short for Unified Modeling Language, UML is a specification used essentially for modeling software and information systems. It is a graphical language used to visualize, specify and construct any component of software. The official document defining the semantics of UML is principally composed of informal descriptions in English [17], for that reason UML is a semi-formal ontology. Additionally, UML is not adequate to represent all the details required by complex reasoning processes [Cranefield 2001]. Several diagrams are provided by object diagram.
- **SWO**[1]**:** The Software Ontology (SWO) [18] aims to describe the software types used in Bioinformatics. It covers several areas: the manufacturer of the software, the software type, the input and output data types and the objectives of the software. The SWO intends to use BFO as an upper level ontolgoy and subclasses types from biomedical ontology.
- **DOAP:** short for Description Of A Project [19] describes a software project (home page, developers, language, etc.), rather than the software itself.

IV. Conclusion

Ontologies have been employed in several real world applications helping to improve the communication between agents or the reuse of data model or knowledge schema. However, without Ontologies (the heart of knowledge representation system), there cannot exist a vocabulary to represent a knowledge. Thus, several kinds of ontologies have been proposed and evolved incrementally. This paper has presented several ontology concepts and types. Moreover, it has described the core components of each kind of ontology. In addition, this paper has provided a great number of examples in order to facilitate the understanding of the different Ontologies uses.

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Malaysia dengue detection model using frequent outlier

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***Abstract*—** The goal of a health surveillance is to dwindle the possible consequence of an outbreak through the promptly and implement timely with appropriate interventions from the respective officials. A general behavior of surveillance is to detect any unusual or fluctuation in the dataset. While outbreaks can be defined as an increases case from normal distribution of disease cases in specific location over a period of time with detection of the source and cause of epidemic. The investigation methods for outbreak include sophisticated analysis, field investigations, and full of twist and turn laboratory techniques to investigate the source of disease. This is important to determine the outbreak spreading, method of spread and measurement for control on confirm or probable outbreaks. Technically on the sophisticated analysis, frequent pattern mining techniques normally use to retrieve frequent pattern, and be able to determine the fluctuation in dataset. Frequent pattern will be considered as the baseline creation for outbreak detection. Those frequent patterns will be run under the outlier analysis to get the potential outbreak. There are many techniques to detect outliers, for example outlier detection, novelty detection, anomaly detection, noise detection, deviation detection or exception detection is the common usage of outlier mining as reported in most literatur. In this paper we review data mining techniques focusing on frequent mining and outlier mining to be applied with generic outbreak detection model. The propose model using technique named "frequent-outlier" to detect outbreak. The model was tested against the real dengue dataset. The result were promising were be evaluated using detection rate, false positive rate and overall performance. We also manage to produce knowledge rules from the extracted of outbreak cases.

***Keywords*—** Outbreak, Dengue, frequent mining, outlier mining.

I. Introduction

WHAT is surveillance? Generally surveillance can be defined as a "process of monitoring behavior of people, objects or process within a system for conformity to expect or desire norms in trusted systems for security or social control". There are numbers of definition being used in defining surveillance. Generally, surveillance can be highlighted as reporting system which consists of collection, analysis and dissemination of information to authorities for decision making and further actions. This is not cutting edge to health but able to expanded over a various disease detections including food, environment and zoonotic (Ed. Lester Breslow. Gale Cengage 2002; McNabb et al. 2002; Bravata et al. 2004; Buehler et al. 2004; Ritzwoller et al. 2005). Generally the Center Disease Control (CDC) quotes surveillance as "collect and analyze morbidity, mortality and other relevant data and facilitate the timely disseminations of results to appropriate decision making" (CDC 2007). Reported in the systematic review (Bravata et al. 2004) are 115 surveillance systems available including 9 syndromic, 13 collecting Influenza Like Illness (ILI), 23 laboratories, and the rest are for zoonotic and animal, food-borne, hospital based infectious and clinical reporting. The author claims that some of the systems are possible to stretch out in accommodating both early detection and situational awareness.

The surveillance is an essential tool for public health decision making including dissemination of vaccination and identification of the potential of outbreak. Passive system and depending on practitioner's input or voluntary report are the main characteristic of the most surveillance system now a day. This include the rapid recognition of disease outbreak and offer historical as well as trend inside the data to be used as baseline comparisons and also for extensive monitoring. The direction of public health surveillance system is to allow the appropriate intervention by respective agency from government or bodies under government agency to be able to trim down the consequences of outbreaks. This will lead to the reduce of mortality, morbidity and economic effect through identification of outbreak as soon as possible. Quoted by (Pavlin et al. 2003) in the workshop, the surveillance system should be able to facilitate the rapid recognition of disease outbreak, improve data transmission and analysis speed, integrate with other surveillance systems at all government level and provide historical and trend data to be used in baseline comparisons and long-term monitoring. (Pavlin et al. 2003; Connolly 2005)

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Dengue outbreaks are one of the critical communicable diseases and becoming more serious in Malaysia. It was first reported that dengue outbreak in Malaysia was in 1901 in Penang, more than century ago. Since then, more dengue outbreak cases were reported with most of the cases occurred in urban district. Quoted from (Choy EA 2009), the dengue hemorrhagic fever (DHF) was initially detected in 1962 and has exponentially increased with the development of the country. Dengue fever (DF) and dengue hemorrhagic fever (DHF) persistent becoming a public health related issues in Malaysia and budding becoming pandemic as reported in World Health Organization (WHO) projected 50 million cases of dengue fevers with 500,000 people with DHF require hospitalization each year. The dengue outbreaks continue to increase not only in Malaysia but also in Thailand, Vietnam and Singapore. In Malaysia, there are 24 dengue hotspots and most of them are in Selangor as stated by Malaysia Health Minister during a press conference(Cruez 2009).

Surveillance for DF and DHF outbreak in Malaysia is based on Laboratory-based surveillance system. In many cases of DF and DHF, surveillance system addresses both a clinical and non-clinical perspective. In most cases, dengue surveillance system is considered as a passive system as it depends on case reported from physicians through the routine reporting system. In Malaysia, mandated by law under Seksyen 10(2) Akta 342, all communicable diseases must be reported to the Ministry of Health(Web site Seksyen Penyakit Berjangkit 2009). In order to permit action on DF and DHF or control epidemic dengue, a surveillance system must gather information either clinical or non-clinical data. The nature of passive surveillance system may not incorporate the capability to determine the potential of combination related non-clinical data in generating outbreak particularly in dengue cases. One of the ways to enhance early detection of the dengue outbreak is to look at the historical data from the passive surveillance system to identify the potential of collected attribution or data to be used for early detection of dengue outbreak. It possible to promote public health surveillance system particularly in Malaysia to control such epidemics and mitigate the impact to the nations.

The determinations of early detection of dengue outbreak or prediction of potential dengue outbreak are very limitedly discussed in literature. Outbreak determination is based on descriptive epidemiology across three main dimensions: time, place and people. Analyzing dengue outbreak is based on vector-borne diseases epidemic curve. The analyses were considered the increase, peak and decrease to determine the outbreak. Most of the studies focus on determining outbreak based on case counts over a period of time to predict the dengue outbreak. Therefore, in this study we focus on dengue outbreak predominantly in Malaysia using proposed technique named frequent-outlier based on proposed model.

II. Related Study

Related study focusing into two main domain; the first was on dengue background and the second as data mining technology as an solution potential for dengue outbreak.

A. Dengue background

Dengue fever (DF) and dengue hemorrhagic fever (DHF) are considers as endemic in tropical country and generally occurs for arthropod-borne viral disease. (Chen et al. 2006; Ooi et al. 2007) Reported dengue cases were increasing in Malaysia and becoming epidemic in most of ASEAN countries. World Health Organization (WHO) estimated 2.5 million are on risk while 50-100 million were infected and 500,000 were hospitalized.(Teng & Singh 2001; Guha-Sapir & Schimmer 2005; Lian et al. 2006; Osman et al. 2007; Runge-Ranzinger et al. 2008; J. A. Suaya 2010)

Dengue fever infected patient through the bite of an infective female Aedes mosquito (Aedes aegypti) with dengue virus (DENV) belongs to the genus Flavivirus and contains a positive-strand RNA genome that encodes 3 structural protein. DENV consists of 4 genetically and antigenically distinct serotypes,1-4. Dengue virus remains in patient for 3-14 day before showing the symptom. Patient may have mild fever, followed by unspecific symptom (WHO 1999; Seng et al. 2005; Lee et al. 2010) . DF and DHF is the acute febrile diseases cause by either from 4 types of serotype came from genus Flavirus , famili Flaviviridae which made each serotype different without cross protection. This might will lead to DF with multiple serotype (hyperendemicity) . All the serotype can be found in Malaysia. DENV-4 was appear in 1960 and DENV-1, DENV2 and DENV-3 are related in DF/DFH in Malaysia.(WHO 1999; Bakar & Shafee 2002; Osman et al. 2007; Lee et al. 2010)

Based on literature, indicate that most of the studies mention that public health surveillance especially for prevent and control measure. Information on current state of disease, cost, prevention measures and overall effect to the society are the main reason of public health surveillance.(Teutsch 1994; Rigau-Pérez et al. 1998; Ooi et al. 2007; Runge-Ranzinger et al. 2008; Ang et al. 2010) As indicated by (Ooi et al. 2007) surveillance for dengue consider as passive surveillance. Recent literature by (Ang et al. 2010), reported that dengue surveillance system in Malaysia being categories as good for DF surveillance, while for DFH as being rated very good but still under passive surveillance. On the other hand, dengue surveillance system also facing the problem in defining outbreak definition(Runge-Ranzinger et al. 2008). Table 1 below were adopted based on (Seng et al. 2005; Ooi et al. 2007; Runge-Ranzinger et al. 2008)

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Table 1. Dengue surveillance system dan definition

Surveillance system (Ooi et al. 2007)	**Passive**	**exists**	India, Cambodia, Lao People's Democratic Republic, South Pacific Island
		Good	**Malaysia, New Caledonia, Tahiti**
		V.good	**Singapore**
	Active	Exists	-
		Good	**Australia**
		V.Good	-
Outbreak Definition (Runge-Ranzinger et al. 2008)	***"Epidemic Month = incidence of notified DHF > 1SD above average"* (Barbazan et al. 2002).**		
	"Outbreak = sudden increase of cases per week persisting for at least 3 successive weeks to a level at least three times above the mean of the previous 3 weeks." (Carme et al. 2003)		
	"Outbreak = number of cases 2 SD above mean baseline during non-endemic period. Suspected dengue case = fever cases where malaria was excluded (Talarmin et al 2000)		
	"Outbreak => 2 SD above monthly mean number of cases during the past 3 years in a location (Tourdjman et al. 2005)		
	Outbreak = Cluster of cases (five or more similar cases close together in any village within a week (Oum et al. 2005)		
	Epidemic threshold = case number 2 SDs above average in 5 non-epidemic years. (Rigau-Perez et al. 2002)		
	Outbreak = autochthonous transmission (Gill et al. 2000)(hafkin et al 1982)		
	Two reports of locally acquired cases lead to an outbreak declaration (Hills et al. 2002)		
(Seng et al. 2005)	***According to the Johor State Health Department , Outbreak = occurrence of more than one case in the same locality, where the date of onset between the cases < 14 days. The outbreak is clear when no new case has been reported within 14 days.***		

Definition quoted by (Seng et al. 2005) is most accurately being uses in defining dengue outbreak in Malaysia and adopted in this study.

B. Detection model

Various techniques for outbreak detection have been introduced ranging from statistics to data mining including machine learning. In analyzing the outbreak, normally the common techniques applied is statistics in which uses several techniques such as scan statistic(Mostashari et al. 2003; Kulldorff et al. 2004; Kulldorff et al. 2005), k-means clustering(Ozonoff et al. 2005; Patil et al. 2005; Guo 2006), holdout method or regression techniques(Held et al. 2006; Höhle et al. 2007) that is useful to subtract irrelevant patterns, leaving only useful information or generic techniques Cumulative Sum (CuSUM)(Hutwagner et al. 2005; Lumley et al. 2005; Shmueli 2005; Watkins et al. 2008) in detecting the outbreak.

According to (Pavlin et al. 2003) surveillance systems are passive and dependent on practitioners' voluntary reporting to the public health. Rapid recognition of disease outbreak requires historical data and trend data to be used in baseline comparisons to provide information on detected outbreak. The amount of data needed for outbreak is very much dependent on the diseases and number of cases. In explosive outbreak with large number of cases, there will be no time to collect detail information. The high priorities are to collect number of cases while outbreaks that evolve slowly require case investigations for further detail information in determining the outbreaks(Connolly 2005).

In determining the outbreaks, the systems need to detect any abnormal pattern in the surveillance data. Normally, in statistical analysis, it refers to aberration (Wong 2004) and described as a "statistically significant change in the occurrence of health events when compared with normal history".

Outbreak has been defined in many ways depending on the diseases and also vehicle of the diseases. The determinations of dengue outbreaks are based on the data collected for the dengue cases. There are few definitions of dengue outbreak. Reported(Runge-Ranzinger et al. 2008) quoted by(Barbazan et al. 2002) dengue outbreaks mean incidence of notified dengue cases more than 1SD above average. On the other hand, outbreaks can be defined as number of cases with 2 SD above mean baseline during non-epidemic week (Talarmin et al. 2000). The widely accepted definition based on CDC is "The occurrence of more cases of disease than is expected in a given area over a particular period of time. While epidemic often implies a large number of cases a wide geographic area. Cluster refers to an aggregate of cases in a given area over a particular period of time without regard whether number of cases is greater than expected"(EXCITE 2010). We will use the definition of dengue outbreak based on definition by (Seng et al. 2005) where the dengue outbreak is the occurrence of more than one case in the same locality, where the date of onset between the cases is less than 14 days. The outbreak will be considered clear when there is no new case reported within 14 from the onset date in specific locality. Looking for the possibilities of searching new ways to interpret dengue data , data mining is an option to explore.

Data mining or famously known as Knowledge Discovery in Database (Palace 1996; Han & Kamber 2001; Chen et al. 2006) has evolved along with intensive research focusing in various applications domain. The finding in data mining research has motivated a creation of new techniques to analyze, understand and visualize large amount of data gathered from scientific, business and surveillance (e.g. network, medical records, etc.). The frequent items problem is one of the interesting and popular studies in data mining. The problem is interesting due to its simplicity to state, and its interest and values of associating between the items. As an example, given a set of item, the problem is simply to find those items which occur more frequent. Typically, this involves formalizing as to find whose frequency exceeded the specified fractions of the total number of items and also generating combined items or candidate items. The variation of problem becomes larger and larger as the frequent value can be used in some real life application such as outbreak

detection. This is due to the number of candidate item set which is exponentially increases when the minimum support decreases. The bigger size of database the more complex it will be. It is known as 'curse of dimensionality'. The abstraction of the above problem is viewed as a passive surveillance system particularly in the dengue context. Originally, Apriori-based(Agrawal et al. 1993; Agrawal & Srikant 1994; Han et al. 2007) implemented Apriori algorithm to mine one-dimensional Boolean association rule from transactional database. [34] was the first to introduce the frequent pattern mining for the market basket analysis in form of association mining. The evolving of Apriori concept is based on 'market-basket' analysis.

The ration of outbreak detection by viewing pattern within the dataset lies in the usage of data mining through the definition as below:

- In determining the outbreaks, the systems need to detect any abnormal pattern in the surveillance data. Normally in statistical analysis it refers to aberration.[24] defines the aberration as *"statistically significant change in the occurrence of health events when compared with normal history"*.
- Quoted from (Hodge & Austin 2004) and (Ben-Gal 2005) define outlier based on Bennett & Lewis (1994) as *"…….that an outlying observation, or outlier, is one that* ***appears to deviate markedly from other members*** *of the sample in which it occurs……."*
- Outbreak is data aberrations or changes in the distribution or frequency of health-related events when compared with historical data. Based on the above definition, we viewing frequent pattern as normal behavior and can be uses as baseline. While abnormal derive from set of frequent pattern will be consider as outbreak.

Technically data mining techniques such as frequent mining and outlier mining can be hybridized to detect an outbreak. Based on the above concept we therefore propose a model to detect outbreak using frequent and outlier mining.

III. PROPOSE MODEL

Generally the detection model is based on creation of baseline as the threshold in detecting the outbreak as in EARS, ESSENSE, EWORS, LEADERS, and NEDSS (just to name a few of the surveillance systems). The outbreak of certain cases determined by events that occur more than threshold value will be considered as a potential outbreak. The detector determines the true outbreak based on the physical investigation by the epidemiologist in determining the true outbreak or not. The detection model was inevitably suffered from a very high false positive rate. The outbreak detection model is normally based on framework developed by CDC (German et al. 2001; Buehler et al. 2004). Generic framework for surveillance system adopted by most of the other approaches which is based on the anomaly detection (Wong et al. 2005; Das & Schneider 2007; Singliar & Dash 2007; Das et al. 2008; Das et al. 2009) is a promising approach in reducing the number of false positive rate. WSARE(Wong et al. 2003) and PANDA(Cooper et al. 2004) are two other methods for outbreak detection. WSARE uses rules for gaining knowledge regarding the combination attributes while PANDA uses Bayesian network to specify conditional independence between attribute.

Based on the generic model of the outbreak detection, we propose to integrate data mining techniques focusing on frequent mining as the baseline creation and outlier mining to detect the outbreak. (Zalizah A. L 2008; Zalizah A.L 2009)The technique called frequent-outlier is based on the Apriori algorithm. The proposed model will consist of three main phases. There are learning phase, detecting phase and repository phase.

We introduce the frequent mining analysis to retrieve normal behavior as the baseline. We implement and introduce Multiple Attribute Value (MAV) to calculate the frequent attribution within the surveillance data based on Apriori-based algorithm. The frequent item is calculated based on the value of the item/attribute. Mining frequent item sets using MAV presents interesting challenges over the traditional binary search space. In this approach, we consider the items as 'attributes'. Each attribute may contain more than one attribute values. Each transaction reflects the data point in the dataset or set of transactions assuming the attribute is an item. Assume the attribute is an item. Let P = set of items {P1, P2, P3 …. Pn} denotes as items/attribute. For each P there exist multiple values, P = {pn1, pn2, pn3..... pnm,}. Let Ti has pnj items, so we can write a transaction as ti = { P1, P2, ... Pn} and Pn = { t1, t2, t3 ..... ti}. Following the above reason an indication to calculate frequency for each attribute value can be defined as:

$$\forall\ P_{ij} = P_{kj} \text{ where } i \neq k\ ,\ \exists\ MAV_{ij} = \frac{\sum P_{ij}}{n} \qquad (1)$$

The second computation of outbreak involves calculation detecting outlier based on the frequent analysis using MAV algorithm. In this stage our methods will compute the items which meet the support supply during the first stage. Frequent Outlier (FO) will calculate based on result of MAV. However, further divided records will be divided with numbers of attribute.

$$FO\ Score\ (t_i) = \frac{\sum \frac{MAV_{ij}}{x}}{y}\ ,\ where\quad x = \sum t_i\ ,\ y = \sum P_j \qquad (2)$$

Frequent Outlier analysis provides the weight of outlier-ness of the frequent set. We calculate the outbreak based on the definitions of the diseases. As in the case, we use dengue outbreak definitions.

IV. EXPERIMENT

The measurement used to compare the proposed technique is shown in Table 2. We compare our algorithm with CUSUM in detecting outbreak. We also show result on dengue dataset as displayed in table 3 based on detection rate (DR), false positive rate (FPR) and overall performance (OP) based on our algorithm.

Table 2. Calculation matrix for detection rate (DR) False positive rate (FPR) and overall performance (OP) adopted from(German et al. 2001; Mukhi 2007)

System detected	**Actual cases**		
	Outbreak	**No outbreak**	
Outbreak	True positive (TP)	False positive (FP)	**TP+FP**
No outbreak	False negative (FN)	True negative (TN)	**FN+TN**
	TP+FN	**FP+TN**	**TOTAL**

The extensive experiment was conducted. The data were obtained from the Unit Kawalan Vektor, Pusat Kesihatan Hulu Langat and Fakulti Sains Kesihatan, UKM. In this experiment, we focus on non-clinical dataset. Dataset consist information on year and epic week (week1 to week 52), age, sex, races, address, nature of work, type of dengue, incubation period, epidemic type, recurrent cases and dead code. We focus on demography effect to the recurrent cases and incubation period from the onset onward to confirm diagnose. Approximately 0.14% data reduced through the pre-processing stage. We tried to maintain closely to real sets of the original dataset in analyzing the real dengue dataset. We plot our result as in table 2 below.

V. RESULT & DISCUSSION

We plot our experiment result as in Table 3 below. The experiment was run using Cumulative SUM (CUSUM) as standard techniques to detect outbreak in literature. Our propose techniques Multiple Attribute Value (MAV) using full item length and Frequent-Outlier (FO) as our methods to detect outbreak. We also run the experiment using our first technique MAV and being compared with CUSUM and Moving Average (MA), the result for MA are lower than CUSUM and MAV. The detail on the experiment can be found in (Zalizah A. L 2010). Therefore we are conducting this experiment without using MA.

Table 3. Results on dengue dataset

Measurement	**CuSUM**	**MAV**	**FO**
Detection rate	70.8%	74.1 %	85.0 %
True positive rate	20.0%	18.4 %	65.4 %
False positive rate	28.0%	28.0 %	11.5 %
Overall Accuracy	67.3%	73.1 %	76.9 %

We plot our experiment result as in Table 3 above. The experiment was run using Cumulative SUM (CUSUM), Moving Average (MA) as standard techniques to detect outbreak in literature. Our propose techniques Multiple Attribute Value (MAV) using full item length and Frequent-Outlier (FO) as our methods to detect outbreak.

Based on the result populated in the Table 3, generally, we manage to outperform the CUSUM even though the overall performance does not reach more than 80%. We manage to get as higher as 85% using FO while us able to produce 74.1% using MAV. The commonly uses CUSUM only manage to get 70.8% detection rate for detecting outbreak. In detecting the false positive rate, our algorithm outperforms and manages to get 11.5%. Quoted from (German et al. 2001)

"….. …… *False Positive rate reports can lead to unnecessary interventions, and falsely detected outbreaks can lead to costly investigations and undue concern in the population under surveillance. A public health surveillance system with a high PVP will lead to fewer misdirected resources*….."

Although we able to outperform in detection rate and false positive rate, we unlikely to produce exceptional result in detecting true positive rate as propose by (German et al. 2001)

"……. Predictive Value Positive or True positive rate is important because a low value means that non cases might be investigated, and outbreaks might be identified that are not true but are instead artifacts of the public health surveillance system (e.g., a "pseudo-outbreak").

Therefore we apply our techniques to real dataset to gain as much as knowledge for further improve our techniques as possible. We realize that definition of outbreak vary from disease to disease. We also conduct the statistical analysis to evaluate the performance of our method using ROC (Han & Kamber 2001). ROC indicates that MAV and FO outperform CUSUM, while FO produce more significance 0.01 compared to MAV 0.04. The confidence intervals showed that CUSUM is in lower and upper bound with 95% asymptotic confidence interval for MAV and FO. This indicate that MAV and FO still leading in.

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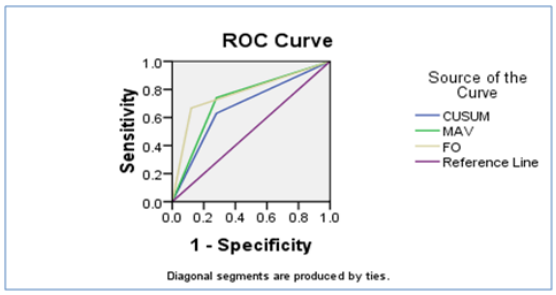

Fig. 1. The ROC curve for the MAV, FO and CUSUM

We manage to produce rules from the FO. With the instance 236 and 10 attributes we highlight some of rules that we generate. Due to limited space we highlighted only a few interesting rule out of 1027 rules generated. The result was classified into length of the rules produces as below:

Result for 1K Length:

1. *Sex=Female 138 ==> Recurrent=Yes 138 Conf:(1)*
2. *Death_Code=No 129 ==> Recurrent=Yes 129 Conf:(1)*
3. *Age=Adult 102 ==> Recurrent=Yes 102 Conf:(1)*
4. *Sex=Male 98 ==> Recurrent=Yes 98 Conf:(1)*
5. *Races=Melayu 89 ==> Recurrent=Yes 89 Conf:(1)*
6. *Address=Cheras 88 ==> Recurrent=Yes 88 Conf:(1)*
7. *Races=Cina 81 ==> Recurrent=Yes 81 Conf:(1)*
8. *Address=Kajang 81 ==> Recurrent=Yes 81 Conf:(1)*
9. *Age=Kid 68 ==> Recurrent=Yes 68 Conf:(1)*
10. *Profesion=Student 68 ==> Recurrent=Yes 68 Conf:(1)*
11. *Profesion=Labour 47 ==> Recurrent=Yes 47 Conf:(1)*

Result for 2K Length:

1. *Sex=Female Death_Code=No 77 ==> Recurrent=Yes 77 Conf:(1)*
2. *Races=Melayu Death_Code=Yes 62 ==> Recurrent=Yes 62 Conf:(1)*
3. *Case=Dd Incubation=5h 60 ==> Recurrent=Yes 60 Conf:(1)*
4. *Age=Adult Sex=Female 59 ==> Recurrent=Yes 59 Conf:(1)*
5. *Age=Adult Death_Code=No 56 ==> Recurrent=Yes 56 Conf:(1)*
6. *Address=Cheras Death_Code=No 54 ==> Recurrent=Yes 54 Conf:(1)*
7. *Races=Cina Death_Code=No 53 ==> Recurrent=Yes 53 Conf:(1)*
8. *Races=India Death_Code=No 39 ==> Recurrent=Yes 39 Conf:(1)*
9. *Age=Young_Adult Death_Code=No 36 ==> Recurrent=Yes 36 Conf:(1)*
10. *Incubation=5h Death_Code=Yes 29 ==> Recurrent=Yes 29 Conf:(1)*

Result for 3K Length:

1. *Age=Adult Death_Code=No Plague=Dkw 37 ==> Recurrent=Yes 37 Conf:(1)*
2. *Sex=Female Death_Code=No Plague=Tkw 36 ==> Recurrent=Yes 36 Conf:(1)*
3. *=Female Races=Melayu Death_Code=Yes 35 ==> Recurrent=Yes 35 Conf:(1)*
4. *Races=Melayu Address=Kajang Death_Code=Yes 35 ==> Recurrent=Yes 35 Conf:(1)*
5. *Sex=Female Death_Code=Yes Plague=Tkw 34 ==> Recurrent=Yes 34 Conf:(1)*
6. *Sex=Female Races=Cina Death_Code=No 33 ==> Recurrent=Yes 33 Conf:(1)*
7. *Races=India Death_Code=Tidak Plague=Dkw 31 ==> Recurrent=Yes 31 Conf:(1)*
8. *Sex=Female Address=Kajang Death_Code=Yes 29 ==> Recurrent=Yes 29 Conf:(1)*
9. *=Male Address=Cheras Death_Code=Tidak 27 ==> Recurrent=Yes 27 Conf:(1)*
10. *Address=Kajang Death_Code=Yes Plague=Tkw 27 ==> Recurrent=Yes 27 Conf:(1)*

Result for 4K Length:

1. *Case=Dd Sex=Female Death_Code=No Plague=Dkw 40 ==> Recurrent=Yes 40 Conf:(1)*
2. *Case=Dd Races=Melayu Address=Kajang Death_Code=Yes 35 ==> Recurrent=Yes 35 Conf:(1)*

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3. *Case=Dd Sex=Female Races=Cina Death_Code=Tidak 33 ==> Recurrent=Yes 33 Conf:(1)*

4. *Case=Dd Races=India Death_Code=No Plague=Dkw 31 ==> Recurrent=Yes 31 Conf:(1)*

5. *Case=Dd Age=Adult Sex=Female Death_Code=Yes 29 ==> Recurrent=Yes 29 Conf:(1)*

6. *Case=Dd Sex=Female Address=Kajang Death_Code=Yes 29 ==> Recurrent=Yes 29 Conf:(1)*

7. *Case=Dd Sex=Male Address=Cheras Death_Code=No 27 ==> Recurrent=Yes 27 Conf:(1)*

8. *Case=Dd Races=Melayu Address=Kajang Plague=Dkw 25 ==> Recurrent=Yes 25 Conf:(1)*

9. *Case=Dd Profesion=Nil Address=Ampang Plague=Tkw 25 ==> Recurrent=Yes 25 Conf:(1)*

10. *Case=Dd Races=Cina Address=Cheras Death_Code=No 24 ==> Recurrent=Yes 24 Conf:(1)*

In our future work we will improve our method to be able to generalize the detection without relying on outbreak definitions.

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Connection Management System based on MIH and MIP over NS-3

Juan C. Chaparro-Marroquín and Roberto Bustamante-Miller

***Abstract*—** With the constantly growing demand for voice, data and video services on both mobile and fixed clients, heterogeneous convergent network have been proposed. In order to keep up with this new paradigm, the integration of different access technologies is required, vying to offer better experience to the network users. In this article, a connection management architecture is presented, based on both Media Independent Handover (MIH), and Mobile IP (MIP), in order to maximize the usage of the available resources on Wifi, WiMAX and LTE networks. To validate the proposed approach, different simulation scenarios are run on Network Simulator 3 (NS-3).

***Keywords*—** MIH, MIP, PMIPv6, Convergence, Heterogeneous Networks, NS-3.

I. Introduction

IN recent times, a trend of increasing demands in information services for mobile users has been observed, with some reports of network operators pointing to a 5000% increase in the last 4 years [1]. This increase, has been possible mainly because of the innovation on access technologies, both mobile and fixed, enhancing the quality and ubiquity of voice, data and video services offered, a fact which is in general, attractive to consumers.

The continuous rise on the demand of information services has brought new challenges for service providers, researchers and the scientific community overall, given the larger efforts required, mostly on infrastructure, in order to guarantee the achievement of strictly defined quality standards, across a large and growing services portfolio.

As a new paradigm in network architecture, convergence has been introduced recently on the communications field. Convergent networks are defined as service-oriented or customer-oriented networks, in which services are offered over different access media, technologies, etc. All while maintaining quality of service, and quality of experience.

The development and deployment of convergent networks presents as well, varying new challenges for Communications Engineering, taking into account the key differences existing between the available choices a user may have in terms of its access technology. Additionally, it must be considered that the amount of alternatives in this regard, keeps increasing constantly as well.

From an academic standpoint, the implementation of Connection Management System is a subject of study from different perspectives, keeping in mind particular considerations and approximations. In [2], the implementation of vertical handovers in several scenarios composed of UMTS networks is shown, using IEEE 802.21 (MIH), as framework for the handovers.

In [3], a scheme using FMIPv6 and MIH is presented, conceived for the realization of vertical handovers en vehicular networks, along with related experiments. Meanwhile, in [4], the usage of a Multimedia IP System (IMS), is shown as a way to achieve internetworking across WiMAX, WiFi and UMTS.

In this article, the concept and proof of a connection management system for convergent heterogeneous networks is presented, specifically for three different access technologies: WiFi (IEEE 802.11), WiMAX (IEEE 802.16) y LTE (3GPP Release 8).

The proposed architecture is based on MIH and MIP (PMIPv6), looking forward to a system that allows to keep a permanent connection for each client in a convergent heterogeneous network, also allowing for further management of the different networks by the service providers and regulation agencies. The proposed system is validated by using the simulation software NS-3.

This document is organized as follows: First, the theoretical basis of the proposed system are detailed. Next, a thorough description of the system is done, continuing with its implementation on NS-3. Then, the simulation scenarios designed for validation are presented, and the results of the aforementioned simulations is discussed, along with the obtained conclusions.

II. Key Concepts

In this section some of the most relevant concepts, tools and techniques for the implementation of the connection management system are detailed, along with further references for the reader.

A. Media Independent Handover (MIH)

The IEEE 802.21 standard, "Media Independent Handover" (MIH), defines a framework for the connection management between different access technologies, in a single, convergent network. It is to be noted that the standard

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does not define the technologies that should be used in the implementation of the connection management itself, it actually defines a formal structure of events, proposed for such means.

The standard defines user profiles and a specific set of functions for each technology involved. The users in this case, are the entities which consume the services provided by the functions implementation; for example, an MIH user, may be de session layer of the stack of a particular technology or protocol, which requires information about the active link (IP address and DNS in a certain window of time), while the functions corresponding to such a case would be the means used with the purpose of getting such information, which may come from internal sources (packet transfer entities or any other internal entities), or external (an information server).

The communication between users and function in MIH is done through a set of services to be implemented according to the standard. Three main services are defined: Information (MIIS), events (MIES) and command (MICS). These services allow to obtain information of an entity, receive notifications about the status and changes on the entity, and perform changes on the entity, respectively.

The command service allows to adjust the settings and characteristics of an specific entity, like the boundaries or limits on the channel quality (Configure Thresholds), obtain the current status of the defining parameters of the channel quality (Get Parameters), validate the status of other available channels or links to perform a handover (Candidate Query), and finally perform a handover to other link or technology (Commit).

For the case of the event services, these represent mainly a notification system about the specific conditions of the available communication links for an entity, in these case, a subscriber station (or user equipment). The evet services provide information about the detection or discovery of a new link (Link Detected), an established connection to any of the available links (Link Up), the detection of a threshold in the quality parameters of the link (Link Parameters), the detection of a degrading quality link (Link Going Down), the loss of connection (Link Down), or the change in the thresholds for the quality parameters of any of the available access technologies (Link Parameters Report).

The information services, represent the possibility of any MIH user of receiving general information on an immediate or periodic bases, regarding other entities on the network. With the setup of a common information server, for example, the information services can provide an entity with information about the current access network (connected subscribers, service provider, etc.).

The discussed services allow MIH to perform the management of different connections on a variety of access technologies, regardless of the application being used on higher layers, allowing as well the usage of reliable transport protocols or connection-oriented protocols (TCP). The setting of parameters makes the management of Quality of Service over the links a possibility for MIH implementations. Figure 1 shows the reference model for MIH [5].

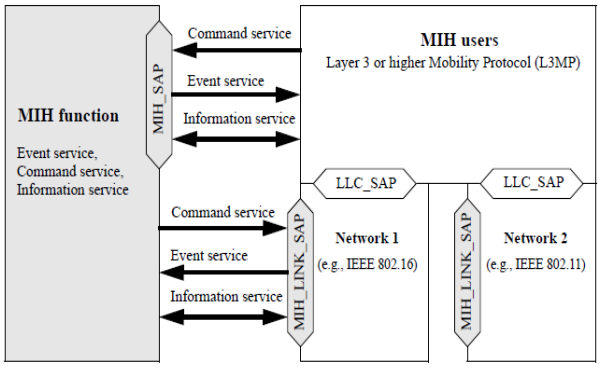

Fig. 1, Reference Model for MIH (IEEE 802.21). Extracted from [5]

B. MIP

For the correct functioning of a connection management system, it is necessary to take into account the routing consideration over different IP networks in which a Mobile Subscriber might connect. In general, for these purposes, the IETF has defined Mobile IP (MIP) and its different schemes.

One of such schemes conceived as part of MIP is Proxy Mobile IPv6 (PMIPv6), which considers the existence of a pool of IP addresses for a subscriber or node, establishing IP tunnels between different nodes on the network's backhaul for the handover of the subscriber to other networks, which may or may not be of the same access technology.

As the name indicates, PMIPv6 is a protocol based on IPv6, due to the larger amount of IP addresses required in order to create the pools needed for the mobile subscribers connected to the network.

PMIPv6 starts by assigning a single IP address for every node, then making changes over the routing tables of the backhaul network whenever a mobile subscriber changes its access network. Every request, either on the uplink or the downlink, that has as source or destination a node outside the local domain network (the local domain network corresponds to the entire network associated to the current access technology in use) must be managed by the Local Mobility Anchor (LMA).

The LMA, acts as a local domain server on the current active path of inbound and outbound traffic of a particular mobile subscriber, therefore, it has the capacity of directing packets to every other node registered in it, by directing them to the active network interface of the desired node. If the active interface and network changes, an specific Exchange of messages is required.

When a change of access network is required, as in the case when a better quality network is found available in a certain time, the mobile node sends a proxy update request, or proxy solicitation (PRSol). The current access gateway (MAG), then redirects the request to the desired access Gateway, in order to determine whether the request is accepted or rejected.

In case the request is accepted, the current access gateway sends an acknowledgement to the mobile node (PrACK), and a proxy bind update (PBU) to the LMA, which in turn updates the routing tables through Proxy Bind

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Acknowledgement messages (PBA). The current access gateway deletes the routing to the mobile node from its routing table, while the new access gateway includes the mobile node on its. Finally a PBA message is sent to the mobile node, to activate the corresponding network interface, completing the handover process.

In case the request is rejected, a corresponding message is sent to the mobile node. Figure 2 shows the reference model of MIPv6 and PMIPv6. [6].

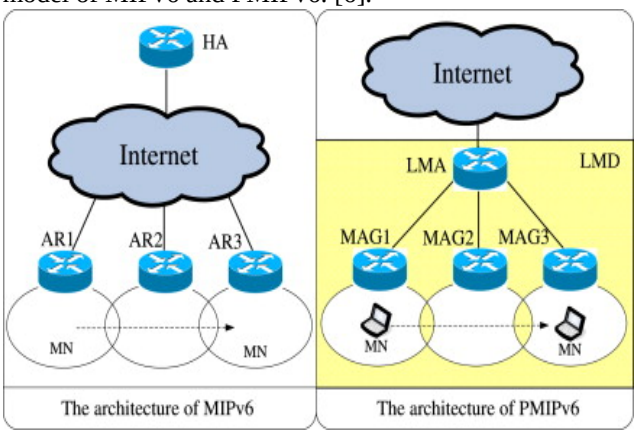

Fig. 2, Reference model for MIPv6 and PMIPv6. Extracted from [6]

C. Network-Simulator 3 (NS-3)

In order to validate the solution strategy for connection management, it is necessary to have simulation software capable of handle scenarios with multiple access networks, as well as their different characteristics. In this case, the required technologies are: WiFi, WiMAX, and LTE.

After reviewing the available tools, the network simulator NS-3 was selected for the project, given its features regarding the simulation of the three aforementioned technologies, as well as the possibilities of extension it offered, through the C++ programming language. Also, its usage in different academic projects around the world, further motivated the choice [7][8].

NS-3 has as well, a novel module for the simulation of LTE-EPC scenarios (LENA) [9], and a complete module for the extraction of statistics of any simulation scenario (FlowMonitor) [10], which come handy when doing analysis about Quality of Service, in terms of packet loss, delay and jitter.

In NS-3, access technologies are implemented through a basic modular structure, corresponding to physical layer and data link layer devices, controlled through network devices, which work in intermediate layers, relating to layers 2 and 3 in the OSI model.

From such layer on, the higher layers are implemented through the Internet Protocol stack, whose structure is shown in Figure 3; this implements both network and transport elements, whilst applications complement the remaining network elements.

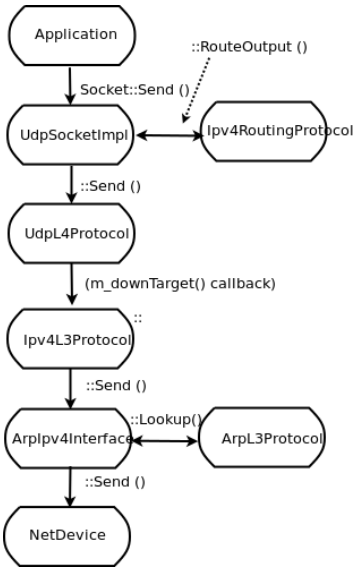

Fig. 3, Modular structure of the "Internet Stack" in NS-3. Taken of [10].

As a part of the modular structure of NS-3, in the Data Link Layer, specifically in Media Access Control (MAC), scheduling models are available in all three access technologies, while in terms of the physical layer, interference is appropriately modeled for every technology as well [9].

For the proposed connection management system, in general, the default physical layer parameters will be used for each access technology, considering, without loss of generality, the proposed system should remain independent of such parameters, remaining in accord with the 802.21 standard

The readers are invited to read [9], [11] y [12], for further information regarding such default parameters.

III. Connection Management System

For the development of a connection management system, based on MIH and PMIPv6 over NS-3, it is required to first conceive a complete structure regarding the information Exchange needed to articulate the handover and connection management.

A. PMIPv4

In the preceding section, the basic operation principles of PMIPv6 were presented, being PMIPv6 a valid scheme for the handling of the routing required for a mobile subscriber roaming through distinct IP networks. Such principles, are equally valid, when applied to an implementation base don IPv4.

For this implementation, the usage of IPv4 is mandatory, as IPv6 is not fully supported either for WiMAX or LTE in the currently available version of NS-3. Therefore, a simplified model called tentatively "PMIPv4", is introduced.

As in the case of PMIPv6, an LMA is considered, containing an updated version of the routing tables with the active interface or active access technology in a specific time for each and every mobile subscriber.

The two-way traffic between a corresponding host and a mobile subscriber associated to the LMA, will include along

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its way a route through it, so that in case of a handover, the traffic control is done on the local context of the network.

The considered simplified model, is different from PMIPv6, in terms of the length of the IP addresses, and the existence of the IP address pool, which taking into account the available addresses, is reduced to a single IP address for each node. This last consideration, though significant for the creation of IP tunneling across the network, does not overly affect the fundamentals of MIP.

B. Context Information Server

The provision of up to date information and the subscription to such information about active network is an integral part of the implementation of the MIH function, in terms of the command and information services of MIH. For those purposes, a provider of such content, of all the information of the network, considered important or pertinent to network entities, must be created, with the possibility of providing such information on a real-time basis.

These information helps the decision making process, around the choice of a new access network, when there is a connection loss, or a perceived loss of quality in a mobile subscriber, depending on the status of the available access networks.

Since the content provider described would be a part of the MIIS, it must be available to every node that may need its information, for example, in the case of a handover, the entire access network, associated to the LMA, must be aware of such event, in order to adjust their routing accordingly.

With the previous discussion in mind, and taking into account [13] and [14], a Contextual Common Information Server (CCIS) is proposed. This server will store the information related to the mobile subscribers connected in the network, as well as its active access technology and subnet (As an LMA may have multiple subnets of the same technology access).

The CCIS, must as well, store the information of the access gateways of the network, whether they are Access Points, Base Stations, or eNodeB's, specifically the information regarding its geographical position and their congestion level, so it can provide subscribers and other network entities, with the information they need for decision making.

C. MIH decision making process

Once the operating structure of the network has been defined, in the backhaul network, the handover criteria must be established for the mobile subscribers of the network, between the different access networks.

At first, it must be mentioned that the handover might be triggered or started by either the subscriber (User Initiated Handover), or by any other entity of the network (Network Initiated Handover).

The first case corresponds, for example, to a mobile subscriber losing connectivity in its current access network and desiring to switch to different access technology, while the second case corresponds to a forced handover in order to accommodate other subscribers in cases of outage or congestion.

The management system must be able to support both kinds of handover, requiring then both control and access means to the different mobile subscribers.

Additionally, given that three access network are being considered, a quality parameter or measurement must be defined in a unified fashion, so the quality of the access networks may be compared.

As shown in [15], the available indicator of each access technology may not provide comparable information (RSSI, for example), so a different performance measurement may aid the assessment, like data rate.

On the other hand, depending of the client profiles set, the data rate may not be a good enough measurement to obey to the client preferences regarding access technologies. Other factors should be taken into account, like costs for the user, reliability, availability, etc.

In this particular study, an evaluation method for the network characteristics, introducing a hypothetical cost function in the MIH function.

Finally, in the possibilities of handover, the speed of the mobile subscriber must be considered, establishing that for speeds of 15km/h or higher, WiFi networks must not be considered as candidates for handover, given the range of such networks. The online time of such connections at the considered speed would be very limited, inferior, in some cases to less than 30 seconds of availability, which may introduce further packet loss to the mobile subscriber.

IV. NS-3 Implementation

With the previous considerations, the proposed system was implemented in NS-3, through the creation of four main elements: The MIH function for mobile subscribers, the contextual information server, the network and routing manager and the Quality of Service manager.

A. MIH function for mobile subscribers

Taking into account the modular structure of NS-3, the creation of a special network device ("NetDevice"), form MIH was done, this device receives each access network parameters, to determine which of them offers the best quality link, as well as the active link for sending and receiving packets.

It is important to mention that the measurement of quality parameters of each access network must be performed on the physical layer, starting from the available parameters of each one. Table 1 shows the available parameters for the three access technologies considered.

TABLE I, parameters for the estimation of effective data rate of each access technology.

Technology	Information
Wi-Fi	MCS, BER
WiMAX	SINR, BLER
LTE	MCS, BLER

Regarding the cost function, a simple model is used, where the connection to LTE costs 4 units, while the

connection to WiMAX costs 2 units, and the WiFi connection costs 1 unit.

As mentioned in the previous section, the cost function is hypothetical, used to establish a precedence between the preferred access technology, resembling a reward system for the decision making process of the connection management system.

On the physical layer, the data rate estimations are sent to the MIH network device, using special headers on the incoming packets that each mobile subscriber receives.

As a consequence, the measurement of the network parameters requires the existence of a downlink active flow or probing flow, for each access technology. The probing flow may or not may be available, depending on the subscriber's profile, a fact that will be taken into account in the Quality of Service assessment, in later sections.

For the threshold parameters, and the detection of connection loss events ("Link Going Down"), table 2 shows the defined thresholds for each access technologies, obtained through separate simulations for each access network.

TABLE II, threshold parameters for connection loss events in MIH connection

Technology	Information
Wi-Fi	Minimum MCS, BER>35%
WiMAX	BLER > 15%
LTE	MCS= 0 BLER>25%

B. Contextual Information Server

For the implementation of the CCIS, a series of information structures were devised for each access subnet, these structures are called Network Charts ("NetChart"). Each Network Chart contains the information corresponding to the geographical location of the subnet's access gateway, the amount of subscribers connected to each access gateway, the access technology, and a unique identifier.

Additionally, the Network Chart allows to access and modify the routing of the existing backhaul between the LMA and the mobile subscribers, in order to recognize, update or reestablish the routing required for each mobile subscriber, in case such operations are required

C. Network Manager and Routing

The network manager was implemented as a composite structure, lying mostly on the LMA, although keeping access to the Network Charts, and the MIH devices of the subscribers, giving the system a cloud architecture, as it is shown on Figure 4.

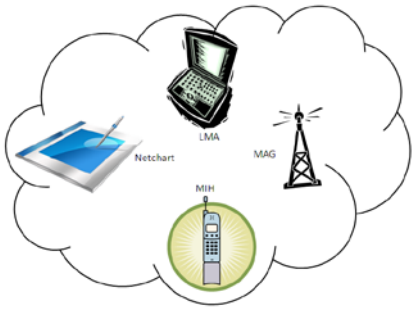

Fig. 4, Cloud architecture for contextual information (concept).[1]

The network manager considers the decision making process for the handover of any subscriber between two access technologies, by using the Proxy requests (PrSol), sent by the MIH function (linked to a Candidate Query Request).

The network manager, according to the request, must establish if a handover is considered as valid, according to the distance between the mobile subscriber and the access gateway requested, and the congestion of the associated to the specific gateway, information available to the etwork manager, via the Network Charts.

The network manager also evaluates the Quality of Service of the access networks, in order to determine whether a handover is required due to congestion,, to provide the best quality service to all the connected subscribers (at least, in an aggregate).

D. Quality of Service (QoS)

In the implementation two aspects of Quality of Service were considered: the availability of real-time information regarding the access networks, and the existence of two subscriber profiles of choice, giving way to four possible levels of Quality of Service.

In terms of the availability of information, as it was previously mentioned, this availability depends on the existences of downlink probing flows, which depending on user equipment and subscriber preferences may not be available, depending on costs, energy consumption or hardware features.

If a user only has information available of its current access network, it will attempt a handover only if it loses connectivity, while a user with fully available information may attempt a handover to the best possible network, whenever it detects a better network than the one to which it is currently connected, in any given time.

On the other hand, regarding subscriber profiles, these are used for decision making in the case of congestion. In general a higher profile has the right over a subscriber with a lower profile. This means that if a higher profile subscriber tries to connect to a congested network, to which a lower profile subscriber is connected, the network manager will perform a handover on the second one to other access network, to offer the best quality resource to the first one, if another access network is available for the second

[1] Images taken from Microsoft Office 2007, for non-commercial use only

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subscriber.

V. Results and Analysis

Once the architecture of the Connection Management System was completely implemented in NS-3, simulations over two different scenarios were done, to serve as proof of the correct functioning of the system. First, simulations were done to determine the range of the access gateways of each technology, obtaining the results shown in table 3.

TABLE III, access gateway ranges on each access technology

Technology	Uplink Range (m)	Downlink Range (m)
Wi-Fi	80	120
WiMAX	750	750
LTE	2520	>16500

A. Scenario 1: Radial fading way roaming

The first simulation scenario is shown in figure 5. This scenario consists in the roaming of 5 mobile subscribers, divided in two separate groups: One group goes in a direction were it will find a WiFi network halfway through the roaming way, while the other group will go in a direction were it won't find the WiFi network. Every node in the scenario begin from a WiFi coverage area, making handovers to other access networks as they require.

Both groups go in radial trajectories from the access gateways, located at the starting point of the roaming process. Each mobile subscriber gets traffic from a UDP data application with a data rate of 162kbps, resembling a data and voice service, for a total time of 33 minutes.

The goal of this scenario is to show the potential benefits of performing a handover for load balancing by exploiting the capabilities of the network manager, taking into account the performance parameters and indicators of the application, in this scenario

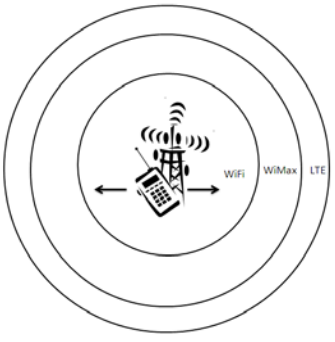

Fig. 5, Visual concept of the radial trajectory scenario[2]

Figures 6 and 7 show the results obtained with the detailed scenario, regarding the perceived reward (according to the cost function) and the application data rate, respectively.

The presence of the WiFi network, in the middle of the trajectory presents an upgrade of the service quality offered for the subscriber that has access to it. Despite the marginal increase in the data rate, given the used application, the performance indicators, shown in table 4, show considerable variations.

TABLE IV, Comparison between performance indicators in MIH-MIP vs No MIH-MIP

MIH	Yes	No
PLR[3]	3.52%	3.01%
Average Delay (s)	0.54	0.68
Average Jitter (ms)	18.5	23.12
Amount of Flow Interruptions	300	391

It can be shown that the packet loss rate exhibits a lower increase, in percentage, than the corresponding decrease of jitter and delay. Additionally, the flow interruptions, defined as the absence of received packets for an interval higher than 1 second, for the application in use; the overall Quality of Service (QoS), and Quality of Experience (QoE), is improved.

[2] Images taken from Microsoft Office 2007, for non-commercial use only

[3] Packet Loss Rate

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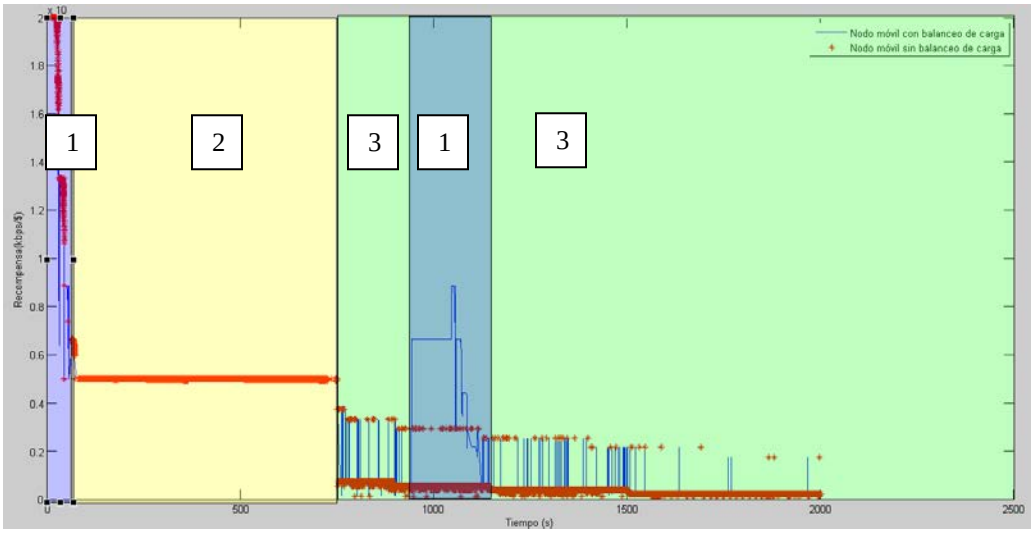

Fig. 6, Reward perceived in time for a node with access to WiFi networks and MIH (blue), and another one without access (red). The access technology is shown according to time: 1 for WiFi, 2 for WiMAX and 3 for LTE.

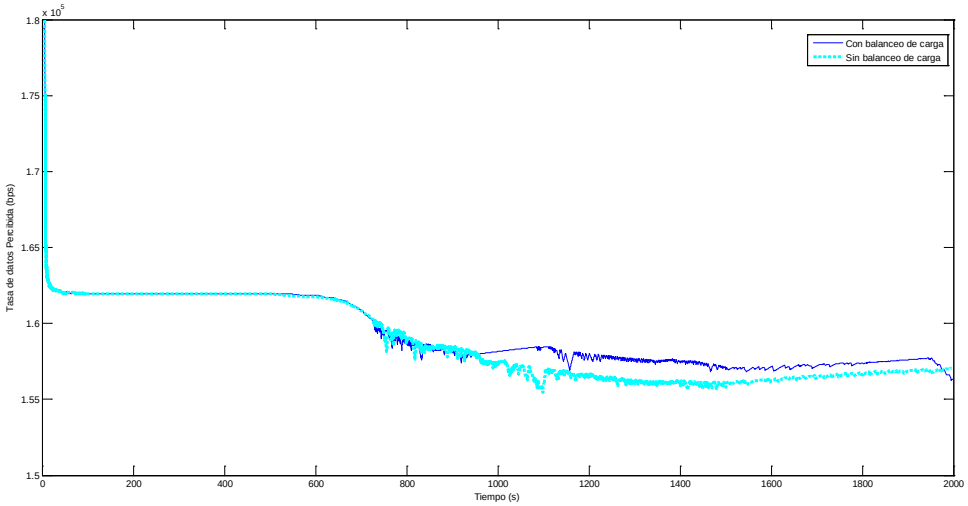

Fig. 7, Data rate perceived, versus application, when MIH is available (blue), or not available (cyan)

In figures 8 and 9, the histogram of delay and jitter for scenarios with and without MIH is shown, obtained using the FlowMonitor module of NS-3. In such histograms, it can be seen that the distributions of both is accumulated around lower average values when MIH and PMIPv4 is used.

In both cases, there is a considerable amount of packets having delays over 0.5 seconds, which can be explained by the signal strength fading when getting away from access gateways.

B. Congestion and multiple subscribers

The second scenario proposed pretends to show the implementation of the service levels previously described, beginning with 5 mobile subscribers, roaming across the access networks, which are congested. 10 additional static nodes over the WiMAX network, and 2 others in the WiFi network are set for these purposes. The WiFi network is placed in the middle of the roaming trajectory of one of the mobile subscribers.

In this scenario, each node has an UDP application with data rate of 405kbps, conceived as an intensive data, voice or video application [16][17]. Figure 10 shows the behavior of the perceived reward by a static node of Lower profile, a mobile subscriber with full information, and another mobile subscriber with partial information.

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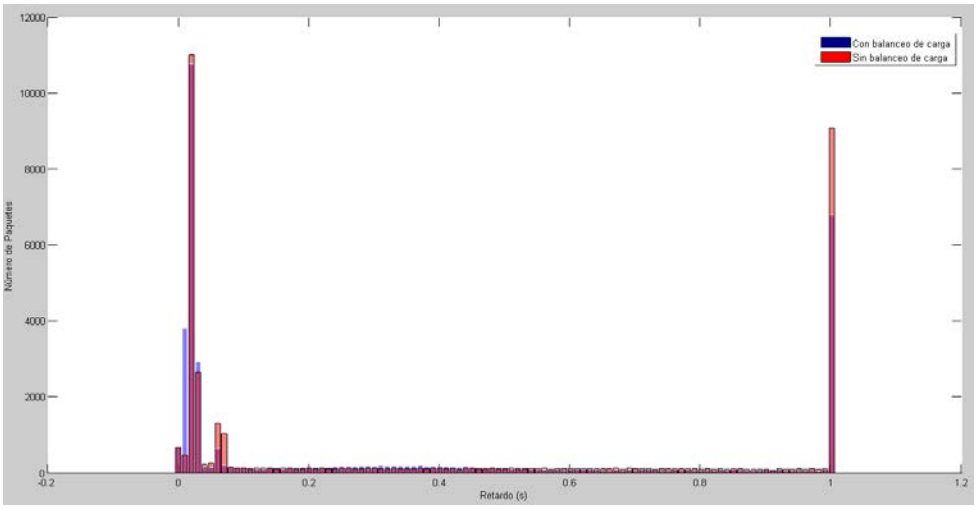

Fig. 8 Histogram of delay for MIH-PMIPv4 (blue), versus not having it available (red)

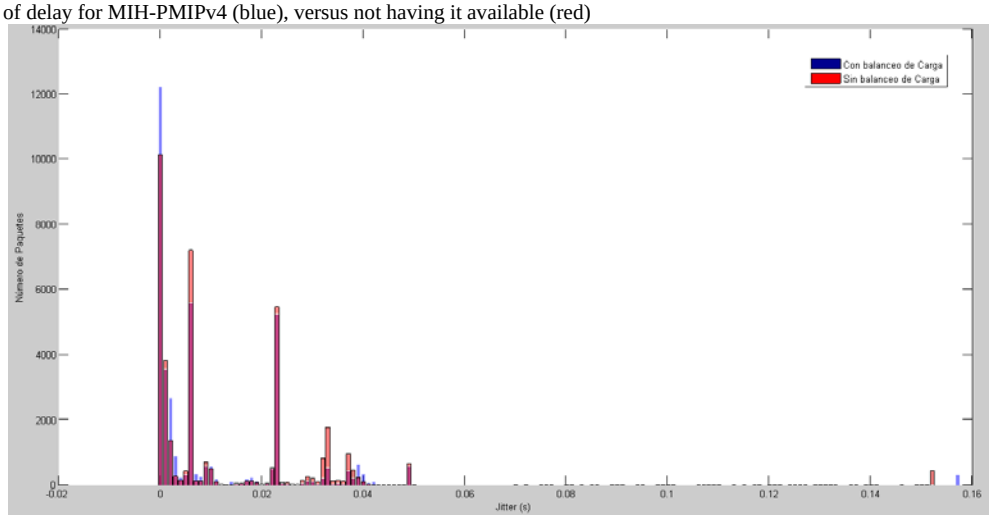

Fig. 9, Histogram of jitter for MIH-PMIPv4 (blue), versus not having it available (red)

Figure 11 shows the behavior of the data rate for the proposed application. In this case, given the congested networks, the data rate variation is more notorious, hence clearly separating the service levels set for the different subscribers.

In general, regarding the existing differences between the implementation of the connection management system, and the static node, it can be predicted that its performance indicators present a decrease, however, as presented in table 5, the corresponding increase in the other served subscribers means that in an aggregate, an improvement in the Quality of Service offered by the network results

TABLE V, Variations in the performance indicators for the congestion scenario

Setup	No MIH, No Service levels		MIH and service levels	
Node Type	WiFi-LTE static	Mobile	WiFi-LTE static	Mobile
PLR	5.24%	25.75%	11.59%	16.72%
Average Delay (s)	0.13	1.86	0.14	0.12
Average Jitter (ms)	0.8	19.22	1.2	8.83
Flow Interruptions	2	412	14	3

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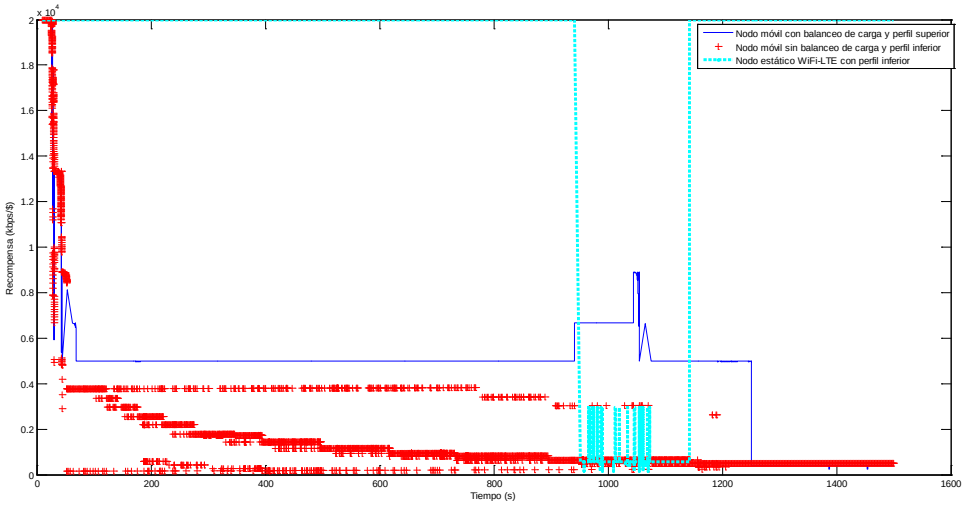

Fig. 10, Reward perceived by the two mobile subscribers, one with higher profile and full information (blue), the other with limited information and lower profile (red), and a static node with lower profile (cyan).

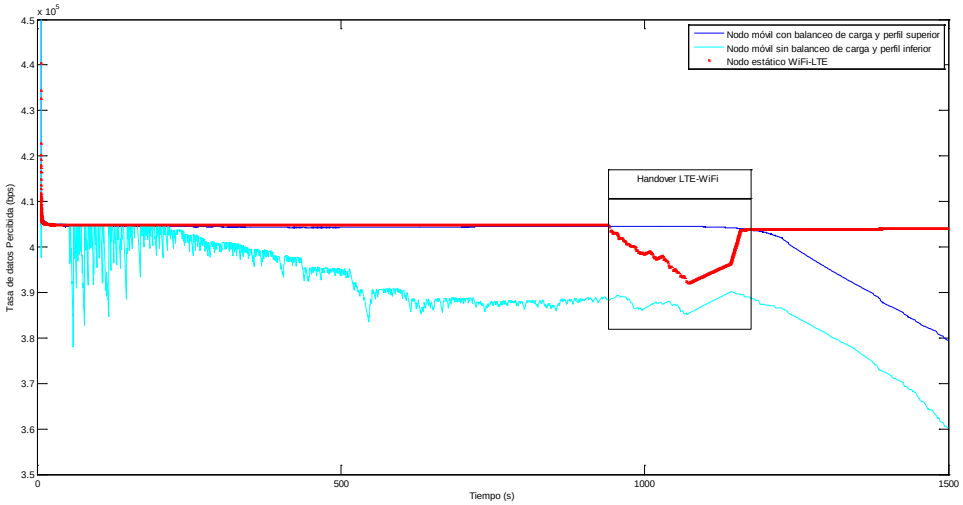

Fig. 11, Perceived data rate for the congestion scenario

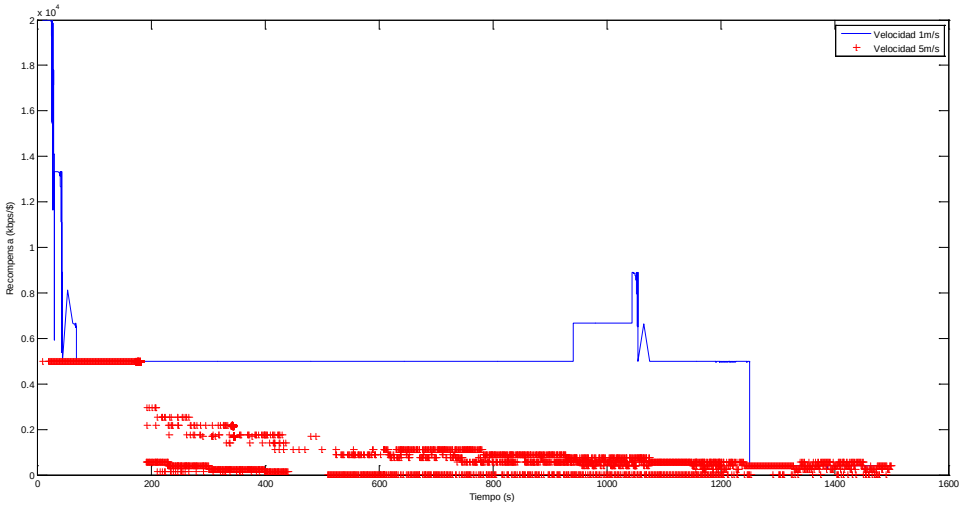

Fig. 12, Reward perceived by 2 subscribers on the same conditions, one with a speed of 1m/s (pedestrian, blue), and other with 5m/s (vehicular, red)

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As an additional exercise, a validation of the WiFi network detection on higher speeds, with the results presented in Figure 12, where it is clear that for a higher speed (18km/h), the WiFi network is not considered as a candidate for handover and therefore not detected

I. Some Common Mistakes

The obtained results show that the presented architecture for the connection management system offers an improvement in the service quality through heterogeneous networks. This allows for further exploration in the possibilities for Service Providers and its resources administrations, looking forward to the evolution to convergent networks.

The framework used, and the architecture of the proposed system, permit the integration of multiple access technologies, different than the ones presented in this article, in a collaborative scheme between service providers and subscribers, keeping in mind the cloud architecture, presented previously.

Service providers may use Connection Management Systems as means to enhance their Resource Planning, taking into account the variety of assets it may have, in order to offer better service quality and in general larger wlefare for both customers and providers.

For the presented scenarios, it was shown that QoS mechanisms can be plugged into the system, at both sides of the communication network, with the added possibility of incorporating decision algorithms in the QoS&QoE-aware network.

Regarding the deployment of these solutions from a commercial standpoint, it is expected that, given the increase in smartphone usage as well as the expansion of LTE infrastructure, the service providers will lean towards the development of heterogeneous networks.

From an academic standpoint, the results obtained show the multiple possibilities available in research regarding Media Independent Handover, in terms of the compromises and analysis of compatibility between multiple access networks, and the research in decision algorithms to control the handover process, being possible the integration of Game Theory and Artificial Intelligence.

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Introducing Social Awareness to Next Generation Wireless Networks

Pavlos Kosmides, Konstantinos Demestichas, Angelos Rouskas, Evgenia Adamopoulou and Miltiades Anagnostou

***Abstract*—**Wireless communications have evolved rapidly during the last decades resulting to an environment of heterogeneous Radio Access Technologies (RATs). The coexistence of these RATs in a seamless manner is one of the most important issues arising in the development of next generation wireless networks. One of the most promising approaches includes the use of Software Defined Networks (SDN) in order to assist the abstraction of multi-RATs into software-based controllers. However, this path results to the increase of the amount of data that will be handled by the controllers. In this paper, in order to enhance software-based controllers in the decision making process, we introduce the use of Social Networks in order to collect necessary information about users that belong to each controller. We also present the proposed systems architecture including Business Processes and Services.

***Keywords*—**Heterogeneous Wireless Networks, Radio Access Technologies, Software Defined Networks, software-based controllers, Social Networks.

I. Introduction

DURING the last decades, wireless networks have been growing at high speed, passing through many stages of evolution like 2G, 3G and recently 4G networks. This evolution has resulted to the existence of many Radio Access Technologies (RATs) with different network characteristics. Similarly, there has been an explosive progression on users' mobile phones (e.g. smart phones), while by 2020 the traffic originating from mobile applications is expected to increase exponentially [1]. In addition, research community has recently started the effort for the development of the next generation (5G) of wireless networks [2]. A major challenge that arises is the concurrent operation of different RATs in a heterogeneous wireless environment.

An approach that has been recently proposed by various researchers is the use of Software Defined Networks (SDNs). One of the main objectives of SDNs, is to centralize the network intelligence in *software-based controllers* [3]. For example, the authors in [4] propose the use of SoftRANs, a software defined centralized control plane for radio access networks and present a preliminary design and architecture along with use cases and a feasibility analysis. Similarly in [5] the authors introduce OpenRAN, an architecture for software-defined RAN via virtualization.

The authors in [6] propose a centralized Software-defined network controller, or Software-defined RAN (SD-RAN), which abstracts all the resources made available by a pool of base stations into a single, large resource pool, namely the Virtual Cell (V-Cell). Finally, in [7] the authors argue that SDNs can simplify the design and management of cellular data networks, while enabling new services. They propose extensions to existing controller platforms, switches and base stations to enable software defined cellular networks.

However, there has not been any effort on introducing Social Network awareness to software-defined networks. In this paper, we combine SDNs with online Social Networks. Specifically, we propose an innovative system architecture that takes advantage of the software-based controllers and imports social awareness from online Social Networks, in order to assist the centralized controller in the decision making process, using Machine Learning techniques.

The following sections present in detail the designed architecture for the implementation of the abovementioned service, including foreseen components and the specified interactions among them. The architecture is designed using *ArchiMate*® [8] showing the application layer entities (application functions) and their relationship.

II. Social Network Connectivity

The *Social Network Connectivity service* is responsible for establishing connection of the software-based controller with available Social Networks. It uses the available APIs that are provided from each Social Network and after applying the required policies that are addressed from the Social Networks services, it links the software-based controller with the Social Network.

Fig. 1 states the main business processes identified for the *Social Network Connectivity service* and show how they map to application layer entities (namely application functions); such relationship is indicated by the "realization" arrow, according to *ArchiMate*® notation [8].

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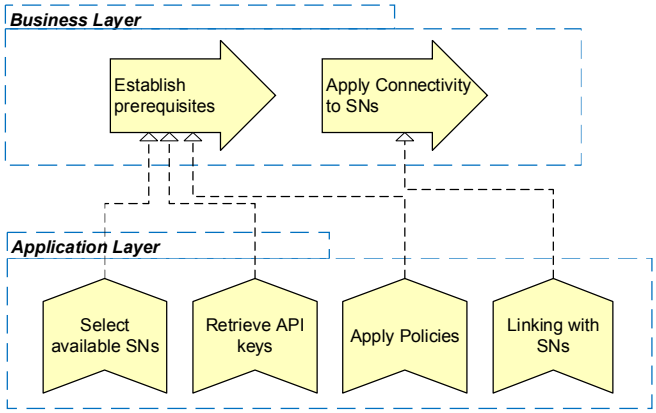

Fig. 1 Social Network Connectivity – mapping business layer to application layer.

As shown, the following functions have been identified for the application layer:

- *Select available SNs*: this application function is responsible for selecting which of the available Social Networks are going to be used in order to crawl necessary data.
- *Retrieve API keys*: this application function retrieves the necessary API keys from the Social Networks developer guides.
- *Apply Policies*: this application function is responsible for applying the policies that are defined by each Social Network.
- *Linking with SNs*: this function establishes the connection with the appropriate Social Network.

Fig. 2 illustrates application functions and components together with relevant interfaces, main data objects and information flows for the *Social Network Connectivity service*.

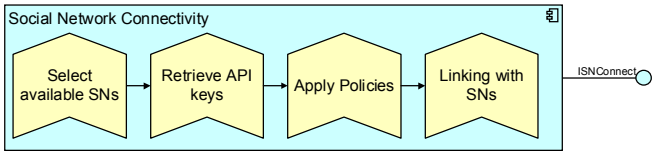

Fig. 2 Social Network Connectivity – main application components, functions, interfaces and data objects.

III. Data Determination

The *Data Determination service* is responsible for collecting information from both Base Stations and connected Social Networks. From the Base Stations, details like the location and each BS's range are defined, while the crawling of data from Social Networks is limited to the users that are located in each BS's range.

Fig. 3 states the main business processes identified for the *Data Determination service* and show how they map to application layer entities (namely application functions).

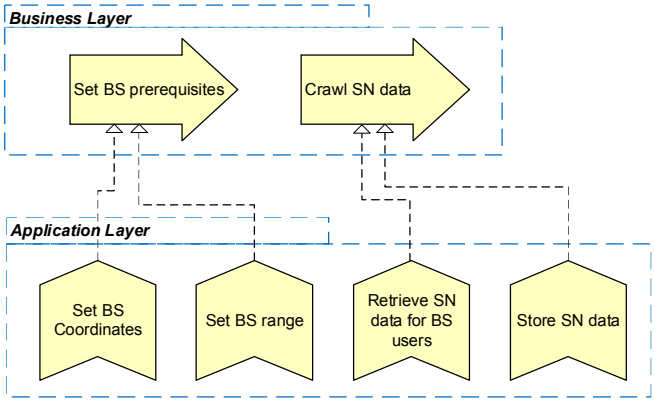

Fig. 3 Data Determination – mapping business layer to application layer.

As shown, the following functions have been identified for the application layer:

- *Set BS Coordinates*: this application function declares the coordinates of the corresponding Base Station.
- *Set BS range*: this application function is responsible for estimating the range of the corresponding Base Station.
- *Retrieve SN data for BS users*: this function limits the crawled data from the Social Networks for users that are located inside the BSs' range.
- *Store SN data*: the retrieved data that refer to the specific BS and its users are stored in the SNDB (Social Network Database) through this application function.

Fig. 4 illustrates application functions and components together with relevant interfaces, main data objects and information flows for the *Data Determination service*.

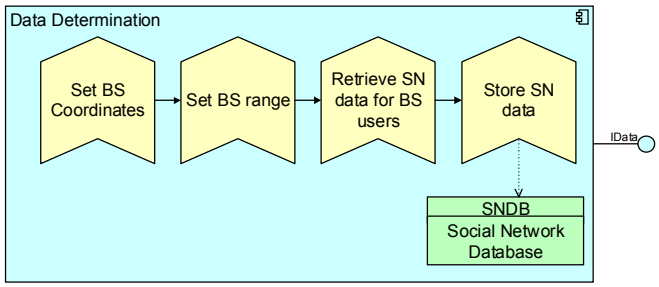

Fig. 4 Data Determination – main application components, functions, interfaces and data objects.

IV. Machine-Learning Engine Training

The *Machine-Learning Engine Training service* is responsible for the centralized training of machine-learning engines which will be used by Intelligent Decision Making service (described in Section V). The centralized training is made on the software-based controller side.

Fig. 5 summarized the main business processes identified for the *Machine-Learning Engine Training service* and shows how they map to application layer entities.

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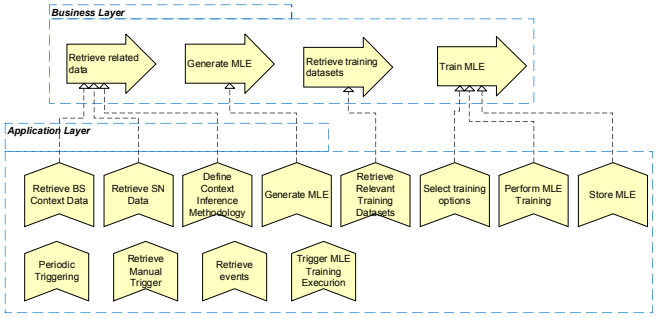

Fig. 5 Machine-Learning Engine Training – mapping business layer to application layer.

As observed from the diagram presented, the application functions can be divided into two categories. The following application functions have been identified for the first category:

- *Retrieve BS Context Data*: this application function is responsible for retrieving context data related to the specified Base Station.
- *Retrieve SN Data*: the data that were stored in the SNDB (Social Network Database) and are related to the specified Base Station, are retrieved through this application function.
- *Define Context inference methodology*: this function is responsible for applying inference mechanisms in order to infer knowledge from the retrieved data.
- *Generate MLE*: this application function is responsible for the creation of Machine-Learning Engines that will be used for the training process.
- *Retrieve Relevant Training Datasets*: this application function retrieves the relevant dataset that will be used for the training process from the MLTDB (Machine Learning Training Database).
- *Select training options*: this application function selects and defines the training options for training the datasets.
- *Perform MLE Training*: MLE training is performed on this application function with regard to the retrieved training datasets and the options that were defined in the previous application functions.
- *Store MLE*: the resulting MLEs are stored in the MLEDB (Machine Learning Engine Database) through this application function.

The above mentioned application functions are implemented by the application component named *MLE Training Execution*.

The application functions of the second category are:

- *Periodic Triggering*: this application function periodically sends messages to trigger the Machine-Learning Engine Training.
- *Retrieve Manual Trigger*: this application function allows manual triggering of the Machine-Learning Engine Training.
- *Retrieve events*: this application function triggers the Machine-Learning Engine Training based on events.
- *Trigger MLE Training Execution*: this application function is responsible for triggering the *MLE Training Execution* component, after it receives the appropriate message from the above functions.

These application functions are implemented by the application component named *MLE Training Scheduler*. The main purpose of this component is to initiate the generation of new MLEs and its application functions are not mapped to any business layer processes. Fig. 6 illustrates application functions and components together with relevant interfaces, main data objects and information flow.

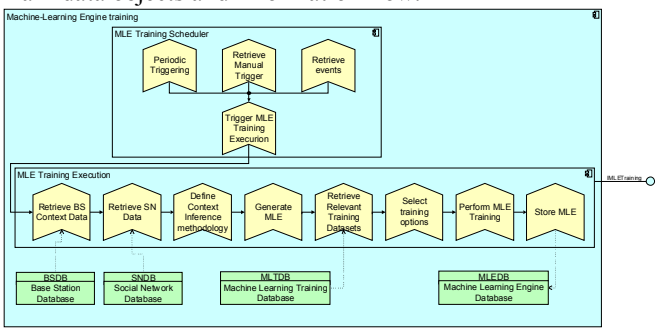

Fig. 6 Machine-Learning Engine Training – main application components, functions, interfaces and data objects.

V. Intelligent Decision Making

The *Intelligent Decision Making service* is responsible for taking into account the current status of the software-based controller and using the trained MLEs reaches to decisions such as resource allocation, energy efficiency etc.

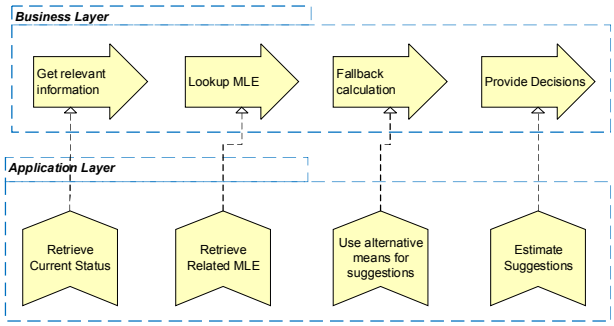

Fig. 7 Intelligent Decision Making – mapping business layer to application layer.

Fig. 7 states the main business processes identified for the *Intelligent Decision Making service* along with their mapping to the application layer entities.

The applications that can be identified from the presented diagram are the following:

- *Retrieve Current Status*: this function retrieves details about the current status of each BS which is part of the software-based controller.
- *Retrieve Related MLE*: the MLE that has been trained from the *Machine-Learning Engine*

training service is retrieved from the MLEDB (Machine Learning Engine Database).

- *Use alternative means for suggestions*: in case there is any problem retrieving data required for successfully estimating the suggestions list, such as no relevant MLE having been created yet, this function uses a fallback mechanism to provide estimations with alternative means.
- *Estimate Suggestions*: This function finally provides the estimated list with suggestions that will assist the decision making process.

Fig. 8 illustrates application functions and components together with relevant interfaces, main data objects and information flows for the *Intelligent Decision Making* service.

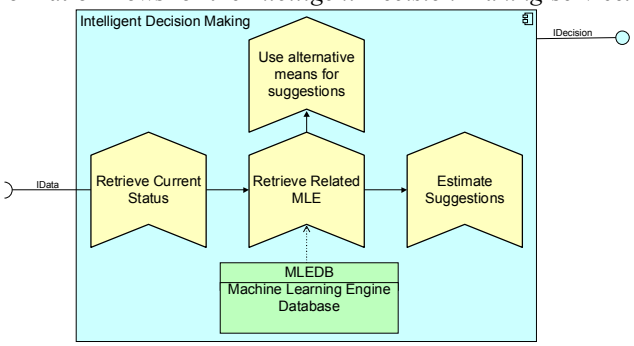

Fig. 8 Intelligent Decision Making – main application components, functions, interfaces and data objects.

VI. Conclusions

In this paper, we have discussed a novel approach for extracting knowledge from online Social Networks, in order to assist software-based controllers that rely on SDNs. The application and business layers of the identified architecture, including foreseen components and their interactions, were presented in detail. Further research activities include the testing and validation of the discussed approach, proving the concept's wide degree of feasibility.

Acknowledgment

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Voice Processing for Sobriety Test: Its Scope and Application

Myung-sook Kim and Myung-jin Bae

***Abstract*—**Human voices contain robust information about the speaker, including his/her current physical and emotional conditions. Thus, voices can be utilized for many practical purposes to make our daily lives more comfortable and safe. This paper will explore the previous and current research on the most effective and reliable way to process human voices for a sobriety test, a test to determine whether or not the speaker is intoxicated based on his/her voice qualities. Frequency domain, time domain and transform domain are parameters that have been accommodated to process voices for the said sobriety test. Additional factors like age and gender are also taken into account to yield more reliable and accurate judgments so that the voice sobriety test can be applied and implemented in a variety of relevant fields, such as testing captains at sea remotely.

***Keywords*—**Frequency domain, sobriety test, time domain, transform domain, voice processing.

I. Introduction

HUMAN voices are robust in information about the speaker, including his/her gender, age and body type. Voices can also tell us about the current conditions of a certain speaker including his/her health and/or emotional conditions. This is because some characteristics of the human voice can change depending on the internal as well as the external environment in which the speaker faces. Therefore, voices can be processed and utilized to identify a specific condition of the speaker in a certain environment.

Among the many possible applications for the human voice, the use of human voice for sobriety test can be considered as one of the most prospective cases in the field. The voice sobriety test can determine whether the speaker in question is sober or intoxicated and therefore whether he/she should be prohibited from driving any type of vehicle, based on noticeable changes in his/her speech before and after drinking alcohol.

The voice sobriety test has many advantages compared to the traditional sobriety tests, such as the field sobriety test (walking straight on the line), the blood test (taking blood sample to measure alcohol level in blood), or the breathalyzer test (breathing into the breathalyzer to measure alcohol level in breaths). Firstly, it needs no physical contact between the tester and testee (one of the compulsory requirements for the traditional tests), since the voice can be wired through communication devices if necessary. Secondly, the test can be implemented anytime and anywhere by anyone, since the voice processing program automatically determines the degree of intoxication and delivers the warning on the spot to relevant parties in question. Especially in case of sailing under the influence, which is very common, implementation of the sobriety test based on speech analysis through wireless communication can be the best and the most effective way to prevent accidents without needing physical contact. The scope and applications of the sobriety test will be discussed in more details in Chapter VI.

Research on this topic has been going on for a couple of years since 2012 in the Sori Sound Engineering Lab of Soongsil University, Seoul, Korea, led by Prof. Bae, Myung-jin, a co-author of this paper. The lab research team is now working on improving the correct judgment rate for intoxication so that the program can be readily installed and implemented in all the vessels sailing around the Korean Peninsula.

The purpose of this paper is to explore the previous research in the topic of voice processing for sobriety test as well as the recent advancements to improve the correct judgment rate. Chapter 2 outlines the voice production process as well as the voice production model used in the research, and explains the typical changes in human voice when intoxicated. Chapter 3 explores the ongoing research on the topic examining parameters from relevant domains in voice processing. Chapter 4 discusses results and limitations of previous research. It also simulates some additional factors to improve the correct judgment rate for better results. Chapter 5 wraps up the paper with further evaluating the scope and application of the voice sobriety test for its practical realizations in the near future.

II. Changes in Voice When Intoxicated

Human beings produce (or articulate) desired speech sounds by utilizing speech organs, or the vocal tract (the collective term of the pharyngeal cavity, the oral cavity and the nasal cavity) while breathing out the air from the lung. We produce various sounds in diverse manners of articulation such as voiced and voiceless sounds, plosive and fricative sounds, as well as in different places of articulation inside of our vocal tract, such as labial sound around lips and alveolar sound.

The voice production model used this paper is illustrated in Fig.1 below.

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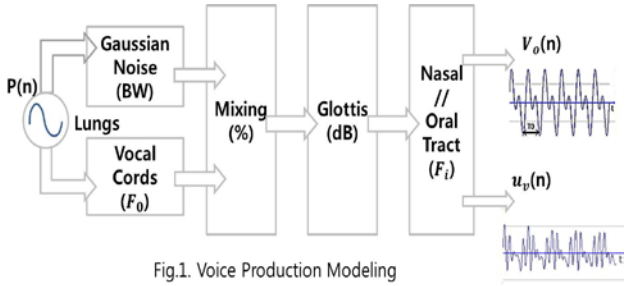

Fig.1. Voice Production Modeling

In this modeling, Gaussian noise is considered as one of input source for the processing, in addition to fundamental frequency from vocal cords, since the human voice as well as telecommunication channels and computer networks evidently produce turbulent sound and noise. Detailed explanation for the voice production modeling used in this paper can be found in Baek and Bae (2013). [1]

When we drink, the alcohol contacts the vocal tract first before getting absorbed into the esophagus and the gastrointestinal tract. Continuous intakes of hard liquor, such as whiskey, soju (Korean hard liquor), and vodka may act as strong stimuli to mucous membrane, which surrounds the esophagus or the top layer (epidermis) and cause dehydration in these organs including the vocal tract. Needless to say, most alcoholic beverages have diuretic effects aggravating dehydration.

As dehydration occurs in these organs, the flexibility and elasticity of the vocal cords may be reduced and thus we may experience incomplete opening/closing of the vocal cords, especially when subglottal pressure is applied. Eventually the clarity of pronunciation becomes degraded. [2] The incomplete opening/closing of the glottis boosts the threshold pressure for phonation, so that the speaker needs more power to initiate and maintain the phonation and therefore the energy (or amplitude) of the voice increases. The pronunciation (or articulation of sounds) starts late and it gets less accurate due to the difficulty of uttering the fast speech. With decreased clarity of pronunciation and increased amplitude of the voice, the pitch can play an important role as a parameter to detect changes in voice when intoxicated. Nasalization of the voice should also be detected from the voice intoxicated. [3][4]

Changes in voice when intoxicated are comparatively illustrated in Fig. 2 showing waveforms of voices before and after drinking.

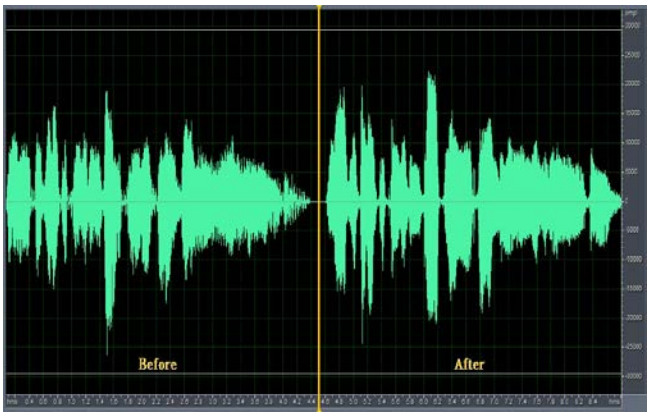

Fig. 2 Waveforms of voices before and after drinking

III. Parameters for Voice Sobriety Test

Parameters used in voice processing for sobriety test can be observed mainly from two basic domains: the time domain and the frequency domain. There are, of course, additional factors to be considered as parameters for voice sobriety test, which will be dealt with in transform domain, a hybrid domain of time and frequency.

A. Time domain

In the time-domain, the intoxicated voice shows some unique characteristics. Firstly, the inconsistency of loudness appears more pronounced than in the sober voice. Secondly, the sound volume is not maintained uniformly, especially in smaller sound production. Thirdly, the intoxicated voice shows an energy distribution in which its ratio increases for higher levels. All of these characteristics are considered to be results of decreased auditory function when intoxicated. The speaker speaks in a louder voice, opens his/her mouth wider, and thus his/her lung capacity tends to increase. Therefore, from the time domain, the change of energy to produce voice is one of the parameters for used in processing. In voice processing, the energy level was calculated for each frame followed by the comparison between the energy of the front and rear parts of the speech signals. [1]

B. Frequency domain

In the frequency domain, we also get some unique characteristics of the intoxicated voice including nasalization of the voice caused by drinking alcohol. [4] The nasalized voice tends to have wider formant bandwidth. The speaker produces louder voice while opening his/her mouth wide and thus the lowest formant shows differences from that of the sober voice. The different position of the tongue (being positioned further back than usual) also affects the size of the second formant. Therefore, the relationship between the slope of the first and fourth formant (F14) and the slope of the second and fourth formant (F24) can be captured in the expression of 'F14 < F24.' [1]

It is true that the judgment (decision of whether the speaker is intoxicated or sober) can be made possible by applying the expression calculating the value of F14 and F24. However, the second and third formants tend to fluctuate depending on the shape and size of articulatory organs while the fourth formant is not sensitive to this factor. Therefore, voice processing for sobriety test uses the slope between the first and fourth formant as the only meaningful parameter.

The algorithm developed for utilizing time domain as well as frequency domain is weighted based on the accuracy of judgment for the intoxicated voice. The specific algorithms are explained in Baek and Bae (2013). [5]

C. Transform domain

There are some additional factors we should consider in order to get a better judgment rate. We may call it transform domain, a hybrid domain of time and frequency domain. There

are two parameters accommodated into the voice sobriety test: the linear predictive coding and formant energy distribution.[3][6]

Before elaborating the transform domain further, it is worth mentioning some of the general acoustic features of the formants. The first formant is related to the opening extent of mouth. When mouth is more open, the first formant is higher. Conversely, the first formant is lower when mouth is less open. The first formant is low at high vowels and high at low vowels. Additionally, the first formant becomes low when the narrowing point appears at the front part of the vocal tract, while it becomes high when the narrowing point appears at the back part of the vocal tract. The second formant is high at front vowels and low at back vowels. As the narrowing point occurs at the more front part of glottis and palate, the second format gets higher. As the narrowing occurs nearer to lip or soft palate, the second format gets lower. The third formant gets higher when the narrowing point occurs nearer to glottis, soft palate and teeth ridge. It gets low when the narrowing point occurs at the upper side of lip, soft palate and pharynx. Generally speaking the third and higher formants identifies individual characteristics in human voices. [7]

The spectrum of the intoxicated voice appears flat ranged from the higher frequencies to the lower frequencies. That is, it has a flatter slope. Therefore, the slopes of the first formant and the fourth formant for the intoxicated voice are flat. Considering this factor, the judgment rate has been improved using the linear predictive coding in order to use the formant parameters. Error between linear coefficients of high order and low order found is called the residual signal. From this signal, a slope between the first formant and the second formant is calculated. If this slope is close to zero, intoxication is confirmed through linear predictive coding methods.

We also employ a new parameter from transform domain, formant energy distribution, for differentiating voiced sound and unvoiced sound coming out of speech signals. The number of peak values in the wave patterns of speech signals is a crucial factor in determining whether or not a certain sound is voice or unvoiced. If the number of peak value is too small or too big, it is considered either a silent sound section or unvoiced sound section; therefore, it will be excluded from evaluation. [8]

IV. Results and Limitations

Voice samples were taken from each age group between 20's and 60's. 22 standard samples were used when developing the algorithm; for standard samples, the same sentence was phonated and a male voice without any dialectal accent was selected as the sample voice. The words and sentences used in voice sample were carefully selected out of difficult words to pronounce.

Voice samples were prepared by recording the voice of each person before and after drinking, using an mp3. Sound level meter was used when recording in a noisy place. In addition, the degree of alcohol was measured using a breathalyzer before recording; the voice of the same person may have been recorded multiple times to improve the accuracy. The timing of the recording after drinking was determined by subjective feelings and general statistical data, which is generally 1-2 hours after drinking 120% of the individual drinking capacity of each person.

The voice files were edited using Adobe Audition program; several sentences pronounced by the same person were edited in constant time intervals and rules. Mat-lab and C programs were used to simulate the development of an algorithm in order to extract the parameters for determining intoxication. The result is illustrated in Fig. 3 below.

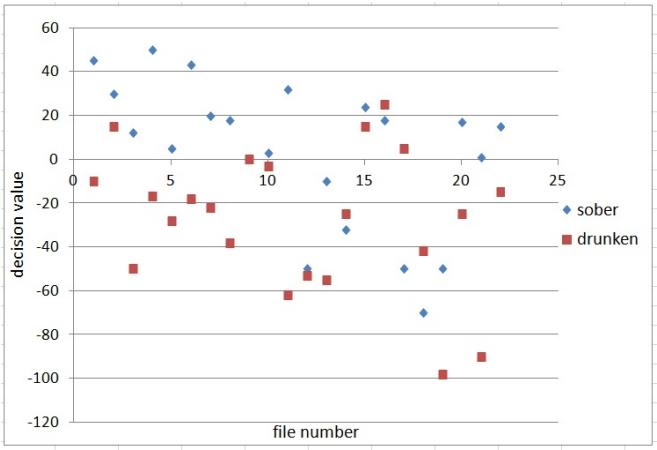

Fig. 3 Judgment results for intoxication

Applying the algorithms developed for the voice sobriety test using extracted and weighted parameters, the judgment rate of intoxication was determined to be 77%. Although the result is not that disappointing, we have been continuously trying to improve the judgment rate.

V. Recent Advancements

One of the major problems in the voice processing algorithms we have discussed so far is age. The younger the speaker is, the more challenging the detection of changes in voice. When we compensated the age factor into voice processing, it produced a promising result for improvement in judgment rate, increasing from 77% to 82-85%. The result clearly shows the improvement in judgment for the intoxication if we employ an additional process of compensating age. Although it is true that we still have cases which were evaluated as sober but drunk in reality and vice versa, the result is very promising with the correct judgment rate of 82-85%. Gender may be a relevant compensation factor to be accommodated in the next step of the research in order to improve the judgment rate although this paper cannot go into more details.

The flow chart of voice processing employed in the recent advancements can be illustrated as in Fig. 4.

VI. Voice Sobriety Test: Its Scope and Application

Voice sobriety test can be one of the most effective ways to prevent accidents caused by operating any type of vehicle under the influence of alcohol. The voice sobriety test does not require a direct contact between the tester and testee since the voice can be wired through communication channels at anytime,

anywhere and by anyone to be processed for the test. Therefore, the scope and applications of voice sobriety test is equally wide and flexible for now and expected to expand in the future.

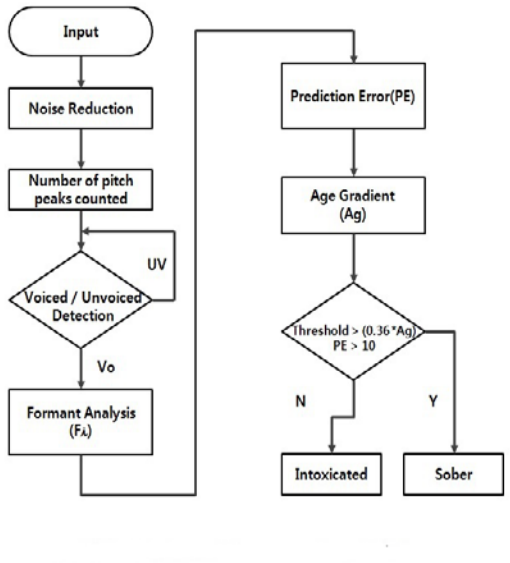

Fig. 4 Flow chart of voice processing for sobriety test

For example, the annual report for the cases of drunk sailing published by the Road Traffic Authority of Korea shows that the number of the cases is quite large (about 30,000 cases a year between 2007 and 2011). As far as accidents related to ships are concerned, there are two representative characteristics on the Korean sea in particular. Firstly, once the accident occurs, large damage is likely suffered even though the accident could have been prevented, since they were caused by human errors. Secondly, there were many cases the initial accidents causing secondary damages including contamination of the water around the vessel. [9] Therefore, we can conclude that the accidents at sea can be prevented from the very beginning if we are able to combat drunk sailing through sobriety tests.

To prevent drunk sailing, the police invoked a policy for measuring blood alcohol level before sailing. According to the 2011 report by Korea Coast Guard, the number of cases for measuring blood alcohol level on the sea is decreasing while number of crackdown cases for drunken sailing has stayed constant. Since measuring blood alcohol level is difficult to enforce at sea, voice sobriety test can be a reliable alternative. Since it is not unusual to communicate frequently between the ship and the land, a voice sobriety test can be used to detect changes in voice when intoxicated. In addition, data is plentiful enough to be processed for determining whether or not the speaker is intoxicated.

This paper certainly confirms that the voice sobriety test is an effective and reliable way to be utilized for many practical purposes. Provided that more parameters are accommodated for the test in order to give a better judgment rate in the future research, the voice sobriety test will be able to replace all the traditional sobriety tests and contribute to reduce the accident rate due to safety negligence in operating any type of vehicles.

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Speaker Recognition System Based on AR-MFCC and SAD Algorithm with Prior SNR Estimation and Adaptive Threshold over AWGN channel

Riadh AJGOU, Salim SBAA, Said GHENDIR, Ali CHAMSA and A. TALEB-AHMED

***Abstract*—**In this paper, robust feature extraction and efficient speech activity detection algorithm are proposed for improvement in remote speaker recognition system over AWGN (Additive White Gaussian Noise) channel. Moreover, The system employs a robust speech feature based on AR-MFCC modeled with GMM model and applying an efficient speech activity detection (SAD) algorithm with adaptive threshold. Furthermore, the proposed speech activity detection algorithm is based on Zero Crossing Rate and Energy Measurements with prior SNR estimation by estimating noise. variance where the algorithms were implemented and tested in MATLAB. Besides, Feature extraction requires much attention because recognition performance depends heavily on this phase. The Mel-Frequency Cepstral coefficient (MFCC) is a very useful feature for speaker recognition in clean conditions but it deteriorates in the presence of noise. Thus, in our work, feature extraction framework based on the combination of MFCC and Autoregressive model (AR) parameters has been proposed. , the TIMIT database with speech from 630 speakers has been used in MATLAB simulation. The first four utterances for each speaker could be defined as the training set while 1 utterance as the test set. The use of AR-MFCC approach has provided significant improvements in identification rate accuracy when compared with MFCC. However, in terms of runtime, AR-MFCC requires more time to execute than MFCC

***Keywords*—S**peaker recognition, AR-MFCC, GMM; SAD; EZR.

I. Introduction

Speaker recognition is the ability of recognizing a person only from his voice. The most difficult tasks in the speaker recognition are feature extraction, speaker modeling and Speech/non-speech determination witch known as speech activity detection (SAD). The Gaussian mixture model (GMM) is the most common approach for speaker modeling in text-independent speaker recognition [1, 2]. Otherwise, the well known feature extraction method is Mel Frequency Cepstral Coefficients (MFCC) [3, 4]. However, MFCC's are very useful features for speech processing in clean conditions and performance using MFCC features deteriorates in the presence of noise [5]. Furthermore, Autoregressive models, is also important to represent speech signal[6, 7]. Thus, In our work we suggest to improve the speaker identification accuracy by combining MFCC and autoregressive features in noisy environment. Furthermore, in our work we have proposed a SAD algorithm based on adaptive threshold to speech/non speech detection.

In this paper, a robust feature extraction (AR-MFCC) and efficient speech activity detection algorithm are proposed for improvement in remote speaker recognition system over AWGN (Additive White Gaussian Noise) channel.

There are several possibilities for the implementation of a remote *speaker/speech recognition system over a digital channel* [8]. The recognition is usually performed over features extracted from the decoded signal, although it is also possible to extract the recognition features directly from the codec parameters. Figure 1 shows a scheme of this system architecture where the implementation is over an IP network [8].

Our proposal speaker identification system on the remote communication channel is described in more detail in the next section.

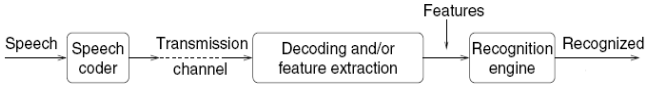

Fig.1 Scheme of a network speaker/speech recognition system

II. Configuration of the Proposed System

The system we used for experiments include a remote text independent speaker recognition system which was established according to the following diagram in Figure 2.

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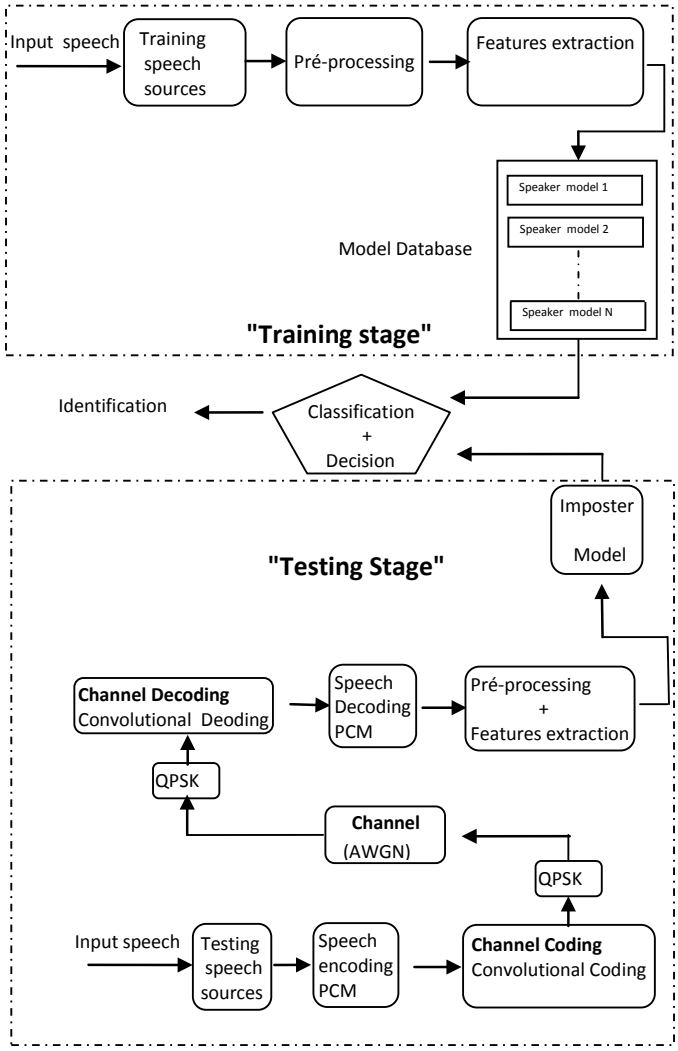

Fig.2 Block diagram of the Proposed system

A. *Training phase*

In the training stage, pattern generation is the process of generating speaker specific models with collected data. The generative model used in speaker recognition is the Gaussian mixture model (GMM)[1, 2]. The system was trained using speakers from the TIMIT database [9] where we have chosen 200 speakers from different regions. Moreover, in the training stage, we have used four utterances for each speaker. Speech signal passed through pre-processing phase (emphases + speech activity detection). We emphasize the speech using a high pass filter. Commonly a digital filter with 6dB/ Octave is used. The constant μ in equation (1), is usually chosen to be 0.97 [10] :

$$y(z) = 1 - \mu z^{-1} \tag{1}$$

After emphasizing phase, silence segments are removed by the speech activity detection algorithm SAD [11], so that sixty-four coefficients are extracted (32 mel-frequency cepstral coefficients and 32 parameters of the Autoregressive model) and models characterization using GMM are formed.

B. *Testing phase*

Speech signal is coded using PCM code. In addition, a convolutional code [8], with a rate of ½ as channel forward error correction, has been introduced in order to make the channel more robust to noise, the coded signal is then transmitted through AWGN channel. After demodulation (QPSK), convolutional decoding, and PCM decoding, the binary data is converted back to a synthesized speech file. as a final point, from file synthesized speech, MFCC coefficients and AR parameters are extracted.

C. *D*ecision phase

Pattern matching is the task of calculating the matching scores between the input feature vectors and the given models. The GMM forms the basis for both the training and classification processes. The principle of GMM is to abstract a random process from the speech, then to establish a probability model for each speaker [1, 2]. A Gaussian Mixture density is a weighted sum of M component densities as shown in figure 3.

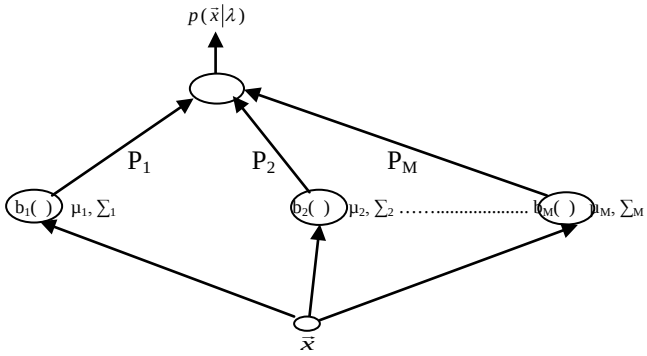

Fig.3 M probability densities forming a GMM

In the GMM model, the features distributions of the speech signal are modeled for each speaker as follows [12]:

$$p(\bar{x}/\lambda) = \sum_{i=1}^{M} P_i \; b_i(\bar{x}) \tag{2}$$

Where: $$\sum_{i=1}^{M} P_i = 1 \tag{3}$$

And x is a random vector of D-dimension, $p(x/\lambda)$ is the speaker model; *pi* is the i[th] mixture weights; *b*i(x) is the i[th] pdf component that is formed by the i[th] mean μ_i and i[th] covariance matrix, where i = 1,2,3,…,*M*. *M* is the number of GMM components [12], each density component is a D-variants Gaussian distribution of the form:

$$b_i(\bar{x}) = \frac{1}{(2\pi)^{D/2}.\left|\sum_m^s\right|^{1/2}} \exp\left[-\frac{1}{2}(\bar{x}-\overline{\mu_i})'(\sum_i^{-1})(\bar{x}-\bar{\mu}_i)\right] \tag{4}$$

A statistical model for each speaker in the set is developed and denoted by λ. For instance, speaker *s* in the set of size *S* can be written as follows [1]:

$\lambda_s = \left(P_i, \bar{\mu}_i, \sum_i\right)$, i=(1.....M), s= {1.....S} (5)

1) ML Parameter Estimation Steps (training)

To obtain an optimum model for each speaker we need to obtain a good estimation of the GMM parameters. The Maximum-Likelihood Estimation (ML) approach can be used; where for a given *T* vectors used for training, **X**=(*x*1,*x*2,...,*xT*), the likelihood of GMM can be written as [1]:

$$p(X/\lambda_s) = \prod_{t=1}^{T} p(x_t/\lambda_s) \quad (6)$$

Since it's impossible to directly maximizes a nonlinear function with GMM likelihood approach, the ML estimations can be done using the EM algorithm iteratively [12]. The training phase consists of two steps, namely *initialization* and *expectation maximization (EM)*. The initialization step provides initial estimates of the means for each Gaussian component in the GMM model. The EM algorithm recomputed the means, covariances, and weights of each component in the GMM iteratively. The EM algorithm steps and formulas are [1,12]:

- new estimates of *'i'* th weight :

$$\bar{P}_i = \frac{1}{T}\sum_{t=1}^{T} P(i \setminus x_t, \lambda) \quad (7)$$

- new estimates of mean:

$$\bar{\mu}_i = \frac{\sum_{i=1}^{T} P(i \setminus x_t, \lambda) x_t}{\sum_{n=1}^{N} P(i \setminus x_t, \lambda)} \quad (8)$$

- New estimates of diagonal elements of *'i'* th covariance matrix [1,12]:
-

$$\bar{\sigma}_i^2 = \frac{\sum_{i=1}^{T} P(i \setminus \bar{x}_t, \lambda) x_t^2}{\sum_{n=1}^{T} P(i \setminus \bar{x}_t, \lambda)} - \bar{\mu}_i^2 \quad (9)$$

- where the likelihood a *posteriori* of the i-th class is given by posterior probability [1,12]:

$$P(i \setminus \bar{x}_t, \lambda) = \frac{p_i b_i(\bar{x}_t)}{\sum_{k=1}^{M} P_k b_k(\bar{x}_t)} \quad (10)$$

This process is repeated until convergence is achieved.

2). Classification based on GMM

After estimating the GMM models for each speaker, the problem is to find a model with maximum likelihood posteriori for an observation sequence. The input to the classification system is denoted as [12]:

$$X = \{x1, x2, x3, \ldots, x_T\}. \quad (11)$$

The rule through which we determine whether *X is* coming from speaker *'s'* can be stated as:

$$p(\lambda s \mid X) > p(\lambda r \mid X), \quad r = 1, 2, \ldots, S \ (r \neq s) \quad (12)$$

The classification system needs to compute and find the value of *'s'* that maximizes $p(\lambda s \mid X)$ according to [12] :

$$\hat{S} = \arg\max_{1 \le s \le S} P(\lambda_s \setminus x) = \arg\max_{1 \le s \le S} \frac{P(x \setminus \lambda_s)\Pr(\lambda_s)}{P(x)} \quad (13)$$

The classification is based on a comparison between the probabilities for each speaker. If it can be assumed that the prior probability of each speaker is equal, then the term of $p(\lambda s)$ can be ignored [12]. The term $p(X)$ can also be ignored as this value is the same for each speaker, so $p(\lambda s \mid X) = p(X \mid \lambda s)$, where [12]:

$$p(X/\lambda_s) = \prod_{t=1}^{T} p(x_t/\lambda_s) \quad (14)$$

The speaker of the test data is statistically chosen according to [1, 12]:

$$\hat{S} = \arg\max_{1 \le s \le S} P(x \setminus \lambda_s) \xrightarrow{take \log} \hat{S} = \arg\max_{1 \le s \le S} \sum_{t=1}^{T} \log P(\bar{x}_t \setminus \lambda_s) \quad (15)$$

D. Proposed feature extraction

We combined MFCC features with autoregressive model coefficients. The number of coefficients is 64 (32 MFCC and 32 AR). Figure 4 shows the process of MFCC calculation.

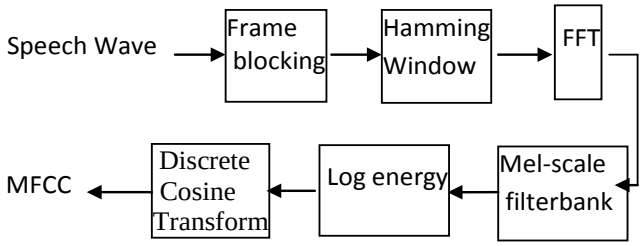

Fig.4 MFCC calculation

Autoregressive models are widely used models, [13]. In general, the number of prediction coefficients $\{a_1, a_2, \ldots a_P\}$ is infinite since the predictor is based on the infinite past, In our case, we limited the number of coefficients to 32 (p=32). The calculation of AR coefficients has been carried out by the Yule-Walker method [13], this method solves the Yule-

Walker equations by means of the Levinson Durbin recursion. The Autoregressive Model (signal model B(z)) is an all-pole filter of the type [13,14]:

$$B(Z) = \frac{1}{A(Z)} = \frac{1}{1 + a_1 Z^{-1} + a_2 Z^{-2} + ...a_p Z^{-p}} \quad (15)$$

Where:

$$A(Z) = 1 + a_1 Z^{-1} + a_2 Z^{-2} + ...a_p Z^{-p} \quad (16)$$

III. ROPOSED SAD ALGORITHM WITH ADAPTIVE THRESHOLD

The robust SAD algorithm is based on two original works [15] and [16]. In [15] the author had used the LPC residual energy and zero crossing rates to detect speech activity using adaptive threshold, where this threshold is calculated for every frame introduced in comparison with previous calculated features of frames. This means probable mistakes for the first frames since the algorithm is initiated and spans up to a few frames (0-15) frames considered as non-speech. The second author in [16] used energy and zero crossing rates ratios to voiced/non voiced classification of speech using a fixed threshold.

Our robust SAD is based on Energy and Zero crossing rate Ratios (EZR) using adaptive threshold mechanism for the detection of voiced segments. Furthermore, the threshold makes use of signal to noise ratio measure for the detection of speech segment. The procedure of calculating threshold is as follows:

A. Segmenting the whole speech signal into frames :

At first the speech signal segmented into frames of 8ms with rectangular window and without overlapping.

B. Calculating energy and zero crossing rate:

we calculate short term energy $\overline{E}[m]$ and zero crossing rate ZCR[m] [17]:

$$\overline{E}(m) = \sum_{n=0}^{N-1} x^2(n).w(m-n) \quad (17)$$

Where: w is a rectangular window of length N (length of a frame) and x(n) is the frame signal with N samples. ZCR is defined as [17, 18]:

$$ZCR(m) = \sum_{n=0}^{N-1} \left| \text{sgn}[x(n)] - \text{sgn}[x(n-1)] \right| w(m-n) \quad (18)$$

Where sgn(.) is the signum function which is defined as [17, 18]:

$$\text{sgn}[x(n)] = \begin{cases} +1, x(n) \geq 0 \\ -1, x(n) < 0 \end{cases} \quad (19)$$

C. Calculating the ratio of the average energy and zero crossing rate (EZR)

Usually speech segments have high energy and low zero crossing rate and nonSpeech segments have low energy and high zero crossing rate. Thus, our method works on the principle of extracting energy and zero crossing rate features from the input speech signal. So that, we calculate the ratio of the energy average and zero crossing rate (EZR) and comparing them to the threshold to classify the frames into speech and nonSpeech classes.

If the EZR of the frame is greater than the threshold, the frame is judged as a speech frame. Otherwise, the frame is considered to be non-speech frame (the recognition system does not extract features from this frame which leads to a good recognition rate):

$$EZR[m] = \frac{\overline{E}[m]}{ZCR[m]} \quad (20)$$

D. Calculating the maximum and minimum of EZR

After segmenting speech signal into frames, we calculate EZR for each frame. So that, we calculate the values of minimum and maximum of EZRs.

E. Signal-to-Noise Measure of speech signal by assuming noise variance

Our SAD algorithm requires a knowledge of SNR to estimate threshold. There are two possibilities of SNR calculation. One is to estimate the ratio of the signal power and the noise variance directly where noise variance is a measure of the statistical dispersion of the noise magnitude of a received signal; the other is to obtain the signal power estimate and the noise variance estimate. SNR estimation is as [19]:

$$\text{SNR}_{dB} = 10 \log_{10} \left(\frac{\sigma_s^2}{\sigma_v^2} \right) \quad (21)$$

where σ_s^2 is the variance value of the signal and σ_v^2 is the variance value of the noise process.

In this section, we describe the method of estimating noise variance from the given segment of the noisy signal. In the presence of additive white Gaussian noise *v(n)*, the observed signal y(n) can be written as [14]:

$$y(n) = x(n) - v(n) \quad (22)$$

where *x (n)* is the uncontaminated signal and *v (n)* is the zero-mean white noise of variance σ_v^2. The aim here is to estimate the noise variance σ_v^2, from the observed noisy signal *y (n)*. In order to solve this problem, we assume that the uncontaminated signal *x(n)* follows the *p*-th-order AR model (Eq 15). AR parameters *ai* satisfy the following set of Yule-Walker equations [20]:

$$\sum_{k=1}^{p} a_k R_x(|i-k|) = -R_x(i) \quad , \quad i > 0 \tag{23}$$

where $R_x(i)$ are the autocorrelation coefficients of the uncontaminated signal $x(n)$. Since the additive noise $v(n)$ is white, the autocorrelation coefficients $R_x(i)$ of the uncontaminated signal $x(n)$ are related to the autocorrelation coefficients $R_y(i)$ of the noisy signal $y(n)$ as follows [20]:

$$R_x(0) = R_y(0) - \sigma_v^2 \tag{20}$$

and

$$R_x(i) = R_y(i) \tag{21}$$

We have three-step procedure for estimating the noise variance σ_v^2. These steps are outlined below [19]:

Step *1:* From the observed (noisy) signal $y(n)$, compute the unbiased estimates of the autocorrelation coefficients $R_y(i)$, i = 0,1.., p + *q*. where $q > p$.

Step 02: Compute the least-squares estimate of AR coefficients by using the Cadzow's method [20] from the q(>p) high-order Yule-Walker equations [i=p+1, p+2,...,p+q].

Step 3: Use the AR coefficients obtained from Step 2 and compute the least-squares estimate of the noise variance from the over-determined set of p low-order Yule-Walker equations [i = 1, 2, . . 1 , p]. This is given by:

$$\sigma_v^2 = \left[\sum_{k=1}^{p} a_i \left\{R_x(i) + \sum_{k=1}^{p} a_k R_y(|i-k|)\right\}\right] \Big/ \sum_{i=1}^{p} a_i^2 \tag{22}$$

After noise variance estimation σ_v^2, we estimate the variance value of the signal σ_s^2 and calculate the noised signal variance σ_x^2 (Speaker signal + AWGN):

$$\sigma_s^2 = \sigma_x^2 - \sigma_v^2 \tag{23}$$

From equation 21 we have:

$$\mathrm{SNR}_{dB} = 10\log_{10}(\sigma_s^2) - 10\log_{10}(\sigma_v^2) \tag{24}$$

F. Threshold Adaptation and Decision

SAD algorithm calculates EZRs of all frames (for speaker's signal) and estimate threshold by:

$$Threshold = \min(EZRs) + \alpha * [DELTA] \tag{25}$$

$$DELTA = \max(EZRs) - \min(EZRs) \tag{26}$$

α: is a real number in the interval of]0,1[. The value of α depends on noise level (SNR). To estimate "α" value, a work is done. The results are reported in Table 1. These results, show that to have high identification accuracy we increase the value of α as SNR level increase. Threshold calculation procedure can be represented by the figure 5.

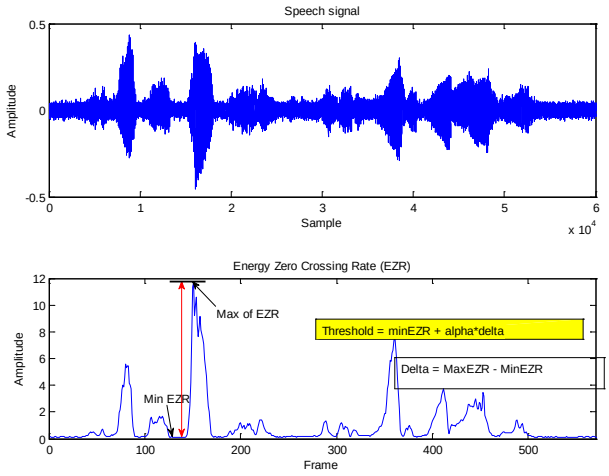

Fig.5 Illustration of Threshold calculation (SNR= 10dB, α=0.2)

G. Implementation

The method is described by the diagram shown in figure 6.

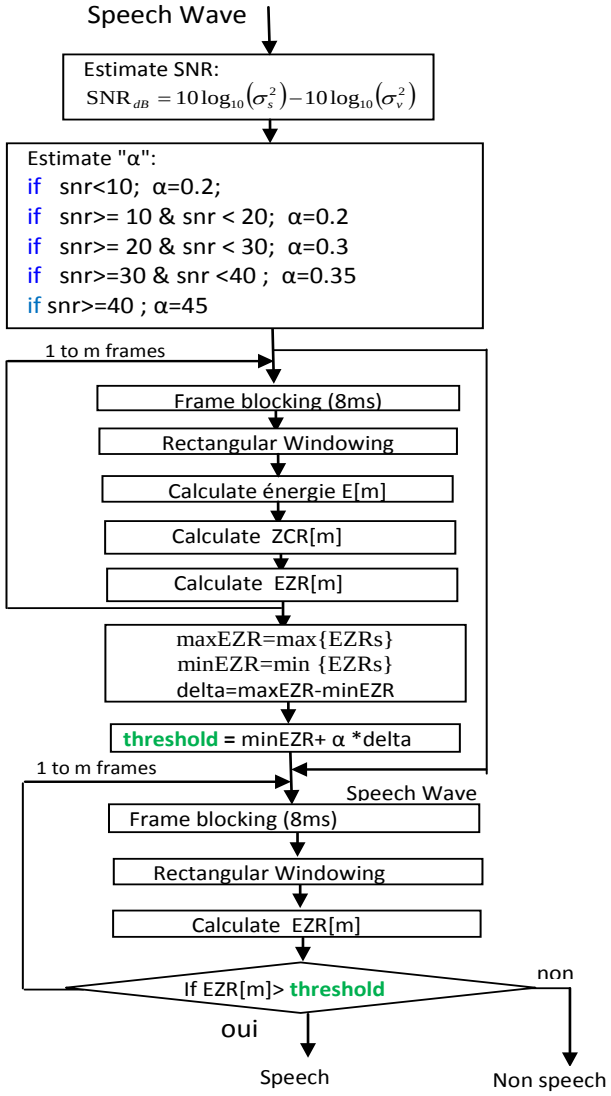

Fig. 6 Block diagram for the SAD algorithm method.

IV. RESULTS AND DISCUSSION

The evaluation of the proposed feature extraction method was performed by text-independent closed-set speaker identification experiments on the TIMIT database. The TIMIT database contains speech from 630 speakers. We defined the first 4 utterances for each speaker as the training set and 1 utterance as the test set. The TIMIT database files are sampled with a rate of 16000 samples/s, these files were downsampled to a rate of 8000 samples/s. The speech signal is segmented into frames. Processing was performed using Hamming windowed frames of 20ms, it takes 160 samples overlapping by 50% (10ms) of 80 samples.

From each frame, 32 coefficients MFCC and 32 coefficients Autoregressive were extracted and used to train the GMM. The GMM forms the basis for both the training and classification processes. We fixed the number of Gaussian mixture at G=64 in the beginning of training stage to model the features extracted from each speaker's voice sample.

A. Demonstrate the performance of SAD algorithm

We pass the speech signal through the algorithm (α = 0.45). The figure 7 represents the speech signal before and after processed through speech activity detection algorithm we can observe the efficiency of the SAD algorithm where silent segments are eliminated. The figure 8 illustrates a speech signal (clean speech) and its speech activity counter. Figures 9, 10 and 11, represent speech signal and their speech activity counter as function of SNR for 10dB, 5dB and 0dB respectively. These figures indicate that the SAD algorithm is robust down to SNR=5 dB

B. The degradation of speaker identification over Channel

To show channel degradation effect on our proposed speaker recognition system, we use original speech and reconstructed wave files after transmition over AWGN channel. The results are reported in Table 2, where we observe performance degradation of speaker identification accuracy when using reconstructed files after transmition.

C. The proposed AR _MFCC versus MFCC

We compare the proposed AR-MFCC with MFCC features in noisy conditions. These results are reported in figure 13. From these results, it can be seen that the proposed AR-MFCC features provides good improvements of speaker identification in comparison with MFCC in noisy environment over AWGN channel.

As a second test we compare AR-MFCC and MFCC in terms of runtime. Table 3 shows simulation results in terms of runtime, where we can observe that AR-MFCC is time consuming more than MFCC.

D. The proposed AR _MFCC versus MFCC

We choose 20 speech signals from TIMIT database, we passed every speech signal over SAD algorithm that calculates the threshold. Figure 13 shows threshold calculation of each speech signal to detect Speech/nonSpeech.

TABLE I. "α" VALUE VERSUS SNR .

SNR dB	Alpha (α)	Identification rate %
50	0.25	86.00
	0.35	85.66
	0.45	87.33
	0.5	85.33
30	0.20	86.33
	0.25	87
	0.35	79
	0.4	77.33
	0.5	76.66
20	0.20	63.66
	0.25	64.33
	0.3	67.67
	0.4	57.66
	0.5	42.33
10	0.25	60.33
	0.3	59.67
	0.35	57.00
	0.4	54.33
	0.5	51.33

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TABLE II. IDENTIFICATION RATE ACCURACY USING ORIGINAL SPEECH WAVEFORM AND RECONSTRUCTED SPEECH AFTER TRANSMITION OVER AWGN CHANNEL

	Speaker identification system	Speaker identification rate over Rayleigh Channel
Identification rate %	96	87

TABLE III. RUN TIME OF: MFCC AND AR_MFCC (FOR 100 SPEAKERS).

	MFCC	AR_MFCC
Elapsed time [sec]	299.091383	433.50024

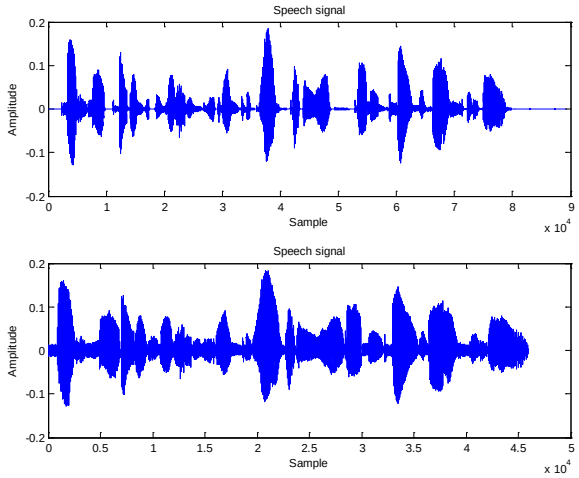

Fig.7 Original speech signal before and after processed through speech activity detection algorithm

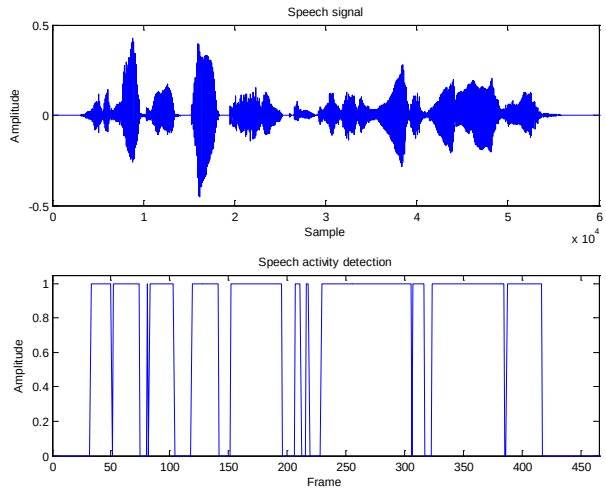

Fig.8 Clean speech signal and its speech activity counter using SAD algorithm

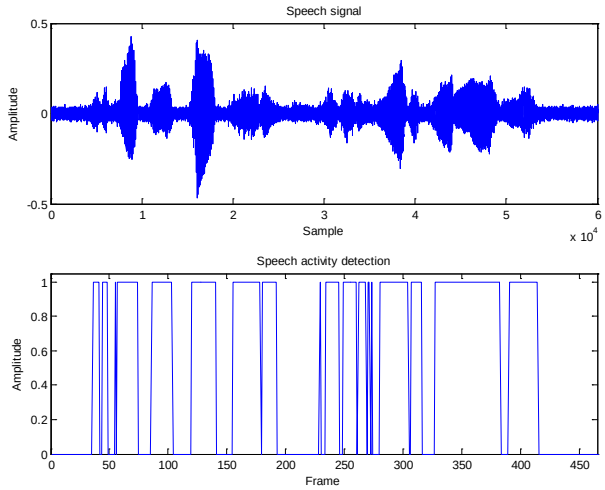

Fig.9 Speech signal and its speech activity counter at SNR= 10dB

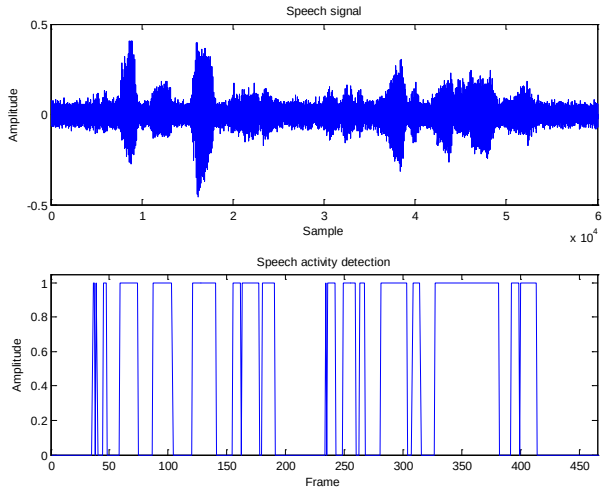

Fig.10 Speech signal and its speech activity counter at SNR= 5dB

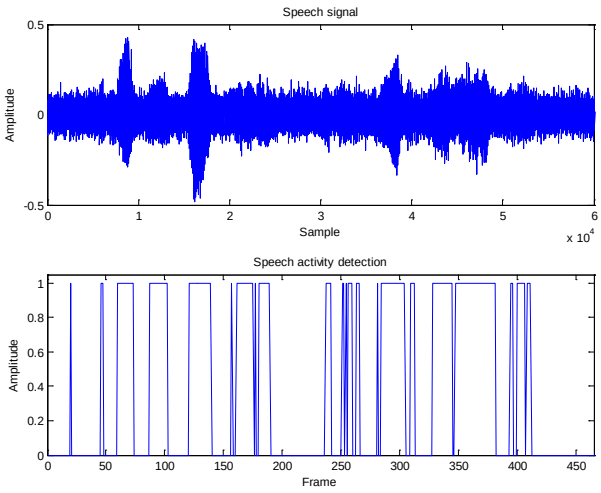

Fig.11 Speech signal and its speech activity counter at SNR= 0dB

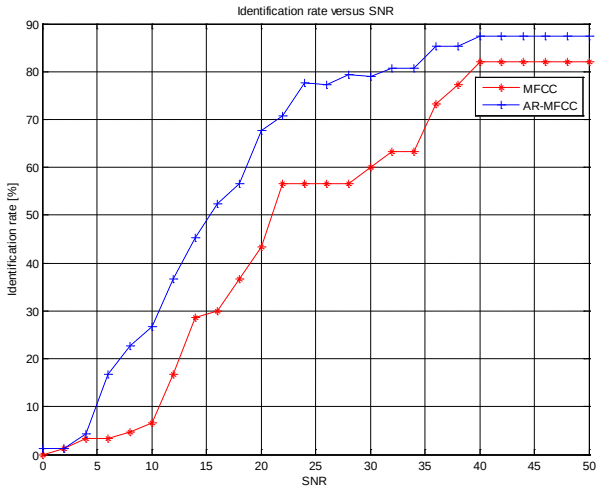

Fig.12 Identification rate of AR-MFCC and MFCC versus SNR accuracy over communication channel

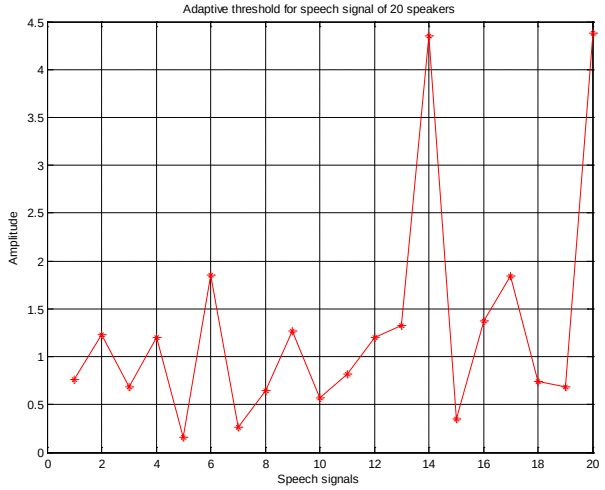

Fig.13 Adaptive threshold for speech signal of 20 speakers from TIMIT database under SNR=35dB

V. Conclusion

The MFCC are very useful features for speech processing in clean conditions but deteriorates in the presence of noise. Thus, in order to enhance the performance of an Automatic Speaker Recognition System over communication channel in noisy environment we have proposed a robust features extraction based on MFCC and AR modeling approach (AR-MFCC). Moreover, the speech/non-Speech detection is important to ameliorate the recognition rate. Therefore, a Speech Activity Detection algorithm with adaptive threshold is developed. SAD algorithm showed a high performance speech / non-speech discrimination in noisy environments which improves memory capacity and identification rate accuracy. The SAD depends on "α" , where to have a high identification rate accuracy we should increase α as SNR level increase. A comparison study of MFCC and AR-MFCC was made in view of their effects on the recognition system performance of remote automatic speaker in noisy environment. The use of AR-MFCC provide significant improvements of identification rate accuracy compared with MFCC in noisy environment. However, in term of runtime, AR-MFCC requires more time to execute than MFCC. SAD performs suitable counter of speech activity. Furthermore, it works accurately in low SNR environments (down to SNR=5 dB) and leads to a good identification accuracy. Our remote speaker recognition system was over AWGN channel and with convolutional code which has been chosen.

Our system may be very effective by decreasing the run time of AR-MFCC and make the SAD algorithm denoising speech signal before processing.

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Towards an Amazigh UNL dictionary

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***Abstract*—** In the perspective to build an automatic translation system for the Amazigh language, we have undertaken the necessary work to incorporate this language into the UNL (Universal Networking Language) structure, which is developed inside the UNDL (Universal Networking Digital Language) foundation. The mission of the UNDL is to allow anyone to access to the information available on the Internet using their mother tongue; this will contribute in promoting multilingualism and reducing access constraints to information due to language barriers. To this end, the project team of UNDL foundation has developed a formal language called UNL that can convert the meaning of a text into semantic graph. This encoding is considered as a pivot interlanguage used in translation systems. Currently, we are at the stage of building an Amazigh-UNL dictionary. In this paper, we focus especially on the noun category.

***Keywords*—**Amazigh noun morphology, Amazigh-UNL dictionary, Inflectional paradigms, Subcategorization Frames, UNL, Universal Word

I. Introduction

Amazigh language, also called Berber, belongs to the Afro-Asiatic languages (Hamito-Semitic) family [1]-[2]. Actually, it is one of the official languages of Morocco along with Arabic, but it was neglected for many years. Since the creation of the Royal Institute of Amazigh Culture in 2003, a number of strategies have been proposed for the digitalization of this language, including the building of linguistic resources and natural language processing tools. Our project, aiming to produce a machine translation system, is one of these tools.

The statistical approach is promising in the field of machine translation. However, its strength depends largely on the amount of resources required in term of corpus [3][4][5]. Since the Amazigh language is still one of the less resourced languages, it is very difficult to find an Amazigh corpus with size larger than thousands of sentences. For this reason, we have opted, in a first stage, for a linguistic approach based on the UNL interlanguage.

The translation of any source language to any target language based on UNL interlanguage is the process of "enconverting" the source sentence to the UNL representation and then "deconverting" the target sentence from the UNL representation. The advantage of UNL-based machine translation is the ability to apply it in a multilingual environment. This approach is the best one in the case of Amazigh, which is still considered as a less resourced language, especially that UNL project includes 16 official languages: Arabic, Chinese, English, French, Russian, Hindi, etc. Thus, the realization of a single Amazigh-UNL enconverter will allow getting the translation of the Amazigh texts into 16 languages. In fact, if there is a UNL-French deconverter, the realization of a single Amazigh-UNL enconverter toggles the Amazigh text into French without needing to master this language.

The remaining of this paper is organized as follows: In Section II, we present the morphological characteristics of the nominal category. In section III, we introduce, briefly, the UNL project and we describe the process of building the Amazigh UNL dictionary. Finally, we draw conclusions, and present potential future research directions.

II. Amazigh Noun Morphology

Amazigh morphology covers three main syntactic categories: nouns, verbs, and particles [7]. However, since the work of this paper is focused on noun category, it will be the subject matter of the rest of this section.

In Amazigh, the noun is a grammatical category that has claimed one of the following three forms:

- Simple noun is a single word (example: 'ⴰⵎⵍⵉⵙ' [Adlis] *book*).
- Compound noun is composed at least of two elements forming a single word that has its own meaning. Example: 'ⴰⵏⴱⵓⵉ ⵏ ⵔⴱⴱⵉ' [anbgui n rbbi] *guest*.
- Derived noun is a noun formed by the processes of affixation of a morpheme to the base form of a simple noun.

The second characteristic of the Amazigh nouns is their variation in gender (female / male), number (singular / plural) and state (free / construct).

A. Gender

Most male nouns begin with 'ⴰ' [a], 'ⵉ' [i], or 'ⵓ' [u] unless some exceptions, namely the case of kinship nouns like 'ⵉⵎⵎⴰ' [imma] *my mother*. Concerning the formulation of female nouns, we transform a singular masculine noun to feminine by affixing the morpheme 'ⵜ' [t] at the beginning and the end of the masculine noun. For example, the word 'ⵜⵉⵙⵍⵉⵜ' [tislit] *the bride* is the feminine noun for the

masculine noun 'ⵙⵓⵍⵙ' [isli] *the groom*. Some female nouns take only the initial morpheme 'ⵜ' [t] or the final 'ⵜ' [t].

B. Number

The noun has a singular and a plural form, whatever it is in masculine or feminine. The plural forms are classified into four types: external plural, broken plural, mixed plural and plural in 'ⵉⵏ' [id] [6]-[7].

- The external plural is formed by an alternation of the first vowel 'ⴰ/ⵉ' [a/i] accompanied by a suffixation of 'ⵏ' [n] or one of its variants.
- The broken plural involves a change in the vowels of the noun.
- The mixed plural is formed by vowels change accompanied sometimes by the use of the suffixation of 'ⵏ' [n].
- The plural in 'ⵉⵏ' [id] is obtained by putting the morpheme 'ⵉⵏ' [id] before the noun. It is applied to a set of nouns including nouns with an initial consonant, proper nouns, parent nouns, compound nouns, numerals, as well as borrowed nouns from foreign languages.

C. State

The noun can be in two different states: Free state or annexed state (also called the construct state). We talk about a noun in the free state, when it is:

- isolated from any grammatical context;
- a direct object;
- a complement of the predictive particle 'ⵏ' [d].

The construct state is marked by a change affecting its initial vowel in the following grammatical contexts:

- the noun has a function of the subject postponed to verb;
- after a preposition except 'ⵓⵍ/ⴰⵔ' [al/ar] and 'ⵖⵍⴰ' [bla];
- after a numeral;
- after the morpheme 'ⵉⵏ' [id];
- after the morphemes of membership and affiliation: 'ⵜ' [u], 'ⵜⵍⵜ' [ult], 'ⴰⵢⵜ' [ayt], 'ⵉⵔⵜ' [ist].

III. AMAZIGH UNL DICTIONARY DEVELOPMENT

A. Components of the UNL system

The meaning of a sentence in its natural language can be expressed in the UNL system by a graph consisting of nodes inter-related by semantic relations [7]. A node is called UW 'Universal Word'. It is often accompanied with a set of grammatical properties called attributes. Arcs binding UNL nodes in the graph represent a relationship between the UWs. The basic structure of the UNL language is:

Universal Words (UWs): they constitute the vocabulary of the UNL language. They are English words, accompanied with a set of linguistic and semantic restrictions. UW is the basic element to build UNL expression of a sentence.

Universal Attributes: they represent the grammatical properties that can enrich the description of the universal word. For example, the UW that corresponds to the English word 'play' is 'play(icl>do)'. (icl>do) is added to describe more the UW. It means that 'play' is a verb. If the word 'play' is conjugated to the past, the attribute '@past' must be added to the UW 'play (icl>do)'. Thus, we obtain the following UW: 'play (icl>do, @past)'.

Universal Relation: it is a syntactic-semantic binary relation that connects a pair of nodes in the UNL graph. The UNL system defines a set of labels for universal relations following to their roles. For instance, the relation agt (agent) defines the thing or the person who initiates an action.

B. Template of the Amazigh UNL dictionary

The Amazigh-UNL dictionary or Analysis Dictionary is a bilingual dictionary linking Amazigh word to UNL words called Universal Words (UWs). This dictionary will be used in UNLization process (enconversion from Amazigh word to UNL graphs). It is presented in the enumerative format which means that it brings all word forms and not only base forms [8]. The Amazigh UNL entry is in the following form:

[NLW] {ID} "UW" (ATTR …) < FLG, FRE, PRI >;

Where:

- ***NLW***: Head Word (Berber word).
- ***ID***: The unique identifier (primary-key) of the entry.
- ***UW***: The Universal Word of UNL, either simple ("book"), modified ("book.@pl") or complex ("aoj(new, book)"). This field can be empty if a word does not need a UW. It can also be a regular expression.
- ***ATTR***: The list of grammatical, morphological and semantic features, subcategorization frames (FRA) and inflectional paradigms (PAR) of the NLW.
- ***FLG:*** The three-character language code according to ISO 639-3 (we use Ber for Berber).
- ***FRE:*** The frequency of NLW in natural texts. Used for natural language analysis. It can range from 0 (less frequent) to 255 (most frequent).
- ***PRI:*** The priority of the NLW. It is used for natural language generation. It can range from 0 to 255.

Fig. 1 below is a screenshot of the Amazigh dictionary that we are developing.

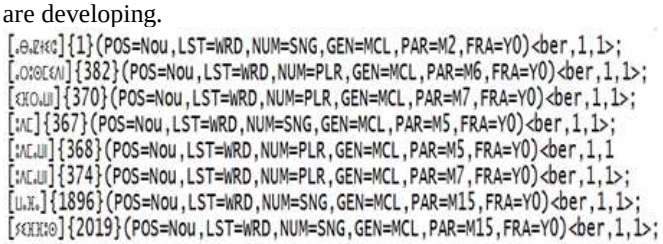

Fig. 1. Screenshot of the Amazigh dictionary

In order to perform well the development of the Amazigh dictionary, we expected to analyze and define the morphological and syntactical behavior of the Amazigh word forms, that by assigning linguistic features (part of speech, gender, number, transitivity, etc.) and informing the corresponding inflectional paradigms and subcategorization frames for each entry of the dictionary [10][13].

C. Definition of inflectional paradigms

We have started feeding our dictionary by nominal entries (1400 nouns at this moment). For this, a set of rules, allowing generating, has been defined for each entry, including inflectional forms according to gender, number and state.

The inflectional rules follow the general standard **<*CONDITION*>*:*=<*ACTION*>;** where:

- <CONDITION> is a set of features (such as MCL&PLR, i.e., masculine and plural);
- <ACTION> describes the changes to be performed over the base form (prefixation, infixation, suffixation or circumfixation).

For instance, the rule FEM&SNG:="ⵜ"<0,0>"ⵜ" means that, in order to form the feminine singular form , we have to add the morpheme 'ⵜ' [t] at the beginning and another at the end of the base form. The grammar formalism adopted within the UNL is described at [10].

For instance, the Amazigh grammar, that we have implemented, contains the following inflectional paradigms applied to a base form such as 'ⵣⵓⵎⵣ'[ISLI] 'Groom'

MCL&SNG:=0>"";
FEM&SNG:="ⵜ"<0,0>"ⵜ";
MCL&PLR:="ⵣ"<1,0>"ⵏ";
FEM&PLR:="ⵜⵣ"<1,0>"ⵜⵣⵏ";

This paradigm generates 4 different word forms: from the base form 'ⵣⵓⵎⵣ':

MCL&SNG=ⵣⵓⵎⵣ
FEM&SNG=ⵜⵣⵓⵎⵣⵜ
MCL&PLR=ⵣⵓⵎⵣⵏ
FEM&PLR=ⵜⵣⵓⵎⵣⵜⵣⵏ

The realization of inflectional paradigms for the noun category has presented for us a real challenge concerning the formalization of the Amazigh plural forms because there are many unpredictable plural forms and there is a scarcity of documents dealing with Amazigh inflectional paradigms.

According to the works of [11]-[12] and to a heuristic study of the nouns of Amazigh vocabulary, we have achieved, at this moment, to find out 42 classes of plural forms.

Table I below shows some examples of inflectional paradigms that we have defined.

TABLE I. AN EXTRACT OF THE LIST OF INFLECTIONAL PARADIGMS DEFINED FOR AMAZIGH NOUNS

Case	Inflectional paradigm in UNL	Explanation	Examples
Class 1	SNG:=0>""; PLR:="ⵉⴰ"<<0;	The rule adds ⵉⴰ [id] before the noun in the plural form.	ⵔⵕⴰⵍ [mraw] *ten* → ⵉⴰ ⵔⵕⴰⵍ [id mraw] *the tens*
Class 2	SNG&MCL:=0>""; SNG&FEM:="ⵓ ":"ⵓⵎⵜ "; MCL&PLR:="ⵓ ":"ⵜⴰⵢⵜ "; FEM&PLR:= "ⵓ ":"ⵉⵓⵜ ";	The morpheme 'ⵓ'[u] is replaced by 'ⵓⵎⵜ' [ult] in the case of feminine singular form, by 'ⵜⴰⵢⵜ' [ayt] in the case of masculine plural form, and by 'ⵉⵓⵜ'[ist] in the case of feminine plural form.	ⵓ ⵜⵎⴰⵣⵉⵖⵜ [u tmazight] *compatriot* → ⵜⴰⵢ ⵜⵎⴰⵣⵉⵖⵜ [ayt tmazight] *compatriots* ⵓⵎⵜ ⵜⵎⴰⵣⵉⵖⵜ [ult tmazight] *woman compatriot* → ⵉⵓⵜ ⵜⵎⴰⵣⵉⵖⵜ[ist tmazight] *women compatriots*
Class 3	SNG:=0>""; PLR:="ⵉ"<1,2>"ⴰ ";	The rule changes the initial vowel into 'ⵉ' [i] and inserts 'ⴰ' [a] before the final consonant.	ⴰⵣⵎⵣ [azmz] *an epoch*→ⵉⵣⵎⴰⵣ [izmaz] *epochs*

D. Implementation of Subcategorization frames

Subcategorization frames are schemes defining the number and the type of specifiers, complements and adjuncts that a base form needs to constitute its corresponding maximal projection [13].

The formalism of subcategorization frames is as following: <HD SYNTACTIC ROLE > (<ARGUMENT>), where:

- <HD SYNTACTIC ROLE> is a head-driven syntactic role (VA, VC, VS, VH, etc) of the term required by the base form.
- <ARGUMENT> is the term required by the base form to saturate its syntactic structure, i.e., in order to form the simplest maximal projection (NP, VP, JP, AP, PP, DP).

Table II below shows some examples of subcategorization frames, that we have defined, for the Amazigh language.

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TABLE II AN EXTRACT OF THE SUBCATEGORIZATION FRAMES LIST DEFINED FOR THE AMAZIGH LANGUAGE

Subcategorization frame	Explanation	Examples
VS(NP)VC(NP);	Direct transitive verbs that require a noun phrase as a specifier (VS) and a noun phrase as a complement (VC)	ⵙⵓⵖⴰ [isgha] *to buy*
AC(PH([ⴰⵏ]));	Adverbs that need a phrase headed by the morpheme 'ⴰⵏ' [ad] *of* as a complement of an adverb.	ⵎⵏⵛⵅ ⴰⵏ [mnchk ad] *how many*,
NC(PH([ⵍ]));	Nouns whose complement is introduced by the preposition 'ⵍ' [n].	ⵉⵎⵉ ⵏ [imi n] *that entrance*

IV. CONCLUSION

In the perspective to realize an UNL-based machine translation for the Amazigh language, we have successfully built the template of UNL Amazigh dictionary by defining most inflectional paradigms and subcategorization frames. Currently, we have treated only nouns; it stills verbs and particles categories. Our future plan is to focus on inflectional paradigms of verbs and to undertake the mapping between Amazigh and UNL words via English or French language.

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Optimization of web technologies for mobile devices

M. Krbeček and V. Veselá

***Abstract*—**Scientific and technical progress of modern society goes hand in hand with new technical devices. Characteristic marks of these devices are an integration and minimization. Users are able to carry these mobile devices (MD) with them everywhere. It obviously leads to increasing of usage and sales of the MDs which are more and more often used for a web page browsing. This situation brings new questions in a field of the web page optimization for the mobile devices.

MDs differ in an operating system and other parameters which can affect correct displaying of the common web page. To avoid this situation, several precautions should be done. There are three concept of solution: mobile, responsive and a classic web page.

In this paper a state of art in the field of mobile devices is described. Each of three mentioned web page solution is described in a detail with a comparison of characteristic features. Chapter four is focused on an optimization of the web page with remote experiment for the mobile devices. As a solution the responsive web was chosen. All crucial parameters are described in detail and proper measures are designed. The selected page was optimized from 10 to 94 percent in a rating of the mobile page validity. Improved page is now fully prepared for usage on various types of the mobile devices.

***Keywords*—**Mobile device, mobile web, remote experiment responsive web, webpage optimization.

I. Mobile Devices - State of Art

Contemporary society is based on working with information. Every man works with information every day. They can be obtained from books, newspapers and public media. However, the most popular source of information is the Internet. One third of people have an access to the Internet. For most of them the Internet is commonplace and it is used every day in a work, school and home. Information is available in many forms on the Internet. Users can meet them as a text, video, images etc. There also are several ways how to reach them. Most user-friendly way is an access through the web pages based on HTML technology. In the past only way how to access the web was by using of computers. It was a reason why many people bought personal computer to the home. Since these computers were used only for browsing of the Internet most of their capacity was unused.

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Change of this situation comes with a new technology of mobile devices (MD). These devices like smartphones or tablets bring exactly what common users need. In combination with other advantages like a small size and connectivity from almost everywhere MDs became a most fast-spreading technology of all time [1].

This fact is also confirmed by a graph below (see Fig. 1) which represents trends of the unit sales of the mobile devices over the past few years. The graph is based on Gartner data [2].

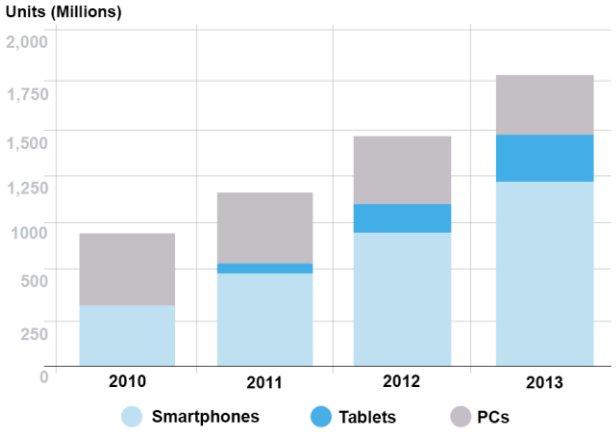

Fig. 1 Global mobile devices sales

There are almost one and half billion of sold mobile devices last year compared with 250 million of sold PC and this trend will continue. With these mobile devices users are able to connect to the Internet, browse web pages and obtain required information. The numbers speak clearly; this trend will soon change a leadership in the term of the most used devices for the internet connection. This situation is already happened in February 2014 in U.S. when the mobile applications overtake PC Internet usage [3].

This situation brings a new problem to solve. The vast majority of the web pages were not created for usage on the MD. In some cases this is not a problem and the web page works fine. However, when the page contains more graphics and some technology elements (e.g. Flash) it may not be displayed correctly. This could lead to a drop of web page's popularity or even to losing of customers and financial loss in the case of business website.

Since this is a current problem we decided to analyze possible solutions. Results are presented in this paper.

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II. Mobile Platforms and Device's Parameters

There are several platforms of MD. Since two of them have a majority of the market only these will be described in detail. Each of them has its supporters and opponents. This paper will not present their comparison or declaration which one is better. Only main functions will be described with an emphasis on a working with the web technologies.

A. Android OS

Android is an operating system developed by Google Inc. Current version of the system is 4.4 KitKat. Android is known as an open system for users and developers. Manufacturer, who uses Android for his devices, is able to customize system for each device type. It helps to optimize the correct operation of the system for each device. On the other hand, for application developers this could be a nightmare. A new application can react slightly different on multiple devices vary with type and system version. Therefore, testing and optimization of application have to be very thorough.

Fortunately, in the field of web browsing situation is different. Displaying of web page is performed by a mobile web browser and is independent on the device type. There are some limitations for specific web technologies like a Java applets, JavaScript and Flash.

Since there is no mobile version of Java Virtual Machine, technology of Java applets is unavailable on Android mobile devices. Usage of Flash technology is also problematic. In June 2012, Adobe released a statement that read: "We have not continued developing and testing Flash Player for this new version of Android and its available browser options. There will be no certified implementations of Flash Player for Android 4.1. [4]". Users are still able to download old version of Flash Player from the store, but its functioning is not guaranteed for new Flash files. This situation arises with the arrival of HTML5 technology which can easily handle all problems which were solved by Flash in the past. It can be considered as a natural development.

Majority of functional elements are currently addressed by JavaScript (JS). There may be some problems on the old devices with their default browsers, where JS may not be fully supported. Fortunately, all users are able to download modern web browser from an application store for free. Since Chrome is a native Android browser on the new devices there is no problem with JS now.

B. IOS

IOS is an operating system developed by Apple Inc. Current version of the system is 8.0.2. IOS is unlike the Android intended only for Apple mobile devices. System is locked for any editing and larger user's customizations. Creation of new application is easier in a term of optimizing and testing but its publishing subject to a stringent control politics.

Situation of web browsing is similar to Android. Displaying of web page is performed by mobile web browser. IOS native browser is iOS Safari but users are allowed to install another one. There are also some limitations for specific web technologies like a Java applets, JavaScript and Flash.

Since there is no mobile version of Java Virtual Machine, technology of Java applets is also unavailable on iOS mobile devices. Usage of Flash technology was never supported on iOS devices. In "Thoughts on Flash", an open letter published by Steve Jobs in April 2010, he asserted that "Rather than use Flash, Apple has adopted HTML5, CSS and JavaScript", which he called as "modern technologies" [5].

IOS uses modern web browsers which fully support JavaScript. Due to this fact, there are no problems with correct displaying of JS on iOS MDs.

C. Crucial Device Parameters

Mobile devices vary in many technical parameters. There are many screen sizes, processor types, memory sizes etc. There are devices with a better camera or a high performance graphic chip. Customers have a wide range of choice. Computing power of MDs is reaching a level of personal computers. Today's phones have a better performance than the computer which transported peoples to the moon [6]. Web browsing is therefore not limited by a MDs performance.

Only one parameter has a significant affect to the correct displaying of the web page. This parameter is a display (screen) resolution. The display resolution is a number of distinct pixels in each dimension that can be displayed. It is usually quoted as width × height, with the units in pixels. The diversity of the mobile devices display resolution brings a problem with an optimization of the web page correct displaying.

Some resolutions are too small for a proper displaying of the classic web page. On the other hand some are too big and the web pages are displayed too small on the MD. Users are usually able to zoom in or out the page and find what they are looking for, but this is not a good in the term of user-friendly control interface.

Another problem may be a web page layout. Smaller screen may completely shuffle the elements of the page. All these facts have to be taken into account during the web page creation. Possible technical solutions of mobile web page creation are described in next chapter.

III. Solutions of the Mobile Web Page

A. Mobile Web Page

This solution comes with two separate web sites for classic PCs and mobile devices. The web page recognizes which device is connecting and choose appropriate version of the page to display. There usually are buttons to switching between both versions. Since the mobile version is designed separately it may be completely optimized for the MD. Less graphic elements are used leading to a smaller volume of transferred data and a faster page loading. Because a content of pages is also independent there can be different information in both versions. On the other hand creation of two different versions needs more time and resources.

A switching between pages is ensured by following

annotation in the HTML code:

On the desktop page:

```
<link rel="alternate" media="only screen
and (max-width: 640px)"
href="http://m.example.com/page-1" >
```

On the mobile page:

```
<link rel="canonical"
href="http://www.example.com/page-1" >
```

B. Responsive Web Page

A responsive web page is a same for both PCs and MDs. There are always same data transferred to the client device but an appearance of the page is varying based on a screen resolution of the device. Appearance is changed directly in a web browser which translates part of source code intended for the current resolution of device. Responsivity of the page can be tested by a size changing of the web browser window on the PC. Developer can set several versions of appearance independent on the devices type based only on the screen resolution.

This function is ensured by breakpoints. The breakpoint is used to display different styles depending on characteristics of the device, like device width or device pixel density. By using of media queries different styles can be applied, giving a completely responsive experience. Media queries only apply their styles if the device matches the query. Query can be specified either by adding a media attribute to the linked CSS file, or directly in the CSS (see example below). For most designs, the min-width query is most helpful. Min-width rules are applied for any browser width over the value defined in the query.

Media attribute to the linked CSS file:

```
<link rel="stylesheet" media="(min-width:
640px)" href="min-640px.css">
```

Directly in the CSS:

```
<style>
  //Style for 0-499px viewports
  @media (min-width: 500px){
    //Style for 500px or wider viewports
  }
</style>
```

C. Standard Web Page

This web is absolutely same both for PCs and mobile devices. Correct displaying on the MDs is achieved by a selection of a proper layout and technology of the page design. These pages usually require zooming and scrolling during their using. Even they are fully functional they are often not so user comfortable as previous mentioned types.

D. Comparison of Mobile Web Solutions

Mentioned types of mobile web pages were compared in a term of maximization of user full experience. Results are shown in the (Table I) below.

TABLE I COMPARISON OF MOBILE WEB SOLUTIONS

	Mobile Web	Responsive Web	Standard Web
Loading speed	Fasters	Average	Slowest
Optimized user interface for mobile devices	YES	YES	NO
Addresses various widths of the monitor / display	NO	YES	NO
Addresses future devices	NO	YES	NO
Switchable to the classic version of the site	YES	NO	-
Customization of the content to the visitor with mobile device (information + SEO[7])	YES	NO	-
Only a part of the content for mobile devices	YES	NO	-
Same interface for all versions	NO	NO	YES

The comparison shows that the alternative mobile web page is a best solution in a term of end user experiences. However, this solution has some disadvantage. Main of them is double time and resources needed for a creation of two separate pages. Mobile website is also not appropriate for all types of web pages.

Responsive web page seems like a most universal solution which does not need special effort in creating. It can be used for most types of the web pages since elements of pages are not recreated for MDs but rearranged only.

Classic web pages may by enough for some types of content (mostly text information); however, the better experiences are obtained by the previous two methods.

For our purposes using of responsive web page is a best choice. Next chapter will be devoted to a practical demonstration optimization of the web page with JavaScript elements.

IV. RESPONSIVE WEB IN ACTION

Since we deal with a problem of remote experimentation as a testing page a remote experiment was chosen (http://remotelab5.truni.sk). Remote experimentation is a growing trend both in science and education which brings many advantages. Principle of remote experimentation is described in detail elsewhere [8-12]. Shortly described, it is a measuring performed remotely through the Internet. With a growing influence of mobile devices, this field is also forced to adapt to the mobile usage.

A. Original Website

Original web page was optimized for a wide screen (see Fig. 2). All controlling elements are created in a JavaScript. Each element is designed as a stand-alone library and added to the

web page like a widget. This kind of page can be easily modulated for a various types of remote experiments. For data displaying widgets like a graph, value display and data record are used. Experiment is controlled by widgets like a button and slider. Users are able to watch live stream from the experiment's web camera. This is also solved by a JavaScript function.

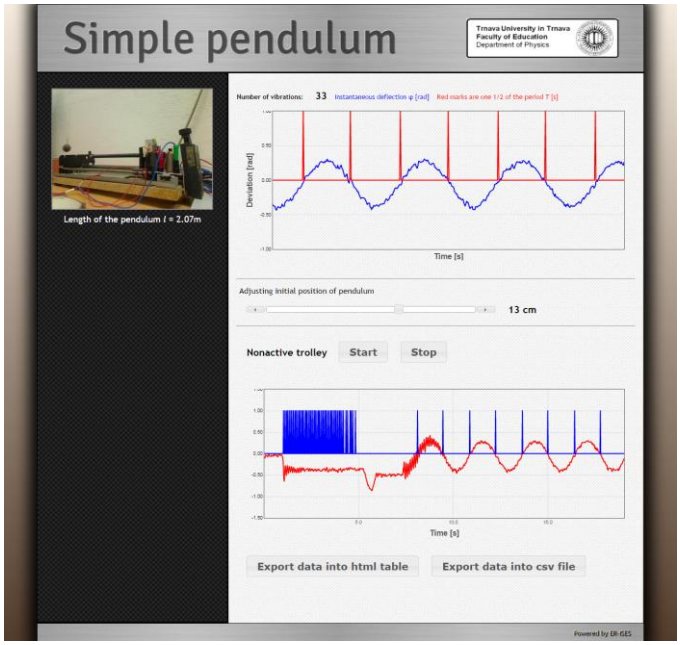

Fig. 2 Original web page for wide resolution

There is no problem with a functioning of JS widgets on mobile devices. Most of modern mobile browsers work with JS automatically. In the case of problem user can always download a new version of the browser from application store for free.

Main problem comes with a low resolution of mobile devices. Layout of original page was not suitable for mobile resolution. Also controlling widgets were too big for a small screen. Incorrect displayed page on the mobile device can be seen in a Fig. 3.

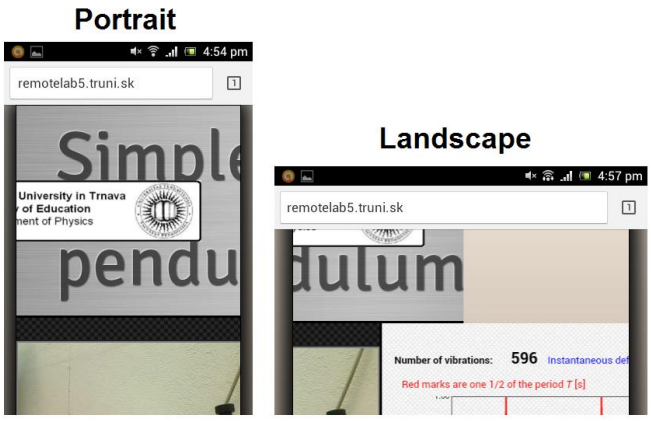

Fig. 3 Wrong function of original web page on mobile devices

B. *Few Steps to a Responsive Web*

First step was a removing of all fixed dimensions. Responsive web should change its dimensions dynamically. Therefore all necessary dimensions were entered as a proportion of the page. This setting ensures correct displaying on all higher resolutions. However, if we kept this setting for the mobile devices, controlling elements would be very small and not suitable for a comfortable usage. At this point CSS media queries come.

Media queries are simple filters that can be applied to CSS styles. They make it easy to change styles based on the characteristics of the device rendering the content, including the display type, width, height, orientation and even resolution. Media queries enable us to create a responsive experience, where specific styles are applied to small screens, large screens and anywhere in between. The media query syntax allows for the creation of rules that can be applied depending on device characteristics [13]. By using of this technology three different page layouts was designed for the different screen resolutions. Layout proposal can be seen in Fig. 4.

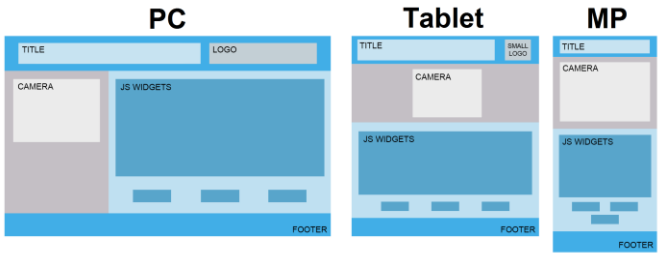

Fig. 4 Proposal of page layout for different resolutions

For each layout specific breakpoints were chosen. Those points mark exact range of screen resolution for which the layout is used. Breakpoints were chosen in order to divide screen resolution to PCs, tablets and mobile phones (MP). However this is not a strict rule. If a tablet is used in a landscape mode, there is a sufficiently high resolution and the layout for PCs screen is used. Users can also use a MP with sufficient resolution for displaying of the tablet layout. Chosen ranges are – PC: (+1001) px; Tablet: (1000 – 491) px; PM: (490 - 0) px.

The last but no least step in the page transformation arises from a data transfer saving at the MDs. Since the screen resolution is not as big as at PCs, there is no need to use large textures. Using of the smaller textures for the mobile devices saves a volume of transferred data and reduces a loading time of the web page.

C. *Final Testing*

For the mobile web page testing the W3C mobileOK Checker was used [14]. It is a free tool for a testing of the mobile web page validity. Not only a mobile validity was tested by this tool but an observance of common HTML standards also. At the start the web page was tested by this tool. The result was surprising; the page reached only a 10 percent and contained many failures (see Fig. 5).

The changes, described in the chapter above, were applied

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on the original web page. Other changes were performed as a reaction on a recommendation obtained from the MobileOK Checker. These were mainly repairs of the code validity (stylistic faults) both in HTML and CSS. After that the same test was performed with a result of 94 percent (see Fig. 5). Nature of the web page with the remote experiment prevents to achieve 100 percent. Nevertheless, reached score is a very good result particularly in comparison with the starting points. Optimized page is fully prepared for the mobile devices and is reachable at http://remotelab5.truni.sk.

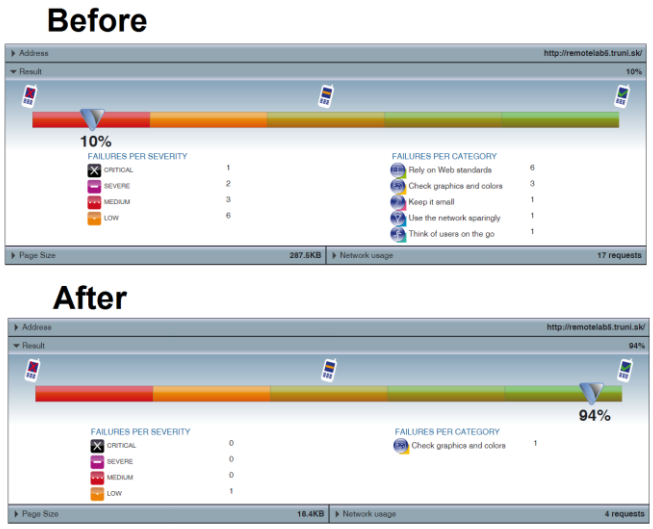

Fig. 5 Web page validity tests results

V. Conclusion And Future Work

Scientific and technical progress of a modern society goes hand in hand with new technical devices. These devices are intended to a simplifying of users everyday activities. Characteristic marks of the devices are an integration and minimization. Users are able to carry these mobile devices with them everywhere. It obviously leads to increasing of usage and sales of the MDs.

MDs are more and more often used for a web page browsing. The trend suggests that a leading share of the devices used for the web browsing will soon change from a PC to the MDs. This situation brings new questions in a field of web page optimization for mobile devices.

MDs are different in operating system and other parameters which can affect correct displaying of the common web page. To avoid this situation, several solutions and precautions should be done. There are three concept of solution: mobile, responsive and classic web page.

For our case the responsive web was used to optimization of a remote experiment's web page. Several measures were applied in order to reach better rating in mobile web page validator. The optimized page reached a significant increase of rating from 10 to 94 percent. Our page is now fully prepared for usage on various types of mobile devices.

Transformation of this remote experiment was just a start of our work. The new page layout will be applied on the other remote experiments under our administration. Users will be soon able to measure on our remote experiments with their mobile devices.

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Tic information services through process management and massive professional communities.

Fernando Prieto Bustamante, Yaneth P. Caviativa, Yoan Manuel Guzman, Victor Manuel Castro Rodríguez

Abstract—The article is about the study on a proposal for the design, development and implementation of an information system using ICT In it, he includes a detailed study of the information needs to have the secretary of health, and how that information stored, so that, starting with this project as a success, by implementing Process Management and massive professional communities to organize a centralized processes to thereby have a greater command and control over these.

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Keywords—Comunidades masivas profesionales gestión de procesos, gestión de procesos de negocio, BPM

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I. Introduction

HE necessity of using technology and health areas represents nowadays and increment measured by the adequate use of technological gadgets that increase access factor, which implies to relate access capacity of health system to which to population has granted access. This project searches to implement Process Management in health adequate from the online participative methodology in massive professional communities which will allow managing all the organization of Information Integrated System in health based in processes, understanding these as a sequence of activities oriented to generate an added value about an input to achieve a result. Allowing to respond to users complaints and necessities, as more and more, citizens, organizations and companies claim to the health sector quality in their services. Critic in health sector management refers to inefficiency of big hierarchical structures of the Administration when trying to adapt to a world in full technological and economic transformation.

The development of this management system will allow achieving a system of processes management (health), dealing with important challenges. Between the main challenges that will have to be overcome are: low quality, automatic processes, management and communication heterogeneity of the process at national level; the widespread perception of lack of use of emergent technologies, the deficient and unreliable information, as well as attention time in the service of information from online collaborative participation. will improve its perception about health processes quality with reliable information, granting access to promotion and prevention programs, and disease control implementing the application of Integral Care Guides and prevalence of diseases of public health system.

Massive professional communities will gain and use for their own benefits the user input. Seeking for related indicators with Risk Management, programs of prevention and implemented disease control, and prevalence of diseases of public health interest for the department, whose form depends on the kind of activity that is being performed, by implementing this new technology it seeks to evaluate the mechanism of Monitoring and Inspection (MI), access and information retrieval, monitoring of information quality, date and certification of provision services of health and efficiency of components, Development and Mandatory standards of Guarantee and Quality, and its impact against the provision of health services for the users in an accessible and equitable.

II. Theoretical approach

A. Problem description

For the Colombian Department, one of the main factors for the tracing, planning and control lies in the management of programs related to Public Health, being this a point of interest from the necessity of the country in this area and particularly in Caribbean region. The mentioned necessity is aligned with Health and Social Protection Ministry politic that considerate in Article 111 of Law 1438 of 2011 a development of an evaluation and qualification system of Health Territorial Directions, of and health promoter entities and health services institutions, as a result of the application of indicators related to: risk Management, disease promotion and control programs, and prevalence of diseases of interest in public health. Similarly in the article 112 of Law 1438 de 2011 commands the Health and Social Protection Ministry to articulate the management and administration of information through the Integrated System of Social Protection Information [1].

. There are different tools to measure the perception of this satisfaction, not being there any processes nor standardized methodologies for the collection of data in health or evaluation of quality in the Situational Analysis that is not systematized either, likewise the compilation of the consults observations and clients and providers interviews, are done in an inconstant way or are not even registered nor there is assumption of implantation of any quality system.

B. Justification

The implantation of processes management, as politic to incorporate, ingrain quality and continuous improvement in organizational culture as a more decentralized and participative system, that will help achieving resolution 4505 of December 28th of 2012 of Health and Social Protection Ministry, by health services institutions, companies administrators of benefits plans, and for this particular case, departmental direction, where with their work, besides of reducing substantially heterogeneity in the quality level amongst the different types of public health services, will accomplish an information system for process management with the functional administration, assigning "owners" to key processes, making possible an international management generator of value for the user and that, therefore, seeks their satisfaction. In order to do the above, it will be determined which processes need to be improved or redesign in contrast to the ones the governorship has at the present, establishing so priorities and a context to initiate and maintain improvement plans which allow to fulfill established objectives. In this way it is possible the comprehension of the mode that business processes are configured, as well as their strengths and weaknesses.

Against the above article 111 of Law 1438 of 2011, suggests orientate the fulfillment of the development of an evaluation and qualification system of Health Territorial Directions, of Health Promote Entities and Health Service Institutions, as a result of the application of indicators related with: risk management, disease prevention and control programs, and prevalence of diseases of interest in public health. All of this can be executed in adequate way with tools such as Business Process Management (BPM) and processes layout languages such as BPMN (Business Process Management Notation) and crowdsourcing, which purpose is to consolidate all the efforts that would make a government administration system in order to achieve its objectives. BPM and BPMN are presented as a new tendency to increase efficiency in business and generate competitive advantages that market demands. Reason why now is important to have in count that the key elements to achieve objectives are processes and their good administration, since processes occupy a transcendent place in technological initiatives, but are important too because they constitute the way organization can generate value for the client [1].

Therefore, departmental directions, must obey articles 43.1.2; 43.1.3; 43.1.6 and 46 of Law 715 of 2001 and 114 of Law 1438 of 2011; Departmental Directions will be responsible of: a) Recollect and consolidate the registry per person of activities of Specific Protection, Early Detection and the application of Integral Care Guides to the diseases of interest in public health of mandatory, remitted by Health Municipal Directions or Health Services Institutions (IPS as in Spanish) of their services net. b) Report to the Health and Social Protection Ministry, the register per person of activities of Specific Protection, Early Detection and the application of Integral Care Guides to the diseases of interest in public health of mandatory according to Technical Annexed that is part of the Resolution. c) Respond for fitting, coverage and quality of the information reported. d) Carry out technical assistance, training, monitoring and feedback to the Health Municipal Direction, Administrators Company of Benefits Plans including the ones in health exception regime and Healt Services Institutions (IPS), which have in their charge the care of people who are not affiliated to the Social Security General System in Health. e) Carry out the verification of the reliability of reported information to Health Municipal Directions or Health Services Institutions (IPS) of their services net.

Besides, it is necessary to find a methodology that eases the use of tools which help to achieve the wished strategy. Business processes management is a sequence of activities that are carried out in series or parallel by two or more individuals or informatics applications, with the goal of finding a common objective. BPM helps to propose a strategy and transform it in measurable objectives. Processes approach allows examining the object (health), through a sequence that goes from macro processes, to procedures and their contribution to the objectives fulfillment, and primarily the relation between what is said, done and obtained.

To achieve the purposes and give answer to necessities that nowadays presents the object (health), it is required to update its management processes, allowing to be at vanguard of technological advances. Taking into account the above, it will be design a system that manages all the processes related to Early Detection and the application of Integral Care Guides for diseases of interest in public health of mandatory, implemented in health services, for their integration into the Integrated System of Information of Social Protection (SISPRO).

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III. Conceptual framework

A. Legal framework

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By which is established the report related to the register of activities of Specific Protection, Early Detection and the application of Integral Care Guides for diseases of interest in public health of mandatory [1].

B. Theoretical framework

Here are exposed the necessary themes to establish a clear context about the topics or issues related with the crowdsourcing implementation project.

- Process management

Process management implies 'reorder workflows so they add value directed to increase satisfaction of clients and to ease tasks to the professionals'. In this sense, a care process should have a clearly definable mission (what, what for, for whom), demarcated borders with concrete inputs and outputs, clearly integrated sequences of stages, and should be measurable (quantity, quality, cost).

But not every process that is carried out in organizations has the same characteristics, motive by which they can be classified, according to the more or less direct impact on the final user, in the following criteria:

-Strategic processes: they adequate the organization to the necessities and expectations of users. Definitely, they lead the organization to increase quality in services that are offered to its clients. They are oriented to strategic activities in the company.
-Operative processes: those that are in direct contact with the user. They include all activities that generate more added value y have more impact on the satisfaction of users. All clinic-care processes can be considered included in this category [2].
-Support processes: they generate resources that other processes need.

Table. 1 Types of processes. Taken of Xavier Badía

Strategic or management processes	Operative or key processes	Support processes
Needed for maintenance and progress of the organization	Direct relation with clients, and the impact on their satisfaction	Support operative processes so they can be fulfilled
Strategic plan, Satisfaction surveys, Quality plans, Investigation plans, Self evaluation	Clinic-care process	Patient management, Storage, Hostel, Maintenance, Pharmacy.

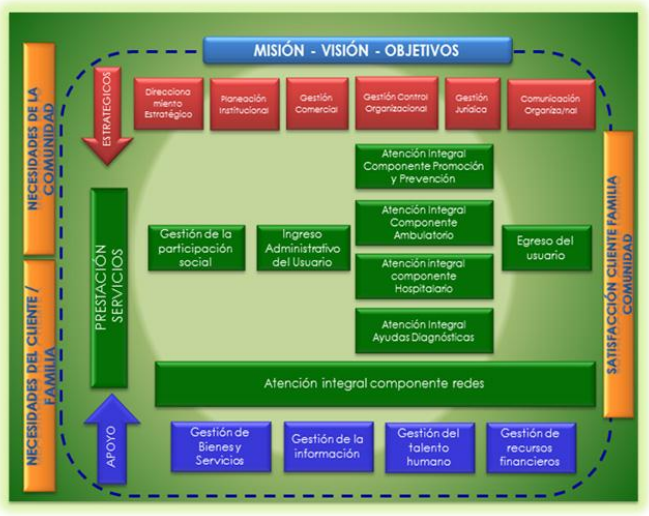

Fig. 1 Tomado Process structure Mario Granados (2014).

As much as total quality concerns, traditional approval methods are not enough. It is necessary to ensure not only of some determined characteristics of the product or service. It is about certifying that the organization or institution is in position of truly offer, and keep offering in the future, the products/services on demand with the characteristics that are specified, with the fulfillment of deadlines, with attention that user expects, etc, ergo, total quality [3].

Processes Management is based on the assignment of a responsibility directive in each process of the organization. In its most radical form, the departmental organization is *substitute*. In other forms, perhaps transitional ones, departmental structure is maintained, but the responsible of one process has its responsibility, and to what that process refers to, he/she can have authority over functional responsible [4] [5].

- BPM: Business Process Management and its implementation in health sector

BPM emerged as a successfully concept of total quality management (TQM) in the decade of 1980 (Crosby, 1979; Powell, 1995) and business process reengineer (BPR) in the decade of 1990 (Hammer, 1990; Hammer & Champy, 1993; Davenport, 1993). After BPR, various systems of Information Technology (IT), such as Enterprises Resources Management (ERP) and Client Relations Management (CRM) gained organizational approach (Jeston & Nelis, 2008a). The decision to improve business processes as a path to obtain higher performance in the results of organizations is not a new theme. Since beginnings of century, processes have been being approached with different methodologies with the goal of increase financial results of firms. Nontheless, overtime these initiatives have approached to the improvement problem from perspectives that do not integrate the variables that affect directly in the results of organizational activities [9].

Overtime, vision about processes and organizational improvement initiatives were changing and there was evidence of efforts to make changes in business activities, which were perceived with a higher importance due to the impact in

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financial performance. From this view were originated systems known as ERP (Enterprise Resource Plannin), which participated as storage elements and consult of information of process, and did not counted with robust mechanisms to control business process management in integral way [9].

In context of processes improvement, BPM constitutes one of the tendencies in management, which allows in a deliberate and collaborative form to systematically manage all business processes of an enterprise. The benefits of BPM to organizations are extensive: it gives visibility to the directives about processes dynamics carried out in unconscious way by human resources of organization, and makes possible its quick modification to accelerate the adoption of change in operations of companies [10] [11].

To Khan Rashid, business process management is a discipline for shaping, automation, management and optimization of a business process through its life cycle with the goal of obtaining higher profits.

Howard Smith on the other hand, defines BPM as a new approach to address and manage innovation processes in companies, which constructs improvement, from the actual state of a process in a determinate time and that raises a radical difference in front of reengineering; which constructs improvement from total redefinition of process. In this view, BPM becomes an answer to the operative chaos that presents companies nowadays [13] [14].

After the impact of Workflow in the nineties, BPM is considerate its evolution, for this reason is interesting to take into account the concepts and terminology of workflow. In fact, the organism Workflow Management Coalition (WMC) defines it as: "the automation of a business process, totally or partly, during which documents, pass information or tasks from one participant to another for the action, according to a group of procedure normative". [6] [11] [15] [16].

BPM is based on information technology to automate tasks and to give agility to required changes for the enterprise. The technology that makes possible the implantation and adoption of BPM constitutes a new category of informatics systems called Business Process Management System (BPMS). Unlike traditional information systems based in data management, these systems specialize in business process management [17].

Generally and integrally, BPM can be defined as an improvement in business processes management of an organization from beginning to the end, from the deliberate, collaborative and increasing definition of technology, so in that sense attain clarity in strategic direction, alignment of resources of the organization and continuous improvement discipline, all of which are necessaries and critical to fulfill the expectations of clients. The role of business processes modeling is to allow vision of processes in different levels (strategic, tactic and operational) as well as identification of processes optimization necessities in those levels.

At present, a question might surge and is how can the organization execute adequately and optimize processes? Organizations only count with two forms of implementing strategy: projects and processes. A project is "a temporal effort that is carried out to create a single product or service", while a process can be define as "a group of activities that transform inputs in products of value for a client" (Hammer & Champy). It is important to note that projects themselves are formed by processes and that 80% of failure or success in projects is related to good administration [20] [21] [22].

In this context, surges with strength the initiative called Business Process Management (BPM) that can help to consolidate all the previous efforts. In year 2000, Gartner (Lawrence, 1997) predicted that BPM would be the next grand phenomenon; and later commented that "BPM wins the triple crown for saving money, saving time and adding value". Another study executed by BPM Institute showed that 96% of respondents indicated that a processes centered approach was critical for success in their company [11].

- Massive Professional Communities

One of the lines of thought that guides educative change is the one that links with collaborative learning, understood

> "As a learning where ideas are shared to solve a task favoring with dialogue, reflections about own approaches; and in individualized learning systems it is tried to create a model of tutor that guides the student, as in collaborative systems is about finding a model which includes the different participants, the tasks to do, and the ways of collaboration. Besides, to the extent that is provided the possibility of registering the processes of work, it also can be established models that allow analyzing and monitoring them and so, proceed, intervene to improve them" [25].

Consequently formation activities executed by university teachers have made obvious new problems, which make necessary advancing in conceptualization of collaborative learning through educative investigation. One of the first elements to considerate as base of all learning, and especially in collaboration, is communicative interaction. In a wide sense, communication is the relation which establishes between two or more people. For the existence of real communication there must be an exchange of messages between the participants.

When analyzing the theme of collaborative learning is necessary to point some details, according to Dillenbourg, et. al, (1996), corresponds differentiate learning from problems resolution, and collaboration from cooperation. From the psychology it is considered that learning and problems resolution share similar processes, but from computational sciences, it is considered different. At the moment, it is shared with [26] Wessner, M. and Pfister, H., (2001), that collaborative learning implies the participation of

> *"Two or more people with the common objective of acquiring knowledge, who are in disposition of sharing their knowing and experiences, in the frame of interaction and communication actions directed to achieved such purposes*" [27].

This way of learning is offered as an alternative to competition and individualism where ideas of solidarity underlie, as well as concepts of conjunctions of efforts and, agreement and interdependence between people.

> *"A collaborative team should have positive interdependence, individual responsibility, promoter interaction and appropriate use of social skills; are*

elements which provide the conditions for an effective collaboration" [28].

As it can be seen in the above described elements, there are some basic principles of group constitution added to actions, skills and abilities that can be enhanced by the implementation of a mechanism of the type promoted by collaborative learning, since this is characterized by its autonomy, leadership, tasks assignment, time management, responsibility in activities and others, while cooperative work is intended to the construction of new ideas, the professor predetermines groups of work and gives the lineaments for working.

The term *Massive Professional Communities* was proposed by Jeff Howe in year 2006 on Wired magazine. Its etymological meaning, separating the two terms that conforms it -crowd and sourcing- means sourcing or supplying from a crowd or multitude.

When defining the term, Howe argues that Massive Professional Communities is –the fact of taking the job that usually was done by an employee and externalize it to a undefined and generally group of people through an open call.

Obviously, this term, as Howe defines it, is possible thanks to Internet and associated information technologies. Before the era of Internet, the fact that there were a crowd in determined moment depended on the physical proximity of people con formed it. Now, thanks to Internet and the rest of related technologies, it is relatively simple to have virtual crowds, which physical distance can be of thousand kilometers.

Attending to the definition, we can adapt *Massive Professional Communities* to health thanks to a net of specialized contacts, each of one in their own matter, on which consults are carried out by an "open call" that has information and wants to share it with the user easing very much the work. Teamwork sensation is wide, and a highly recommended experience, since feeling part of a community is one of the inherent characteristic of human being.

Methodology helps to center in the patient so that collaboratively, new designs are established, problems are solved, or solutions are given to patients with not so frequent diseases, and that are applied in collaboration between actors for the resolution of problems in health sector. Patients who live with their illness know much more and can provide useful and relevant information to other patient in the same conditions about personal a necessary cares, and also difficulties that the sickness brings, sometimes more than what the doctor might explain or say. Patients provide support and many advices because they provide the experience that the medic lacks of. Nowadays instead of being consumers of sanity services, they are becoming providers of the own sanity cares [23] [24].

IV. Results

Collaborative learning will be a diverse experience, both for the size of groups and the internal organization of themselves. For the collaborative learning we expect the implementation of learning experiences in interaction. As a tool that favors learning and the use of software that allows providing more tools, these are all channels for the production of group interaction originating collaboration and learning processes.

The contributions of the integrants of a group put in a collaborative learning situation, offer a change in the knowledge of participants in that process.

Governorship as a future user of the information system will be able to perceive a substantial saving in processes generation as well as in acquisition of an ICT system for this kind of processes, achieving an efficient system which will avoid time expenses to execute procedures since by technology contretemps will be avoid.

Users of health system will have a better attention care because the entity will have a more efficient management system being interoperable, which will avoid contretemps and will make different procedures to be carried out in organize and agile way.

Design, development and implementation of this proposal will generate a success case, for the implementation of BPM, that will ease an efficient communication and management, which will allow in the future to carry out the implementation of this type of information systems in others departments as well as in different secretaries such as environment, education and planning of the same department.

V. Conclusions

System that guides online collaborative processes that allow to bring closer the user and health system to vanguard, and implements technological tools of information to automate tasks and bring agility to changes required by the state enterprise.

System, under this information analysis, can make possible the implantation and adoption of BPM constructing a new category of informatics systems denominated Business Process Management System (BPMS) that for service processes interest, uses better systems of governmental support associated to advance process from online government.

An implementation of a *Massive Professional Communities*, the use of techniques of information update and the environment in which will be carried out, are the main base for its implementation, thus the developer group of the tool will get knowledge based on academic activities since pedagogical engineer that makes stronger and potentiates fundamental dimensions in promotion and prevention systems development; promotion and prevention programs, and disease control implementing the application of Integral Care Guides and prevalence of diseases of interest in public health of mandatory in politics of recent health administration.

The execution of this proposal will allow evaluating *Massive Professional Communities* methodologies, by recollection of data for the generation of indicator related to: risk management, disease prevention and control programs, and prevalence of diseases of interest in public health, relating it in interoperable way with the integrated system of health information of the islands and management itself from the Health and Social

Protection Ministry through the Integrated System of Information of Social Protection (SISPRO).

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Cyber Physics System on Railway Traffic

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Abstract- In the last decades, the information system of railway traffic has been improved greatly. But the wide application of sensors and the improvement of the speed of the railway traffic, the large amount of various data needed to be collected, transferred, processed and give feedback to the physical railway traffic. This paper proposes a framework of Cyber physical system about railway traffic which combines the information world and the physical world. It will synthetically improve the level of railway service.

Keywords—Cyber Physics System, Railway Traffic, Big data

I. INTRODUCTION

Cyber-Physic System (CPS) is a new complex system that is integrations of computation and physical process with many networks and technologies[1]. Railway Cyber Physical System (RCPS) is a new approach which combining the real world and the cyber world. Such systems will grow significantly in the near future as the current railway traffic system requires a lot of change of existing technologies. The systems include set of wireless sensors, embedded computing devices and central computing and memory resource. The synthetic decision of the cyber world will control these devices and give information to the train with a set of command and control statements. RCPS are commonly used in railway traffic related applications. In remote railway traffic monitoring system, these are small wireless sensors that connect trains, stops, passengers, railways, bridges, identifications of tunnel, and surrounding information, etc [2, 3]. The sensor network or the image catcher device will capture various content, process the information locally in real time and send the information back to the computing and storage node through internet or by wireless network [4, 5]. In this paper, we proposed processing framework for RCPS. In section II, we design a framework of the RCPS In section III, we discuss the special features for RCPS consideration. In section IV we give the future work of RCPS.

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II FRAMEWORK OF RAILWAY CYBER PHYSICS SYSTEM

In this part, the paper will describe the RCPS framework of our design of future RCPS.

The new feature to be deal with in railway traffic design ：

1. Mobility
2. Variability of outside surroundings
3. High speed
4. Safety

With the alterations for various railway monitor systems, there is a strong requirement for wireless sensors and embedded devices with efficient and robust communication and control. The term Railway Cyber Physical systems refers to systems that have combination of wireless sensors, embedded devices, communication channel for data and control to transfer, central computing and storage nodes. Erecting robust and effective RCPS requires new design, verification and evaluation techniques due to larger size and more variety of data. The challenges for completion such kind of systems include model formulation development, smart alarms, user fitted design and infrastructure for railway traffic information integration and processing.

We proposed the system with 4 parts including the sensing unit, communication unit, data processing unit and report generating unit.

For the sensor unit, it can be divided to 2 parts.

A. on-train wireless sensors

It mainly collects the velocity of the train, the pressure of the wet temperature, the identification of the train, etc. In this part we mainly get the information of the environment inside and the runtime state of the train to monitor whether it is running in normal way.

In addition to the part which clings to the system state, we also propose the new services of the RCPS for the customer use such as the healthy monitor system for somebody he is not good in health. It can detect the blood pressure, the pulse rate, blood sugar and other healthy parameters. In one hand we should provide the devices in every train carriage, the information

should be transferred to the center node of the train to give the help timely to the customers especially for someone who need immerse health care; In the other hand the system will provide the convenient mechanics for other body healthy wireless devices to access the health network of the train. Telemedicine system is developing more wildly. But in the traffic system such as long travel railway, it will be a specially and necessary component of the telemedicine system in the future. The network media will add more method such as blue tooth and infrared ray for near inside communication.

For the good transfer, the RFID technique will be used to response the situation of the goods for the safety of the traffic.

B. off-train wireless sensors

It is used to detect the railway, stop, tunnel, bridge and other surrounding information. If there are something seriously wrong with that, the forecast-alarm mechanism must make an emergent response to the related trains and devices. The information should be recorded regularly if no emergent situation happens and used for statistics algorithm to intelligent forecast danger degree.

In the transfer unit, the internet, wireless GSM-R/3G/4G/WiMax and satellite communication such as BDS are comprehensively used to connect all the sensors and devices. By them, the sensor relative information is transferred from stop by station and ministry of railways to the cloud networks.

Reliable data transfer is very important for RCPS especially in the uncontrolled outside surroundings.

For the data processing, we should use the high performance computing devices to response to the result in real time. In the cloud computing networks, we utilize cloud computing, fuzzy recognition, data mining and semantic anaonlyze technique, etc. to carry on information fusion and deep analyze to realize the environment of the physical surrounding of railway and intelligent decision control.

In Fig.1 the platform of RCPS is given.

In this part we will propose a method to keep the safety of cloud communication. Many data for the railway traffic need privacy protection. But there is a lot of data to store and processing. The store and computation materials are limited for railway station. We need cloud technique for help. But in one hand, if only we use the public cloud, it is not enough for high protection requirement; on the other hand, if we dead with all the data in the private cloud, there will be too much cost. To combination the efficiency and safety, we should use the private cloud as well as public cloud. We will adapt the distributed cloud environment. We will provide invasion detection method for public and private cloud to detection and prevent the DOC, DDOS, Trojans, etc. In this way, it can reduce the problem caused by invariance and openness from monopoly public cloud. In the distributed cloud system, the most important thing is to divide the high safety data and the other, and allocate them to different cloud. It is much easier for the private cloud to protect the safety.

Because the data set is very large. The processing unit need parallel mechanism accompanied with sequential method.

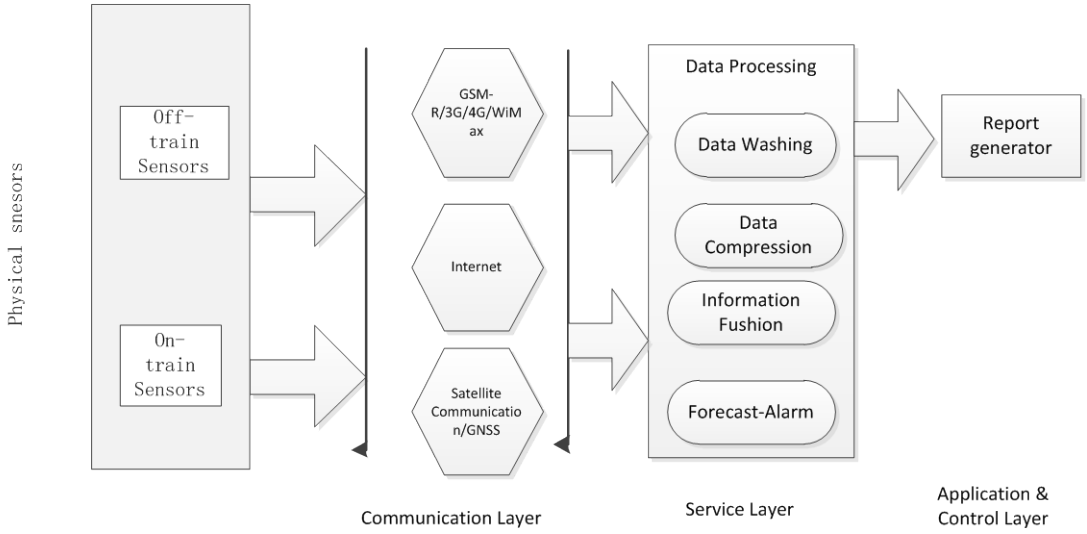

Fig.1 Framework of RCPS

Nowadays the rapid application of the cloud computing can give a strong help to CPS. The system can use the local network and nodes to collect information and transfer them to the cloud center for storage and powerful computation. But in the RCPS, in reality the data is separated in the local part and it is hard to get the right to gain the data. Accordingly it is prevented from transmitting to the public cloud center. If RCPS need a large amount of capable storage and more powerful computation, the private cloud center should be considered to be built. It will cost for additional money compared with other CPS system.

If the public cloud center can be applied for the RCPS, the privacy protection and security should be promoted and it can guarantee the safety of the data safety in high level.

In our design, in the RCPS the system will use the data from two parts. On the one hand, from the public data such as the

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climate and geographical information of the tracking; in the other hand it should use the private data.

The data set will be divided to several subsets. The subset can be processed in different processor respectively firstly. Then the result will be submitted to the main processor for synthetic analysis. It is attributed to the area of parallel and distributed computation. MapReduce framework and Hadoop distributed file system (HDFS) is specifically designed to such kind of distributed system. MapReduce is a simplified parallel programming model which is used for computation in large scale. The name is from two core functions of LISP: Map and Reduce. The feature of MapReduce is that all of the Map operations are independent and all the Map operations can be executed simultaneously as well as all the Reduce operations will dependent on the result of MAP, but all the reduce operations is independent among each other. Hadoop project is an open source project including Hadoop HDFS and Hadoop MapReduce corresponding Google's GFS and Google's MapReduce。

In the design of high speed train system, not only the big data volume should be considered but also high data stream velocity. MapReduce is adaptable to parallel processing of big data, but not the same to analysis high velocity data stream. Stream data processing technique is adaptable for such situation. Because the processing method is based on the Event-driven mode, we can transact things one by one. It is rapid to response for the event coming to the system.

The stream data processing technique should be adapted combining with the MapReduce and Hadoop method.

With the improvement of data processing ability of big data volume and velocity, the miss rate of decision unit will be reduced because of more data can avoid more deviation of judgment.

For the network design of RCPS, a no conflict switch scheduling method is proposed especially for the on-train network. The butterfly topology is used combined with k-selector mechanism. We design a principle for transfer control to avoid contentions among two inputs, the way we design is to let them diverge before they contend with each other later. i.e., set their destinations to different places right after they merge with each other at a switch at level k, or avoid the merging. Assume that two inputs merge at level l, they will sure to contend with each other if the k + 1th digit of their destinations still agree. To prevent this from happening, we either set the i + 1th digit of their destinations to be different; or we can set any of the digit from the first one to the kth one to even prevent the two inputs from merging. In our method, they will never contend with each other later. Thus contention-free is achieved. The earliest prevention can happen as the second digit when two inputs first digit agree. Of course setting even the first digit of their destinations to be different trivially prevents them from merging. There are 4 permutations of the first two digits (00, 01, 10 and 11). It's easily to be seen that any 4 inputs being assigned to these 4 outputs will achieve contention-freeness.

III CONSIDERATIONS OF RCPS

The following considerations need to be paid attention to design the RCPS.

A. Complexity

The railway system is a complex system that is an integration of complex devices, complex running surrounding and complex space-time distributed displacement services. It is a very complex large network system. But the parts of subsystems are lack of cooperation and interaction. The performance and utilization need to be increased. So it is necessary that new theory, methodology and technology are needed to be adopted to analyze the key factors of railway safety with valid check and forecast-alarm. The different wireless systems should be accessed together and each part should solve their own special problems in the mobility and inside or outside environment of train traffic.

B. Compression

For the large scale sensor network, the data to be collected and transferred is very big. Because of the temporal and space dependence, the data has large redundant information. The design of compression algorithm for large wireless data is necessary to efficient data transfer in CPS system. In the rapid moving situation it is no enough time to transfer completely data in frequent cases. In reality, much data is redundant and in mass. The good comprssion method should extract and rescue the key information of the system.

C. Reliable data transfer

The data generated from wireless network off-train should be transferred to the devices on-train. The reliable data transfer mechanism and algorithm is important for RCPS.

II. FUTURE WORK

A. To be adaptive to the improvement of the speed of the train

With the rapid increase of high-speed train, the velocity of the system brings higher difficulty for the RCPS to collect the data in high speed accurately.

B. Efficient Larger Storage

More data should be stored in an instant of time. So it is necessary to improve the efficiency of memory system as well as enlarging the storage size.

C. High performance computing and communication

To deal with the situation according to the higher speed traffic, the RCPS should give the control and alarm information in time[6]. It is important to update the performance of the system to the new situations.

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IV. CONCLUSION

Cyber physics systems design for railway traffic must meet the requirements of reliability and real time. We discussed in this paper what we consider are the main concerns about this topic and we give a framework of the RCPS. The main challenges for the future are given in the end.

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Informatics teaching methodology in improving informatics students' competencies

Danimir Mandic, Gordana Jotanovic, Goran Jausevac, Ljubisa Vladusic, Aleksandra Mandic

Abstract Main task of the research is to examine the level of IT knowledge and skills in the student population of the Faculty of Transport and Traffic Engineering in order to improve IT competencies of students of this profile. The principal aim is to develop a methodology for the advancement and harmonisation of curricula and the improvement of teacher IT competencies in compliance with European standards and the needs of transport and traffic engineering faculties. Additionally, the aim is to implement such a methodology, i.e. to modernise the IT teaching process by using new teaching tools and on-line tests to assess students' knowledge and skills in order to improve their informatics competencies.

Keywords— information technology, teaching, informatics competencies, test of knowledge,

I. INTRODUCTION

The concepts of competency and general competency are synonyms for the basic skills, knowledge, resourcefulness, and literacy as well as mastery of a certain area. The word "competency"signifies a combination of skills, knowledge, aptitudes and attitudes. Definition: "Key competences are a transferable, multifunctional package of knowledge, skills and attitudes necessary to every individual for their self-realisation and development, inclusion and employment. They should be developed by the end of compulsory education or training, and should represent a basis for further learning as part of lifelong learning"[3]. To develop informatics competencies[1] at transport and traffic engineering faculties it is necessary to improve the informatics knowledge and skills in students. Also, IT education of students must be harmonised with European standards (*FCDL - Finnish Computer Driving Licence, ECDL – European Computer Driving Licence)* and the courses of professional informatics education in the field of traffic engineering. What competencies should students of transportation and traffic engineering faculties develop during a course of informatics? Should they improve their general informatics competency[2] or should their education rather be based on the informatics competencies for specific purposes[3]? One of the most important preconditions for students to gain specific informatics knowledge in the field of traffic engineering is to have previously gained the basic knowledge of informatics.

Students develop informatics literacy[4] during their primary, secondary and self- education. The factors that have impact on students' development of new informatics competencies are: quality equipment in computer laboratories, the use of adequate course books, software legalisation and competences of teachers engaged in secondary and primary education.

In late nineties, European Commission started the initiative for informatics literacy level advancement in Europe. The document resulting from it was the "European framework of key competences", which plays a major part in the improvement of informatics competencies in European countries. This document enforced the standardisation of informatics knowledge and skills (*ECDL – European Computer Driving Licence*) and the harmonisation of educational systems of European Union countries.

Within its reform of primary and secondary education, the Ministry of Education of the Republic of Srpska allocated a high percentage of funds for equipping computer laboratories, teacher education and forming school information centres. The aim of the investment was to provide better conditions for the development of basic informatics competencies in students in primary and secondary education. This is an important factor for the improvement of informatics competencies of students at transportation and traffic engineering faculties.

II. SUBJECT OF THE RESEARCH

The subject of the research is assessing the informatics competencies of the students of Transport and Traffic Engineering Faculty in Doboj in order to determine suitable teaching modalities adapted to the needs of students of traffic engineering faculties.

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[1] General informatics competencies

[2] Students' use of informatics for daily purposes

[3] Students' use of informatics for professional purposes

[4] Ability to distinguish, use, search, upload and analyse information.

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Due to the long-term interval spent in learning "Informatics" during primary, secondary and self- education, the question that imposes itself is how useful it is to include informatics in the curricula of traffic engineering faculties. The assumption is that during their previous education students already acquired the informatics competencies necessary for proper participation in the teaching process at traffic engineering faculties; therefore, there is no need for an enhancement of students' informatics competencies to a higher level of knowledge. The question that imposes itself in the process of planning informatics lessons at the Transport and Traffic Engineering Faculty is: Should a model of general informatics teaching be adopted or should traffic engineering faculties rather create their own models of teaching informatics for specific purposes? The following study results from an attempt to answer this question. [1]

The process of developing informatics competencies can prove to be of greater value from the perspective of the already functional methodologies than from the perspective of effects expressed through the ECTS system (*ECTS – European Credit Transfer and Accumulation System*), learning outcomes or the quantity and quality of the knowledge acquired. A fact to be also taken into consideration is that students gain part of their informatics knowledge through their own activity (the *Internet, Social networks*). "Knowledge acquired based on a critical and creative transformation of the contents learned will be of greater value than knowledge gained through cognition, reproduction and information gathering" [2]

Some informatics contents are harder to acquire as they require reasoning and learning through discovery based on the engagement of various thinking skills and a creative and critical approach to studying informatics subjects. In that way, students acquire high quality knowledge which cannot be forgotten, which is easily structured into cognitive schemes, applied, transformed and used in various profession-specific subjects which require informatics knowledge.

We can conclude that informatics literacy and the improvement of students' informatics competencies comprise a unique system. "A complex evaluation system must initiate and generate developmental changes in didactic-methodological and pedagogical organisation of university teaching as a whole" [7]

III. RESEARCH AND THE RESULTS

The research is based on measuring students' basic informatics competencies acquired during primary and secondary education. In order to determine students' informatics competency, as a diagnostic parameter, it is necessary to analyse students' achievement in secondary education in terms of their final grades in informatics subjects. For data reliability, diagnostic testing of students' knowledge and skills was organised based on informatics teaching modules and in compliance with the rules which follow the logic of knowledge assessment. Students were tested with two diagnostic tests of the same structure, with multiple-choice questions, which were used to assess their formerly gained informatics knowledge and skills. The test questions were formed by using the European standard data base (*ECDL – European Computer Driving Licence*).

The first diagnostic test (*Test of Knowledge*) aimed at assessing students' informatics knowledge according to the European standard.

The second diagnostic test (*Test of Skills*) aimed at the evaluation of students' informatics skills according to the European standard.

One of the main parameters for the assessment of informatics knowledge and skills is the system of measuring students' aptitude. The concept of "measuring" herewith means a certain standard which is used to test the level of informatics knowledge and skills in the students of transport and traffic engineering faculties. A number of measuring instruments were used for the evaluation of variable informatics parameters in the students' system of informatics competencies. One of them was a questionnaire related to students' final mark gained in secondary education and the type of school they attended. Evaluation of the Informatics as a subject also represents an important instrument of determining informatics competencies in students during their education at transport and traffic engineering faculties. The internal evaluation of informatics as an academic subject at transport and traffic engineering subjects can help us determine three most important parameters in the system of informatics teaching, and they are:

- The evaluation of informatics skills helps the professor/teaching assistant to gather the data on the knowledge and skills which the student has gained. The evaluation of students' overall informatics knowledge includes the assessment of that knowledge, too.
- Measuring is done to determine the quantitative features of students' achievement and performance.
- Assessment represents evaluation of students' informatics knowledge and skills according to previously determined criteria.

The process of self-evaluation at transport and traffic engineering faculties can also have multiple benefits. It can serve students for a self-improvement of informatics competencies and teachers for giving them proper guidance in that process.

Aims of the research

In the process of informatics teaching the important issue is defining the aims of teaching informatics at transport and traffic engineering faculties bearing in mind students' previous knowledge and skills. Using computerised classrooms, the application of standardised teaching syllabuses based on modern teaching principles, and

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competent teaching staff are the prerequisites for the fulfilment of the aims of teaching informatics. [8]

The main objective of this research is to determine students' previous knowledge and skills in the field of informatics in order to take further steps for the improvement of informatics competencies in students of transport and traffic engineering students. The syllabuses of the subjects in the area of traffic and transportation also imply students' informatics competency. Therefore, the teaching and assessment processes in other profession-related subjects include the assessment of students' informatics knowledge and skills. In that sense, one of the aims of this research is to work out a suitable modality of evaluation of students' general informatics knowledge and skills in order to improve the specific informatics competencies of the students of transport and traffic engineering faculties. The major aim of the research is the analysis of forms and ways of informatics teaching at transport and traffic engineering faculties in order to improve students' competencies to a level matching European standards. [7]

Research hypotheses

New informatics teaching methodologies applicable solely at transport and traffic engineering faculties with the aim of improving students' competencies will be implemented only if the following hypoteses are confirmed:

- (H_0) Previously developed informatics competencies in the first year students of the transport and traffic engineering faculty acquired through primary, secondary and self- education do not meet the requirements for student informatics competencies prescribed by European standards.
- (H_1) Previously developed informatics competencies in the first year students of the transport and traffic engineering faculty acquired through primary, secondary and self- education do not meet the requirements for student competencies prescribed by European standards.

Population and the sample

The research population consists of 219 first-year students of the "Transport and Traffic Engineering faculty" of Doboj University in East Sarajevo enrolled in the academic year 2013/14 who are attending an informatics course for the first time.[5] The used sample belongs to the category of intentional sampling and makes a grooup of 170 tested first-year students of the Transport and Traffic Engineering Faculty in Doboj. In percentages, the used sample makes 77,63% of the total population, so that the sample can be considered valid for further research.

Variables and the mode of data acquisition

The variables in this analysis are presented with the data gathered in two diagnostic tests (*Test of Knowledge* and *Test of Skills*) held during a lesson of "Informatics" and the third variable marks the high-school students' attainment in informatics expressed as the *Average grade in high school*. The aim of the diagnostic tests is to show the overall knowledge and skills (informatics competencies), which students gained during their previous education. During the study we gathered the following data: demographic data about students' gender, the structure of the secondary school they finished, data about students' attainment expressed as the average high school grade, data on the results of the diagnostic tests of knowledge and skills. All the data collected during the study are shown in the following diagrams. According to the demographic data about studetns' gender, out of 170 respondents, 109 were male and 61 female students. Diagram 1. shows an obvious dominance of male population because the study was conducted at the transport and traffic engineering faculty which typically has more male students. Therefore, such gender ratio was expected.

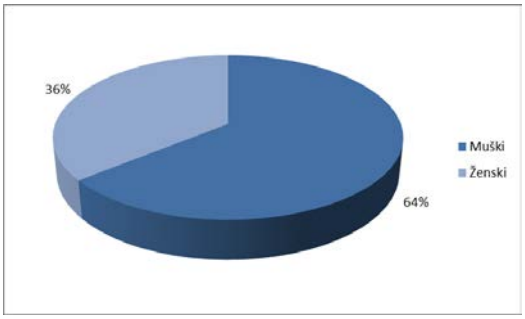


Diagram 1. Demographic student structure (male, female)

By using a questionnaire with the students of Transport and Traffic Engineering faculty in Doboj, we collected the data on the structue of secondary schools they finished,

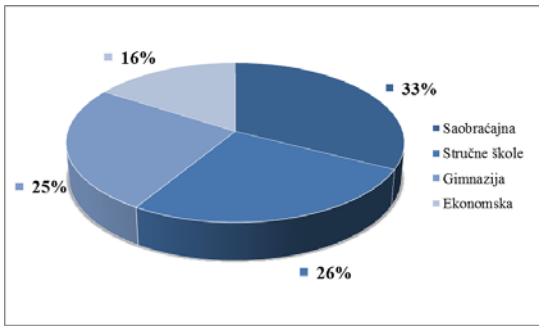


Diagram 2. Types of secondary schools finished by the tested students expressed in percentage (Transport and Traffic Engineering School, Vocational Schools, Grammar School,

[5] Students who are repeating the academic year are not included in the population.

Economic School). The indicator of students' attainment in informatics during their high school education was their average final grade in informatics subjects,

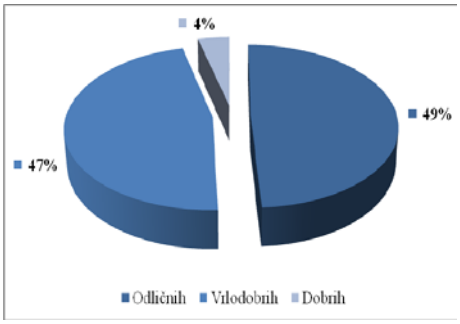


Diagram 3. Average final high school grade (Excellent, Very good, Good).

The data gathered by testing students (*Test of Knowledge* and *Test of Skills*) are shown in percentages in the following diagrams (diagram 4. and diagram 5.). The total number of tested students is 170, whereby the first diagnostic test (*Test of Knowledge*) was done by 128 students, and the second diagnostic test (*Test of Skills*) was done by 127 students of the Transport and Traffic Engineering Faculty in Doboj. The difference in the total number of the tested students and those tested with partial diagnostic tests results from a different number of students who took part in each of the **diagnostic tests.**

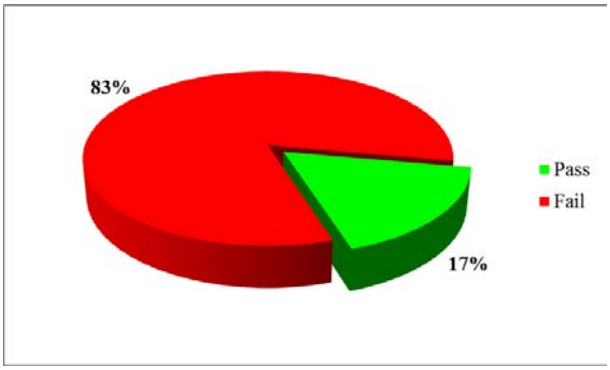


Diagram 4. Evaluation of performance in the test of infor matics knowledge (Test of Knowledge)

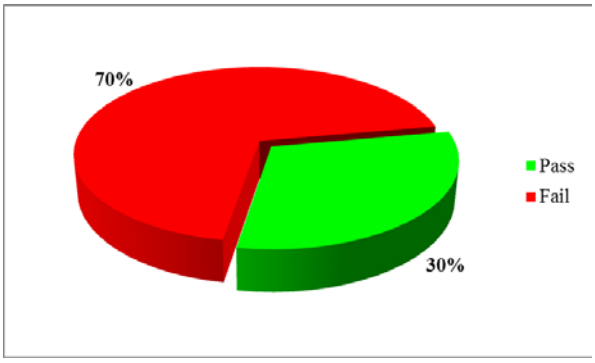


Diagram 5. Evaluation of performance in the test of informatics skills (Test of Skills)

The data gathered in the study will be processed by means of software tools and analysed according to statistical methods

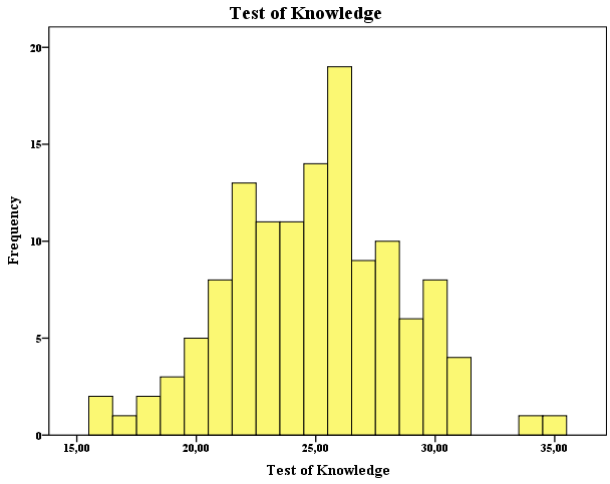
Methodology

The statistical processing and analysis of the data was based on the use of the following tools: Microsoft Excel 2007 and IBM SPSS Statistics 20.
Data processing and analysis were based on the following statistical methods:

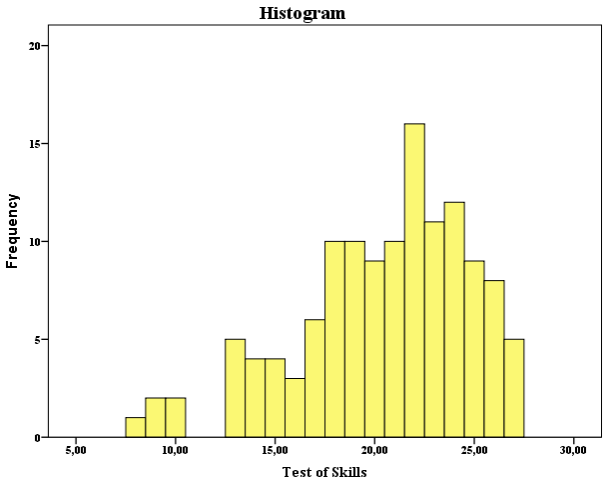
1. Presentation of the variable frequency distribution (*Test of Knowledge, Test of Skills* and *Average grade in high school*).
2. Descriptive statistical method: *Minimum, Median, Maximum, Mean, Standard Deviation, Standard Error of Mean.*
3. Kolmogorov-Smirnov (*KS*) test for proving the normality of variable result distribution (*Test of Knowledge, Test of Skills* and *Average grade in high school*).
4. Method of correlational analysis based on the Pearson coefficient of correlation between pairs of variables (*Test of Knowledge – Average grade in high school* and *Test of Skills – Average grade in high school*).
5. By means of a student or t test we determined the significance of correlation coefficient.
6. The analyses were done at the level of 95% reliability (*probability of error* $r \leq 0{,}05$).

Research results

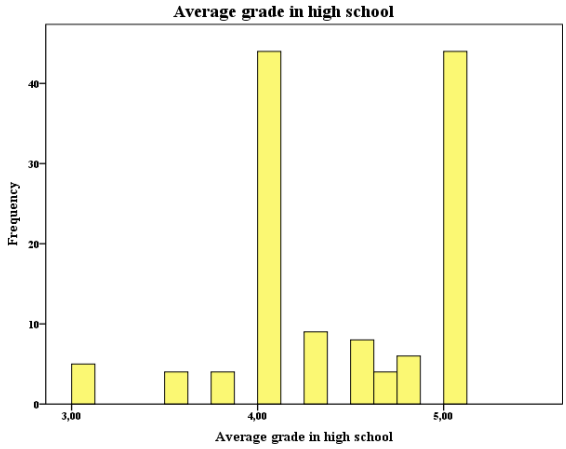
The results of the diagnostic tests and average high school grades are shown in the tables of frequency and histograms



Histogram 1. Test of Knowledge



Histogram 2. Test of Skills



Histogram 3. Average grade in high school

Based on results shown in the tables of frequency and histograms we can suppose that the distribution for each variable is normal. The data shown above were included in a descriptive analysis and the results are shown in Table 5

Table 5. Descriptive statistics

	Test of Knowledge	Test of Skills	Average grade in high school
Valid	128	127	128
Missing	0	0	0
Mean	24,898	20,457	4,388
Std. Error of Mean	0,3159	0,381	0,049
Median	25,000	21,000	4,330
Std. Deviation	3,573	4,294	0,553
Minimum	16,000	8,000	3,000
Maximum	35,000	27,000	5,000

The normality of distribution was checked by means of Kolmogorov-Smirnov (*KS*) test.

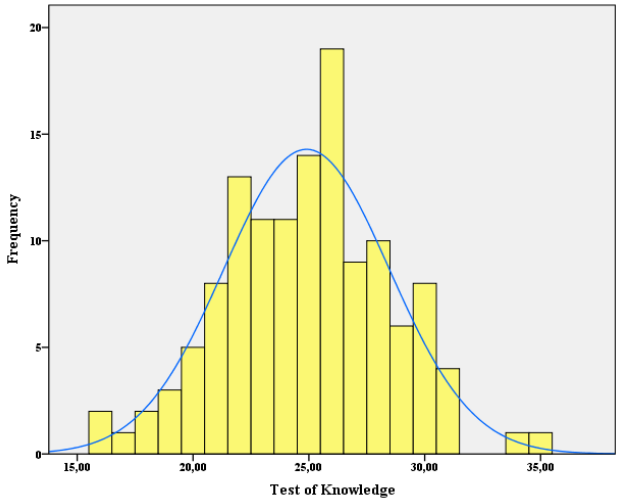
Table 6. Results of KS test

Tabela 6. Rezultati KS testa

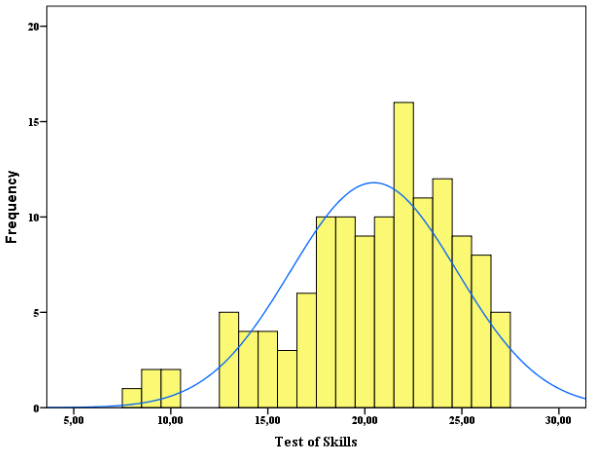
		Test of Knowledge	Test of Skills	Average grade in high school
N		128	127	128
Normal Parameters[a,b]	Mean	24,898	20,457	4,388
	Std. Deviation	3,573	4,294	0,553
Most Extreme Differences	Absolute	0,074	0,121	0,209
	Positive	0,074	0,064	0,204
	Negative	-0,074	-0,121	-0,209
Kolmogorov-Smirnov Z		0,840	1,360	2,370
Asymp. Sig. (2-tailed)		0,481	0,050	0,000

a. Test distribution is Normal.

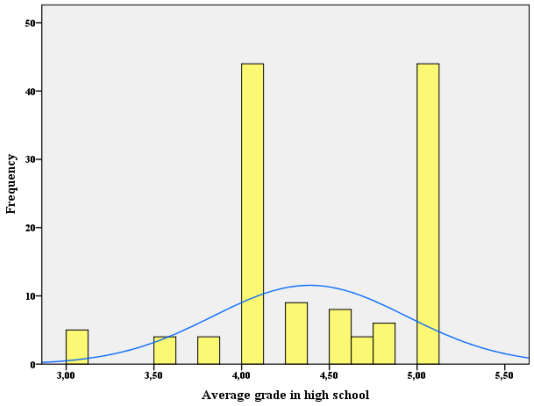
b. Calculated from data.



Histogram 4. Test of Knowledge with the curve of normal distribution.



Histogram 5. Test of skills with the curve of normal distribution.



Histogram 6. Average grade in high school with the curve of normal distribution.

Based on the results shown in Table 6. where the KS test results for the variables are higher than the highest deviation of the empirical distribution from the normal curve, we can conclude with certainty that distribution for all the three variables is normal. By method of correlation we test the connection between the variables (*Test of Knowledge, Test of Skills* and *Average grade in high school*). Based on the proved normality of distribution of the research results we used the Pearson correlation coefficient. Based on the test of correlation and the test of significance of the r correlation coefficient, we can say that the dependence between the diagnostic tests and individual grades in high schools is negligible.Diagnostic tests of knowledge and skills and the average grade high schools in informatics subjects can be used as a valid proof of informatics competencies of students before they are enrolled on a course of Informatics at the Faculty of Transport and Traffic Engineering in Doboj.

Based on the diagnostic test results (Diagrams 6 and 7) and final high school grades, we reached the following conclusion: We can confirm the H0 hypothesis that the informatics competencies of the first-year students of the Transport and Traffic Engineering students do not comply with the competencies defined in European standards, which was proved in a range of statistical analyses. An insight into the statistical analyses done shows that there are no statistically significant correlations between the average grades in high school and the diagnostic tests.

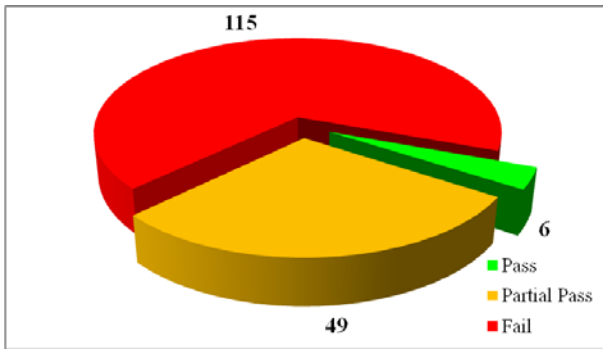


Diagram 6. The overall student performance in the Diagnostic tests

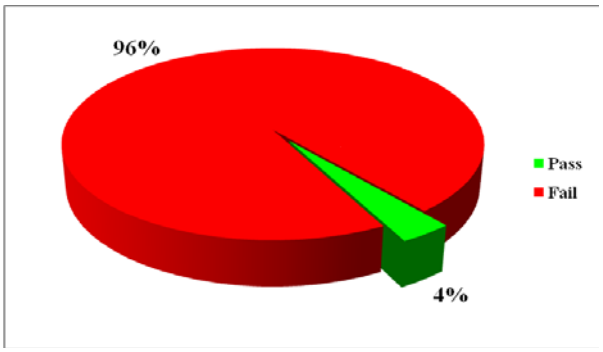


Diagram 7. The overall student performance in the Diagnostic tests in percentages.

III Conclusion

Based on our former experience and the results of the analysis of the level of informatics competencies of the first-year students at the Transport and Traffic Engineering Faculty in Doboj, we can consider the following needs and possibilities. A redesign of the current curricula which includes the standardisation of informatics syllabuses (ECDL – European Computer Driving Licence). Introducing new informatics contents and skills with the aim to improve the informatics competencies of students and their implementation with the aim of the teaching process optimisation. Modelling a system of informatics education at transport and traffic engineering faculties by which we encourage students for individual work on their own informatics knowledge and skills. Implementation of a system of evaluation by which we control further steps in the organisation of teaching informatics and adapt it to the specific needs of the transport and traffic engineering faculty.

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Rule-based recommendation for supporting student learning-pathway selection

Abdelrahman Osman Elfaki, Khaled M. Alhawiti, Yahya M. AlMurtadha, Osman Ahmed Abdalla, Asim Abdallah Elshiekh

***Abstract*—**Nowadays, using Information Technology solutions to handle challenges in education become a common strategy in different ways. In this context, data mining applications have been introduced intensively for solving many obstacles in education. Choosing unsuitable learning pathway is considering a critical problem. As, such problem is discovered after graduation or in the middle way of the learning pathway which make the correction is almost impossible. This problem effects even the whole community by either low quality of graduates or graduates working in unsuitable career. Currently, educational data mining is a common technique that is providing solutions for such kind of problems. This paper is proposing a rule-based recommendation system for students' learning pathway at University of Tabuk, at Kingdom of Saudi Arabia. As a research methodology: first, decision tree has been selected as a data mining algorithm. Second, required data has been collected from University of Tabuk, Faculty of Computers and Information Technology. Third, decision tree has been developed based on the questionnaire's data. Last, induction rules have deduced from the tree paths to provide a recommendation advices. The proposed recommendation has been validated using test samples which are part of collected questionnaires. From the rules there are eight interesting findings have been presented. Expected result is enhancing the overall learning process at University of Tabuk by providing suitable learning pathways.

***Keywords*—** Recommendation System, Educational Data Mining, Decision Tree.

I. Introduction

IN the current era, applications of computer science have been applied in different parts of our daily life. Day after day, computing applications have been involved in improving our life. Education is one of the necessities of life. It has become the use of technology in education a reality. Nowadays, development in education is not grateful only for technology. Computing becomes a key player in the education. The usage of computing in education makes our dreams touch the ground. To explain this sentence, for instance, how the students can be classified based on future academic performance? One more instance like how to predict students' performance. Computing can be used for providing successful solutions for these impossible and insurmountable questions. Thus, it is common to use information technology solutions to handle challenges in education and it becomes a common strategy in different ways. In this context, data mining applications have been introduced intensively for solving many obstacles in education. From there, education data mining has been born as a new science concern with predicting students' academic performance, model student behaviour, and classification of students types [1]. Certainly, the students' achievement depends on desirable learning-pathway [2].

Learning pathway is defined as the chosen route taken by a learner, which allows him to build knowledge progressively, i.e., in learning pathways, the control of choice moves away from the tutor to the learner [3]. Learning pathway aids learners to access information and courses by which they can construct personalized transitions between the information to be accessed and their own cognitive structures [4]. In other words, learning pathway is collection of courses that student should pass it to get the approval certificate.

Usually, students discover their real preferred study field after spending time in their studying. Mismatching between current and preferred learning pathway could be a source for many academic difficulties, such as weak performance, high percentage of absence. Moreover, in the daily life, there are many students who drop their level of education in spite of the promising beginnings. As well, many graduates do not have a desire to work in their field of study. Both of these two problems are a consequence of unsuitable learning pathway.

This paper introduces a rule-based recommendation system that could be used to assist students at University of Tabuk, Faculty of Computers and Information Technology, to select the most suitable academic program. These rules have been generated from decision tree, which is developed based on questionnaire data.

This paper is organized as follow: related works are

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presented and analyzed in section 2. Detailed description of developing the proposed recommendation system has been presented in section 3. Section 4 contains results discussion and future work.

II. Related work

Recommendation system is widely used in social networks and in E-learning systems. In social networks, is used for recommending new friends and E-learning systems is used for recommending new books, courses and learning objects. The successful of recommendation system in these two domains attract researchers to use the same concept in education data mining [5].

Predicting the future academic performance is the main concern of educational data mining [6]. Predicting academic future performance is based mainly on classification or clustering of students regardless the used technique aiming [7]. Then the final aim is to provide guidance or advices for lecturer or student for enhancing the academic performance. Looking for this final aim, we can easy consider that "developing recommendation" is the final aim of educational data mining.

Although social networks are the main target for recommendation's developers, recently education and specially enhancing student performance grab the attention of recommendation's developers. There is huge works of educational data mining with different perspectives that have been published. However, this rich literature, here, in this section, we have focused only on works that discuss literally recommendation systems.

Romero et al.[8[developed a recommendation system to guide student in selection of links within an adaptable educational hypermedia system. Wang et al. [9] proposed a ranking-based recommendation system to help students to get the useful learning resources in suitable ordering. Chen et al. [10] proposed Library recommendation system to propose suitable books based on borrowing record of the library. Khribi et al. [11] developed web-based recommendation for matching between learning objects and learner to minimize the effort of finding suitable learning objects. Wong and Looi [12] proposed a recommendation for e-learning paths by stochastically computing previous learners' performances. García et al. [13] suggest rule-based recommendation to support E-learning teachers classify their students and provide suitable learning objects respectively. Alsalama [14] proposed a hybrid framework recommendation system which matches between users and items. Alsalama's model is proposed to be general and useful in different places. However, it did not validate or test in education field. Vialadir et al. [15] develop a recommendation system to support student in selected their courses based on data from previous students. Nagy et al. [16] proposed a recommendation system that could be used to provide pieces of consultations to a first year university student to pursue a certain education track. Lin et al. [17] proposed personalized learning paths in creativity e-learning system. This model is applied only in E-learning environment. The authors in [15] and [16] developed their recommendation based on previous students' results which may not be fair enough to provide clear or complete picture as the results itself depend on many reasons. Shaw et al. [18[suggested personalized learning platform called Guided Learning Pathways (GLP). GLP is an environment in which learner can get learning materials and topics suited for him. It has been developed for developing countries who may not have access to traditional learning opportunities. GLP did not evaluated with traditional learning.

In the above, two groups of previous works have been discussed. First class was targeted E-learning system and second class was targeting class system. Table 1 summarizes the discussion of related works.

Table 1 summary of educational recommendation system

Work	Technique	Environment
Romero et al. (2007)	Clustering and Sequential Pattern Mining Algorithm	E-learning
Wang et al. (2008)	Transition Probability	Portal
Khribi et al. (2009)	Association Rules	E-learning
Wong and Looi (2009)	Ant Colony Optimization	E-learning
García et al. (2009)	Production Rules	E-learning
Alsalama (2013)	Association Rules	E-learning
Vialadir et al. (2009)	Decision Trees	Class Room
Nagy et al. (2013)	k-Means Clustering	Class Room
Shaw et al. (2014)	Content maps	Non formal Class Room

As our work is classroom based then its features should be compared with the previous classroom works. Vialadir et al. [15] and Nagy et al. [16] developed their recommendation in classroom environment based on academic results. Our recommendation is different as it is developed based on different factors such as demographic, academic and social students' information. We claim that including of all these factors will strengthens the chance of success of the recommendation system. While our recommendation is proposed for formal classroom education, the work of Shaw et al. [18] proposed their recommendation for untraditional classroom or what it called non-formal education.

III. Developing Recommendation System

In this section, detailed description of developing the proposed rule-based recommendation system has been presented. First, variables that might be useful in predicting suitable learning pathway have been defined from the literature. These variables have been collected from [19-25].

Data have been collected using a questionnaire from Faculty of Computers and Information Technology at University of Tabuk. We have targeted students from Computers Science and Information Technology departments. The target group is about 900 students. Successful collected questionnaire are 450 papers, which is considered more than satisfied as a sample size.

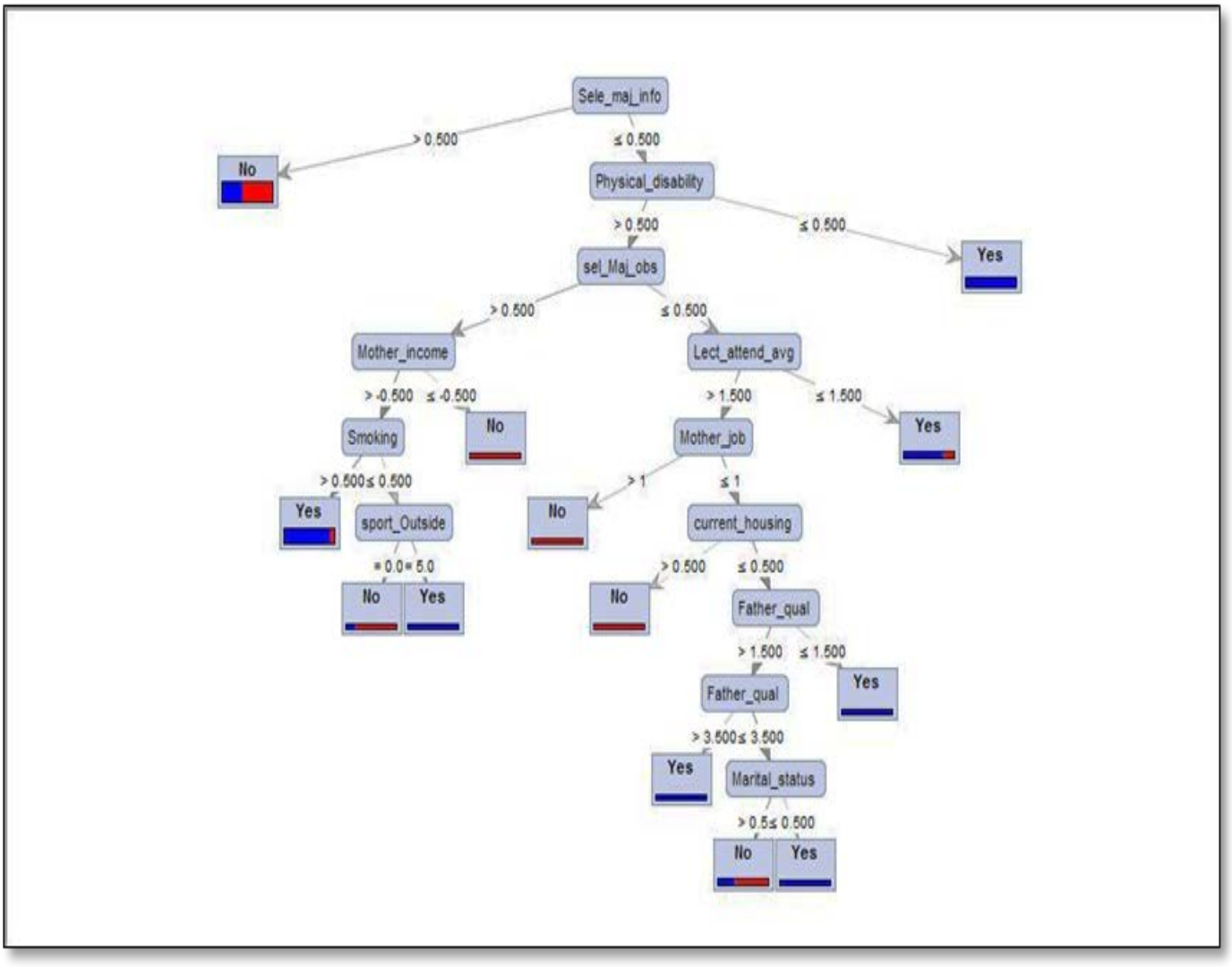

Fig. 1 the obtained decision tree

The questionnaire variables are issued based on four perspectives: basic information, personal information, academic information, and learning pathway information. Although, there are some works deal with learning pathway recommendations, as the best of our knowledge, our proposed recommendation is the first learning pathway recommendation that consider these four perspectives together.

Decision tree has been obtained by mining the questionnaire data. Figure 1 shows the obtained decision tree. In this obtained decision tree, there are two ends: “Yes” and “No”. The word “Yes” means wishing to change the current learning pathway. In other words, means there is a dissatisfaction of the current learning pathway. The word “No” means there is satisfaction of the current learning pathway. Production rules have been extracted from paths or directions in the obtained decision tree to get full benefits from it. Figure 2 shows the extracted rules that will defined the output of the proposed recommendation. There are twelve production rules that result in “Yes” or “No”. In the following, each rule has been explained in details.

Rule1: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is no any problem occurred during facing the selection of current learning pathway, and there is no smoking habit then recommendation is to change your current learning pathway.

Rule 2: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is no any problem occurred during facing the selection of current learning pathway, and there is smoking habit, and the preferable sport is football then recommendation is do not change the current learning pathway.

Rule 3: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is no any problem occurred during facing the selection of current learning pathway, and there is smoking habit, and the preferable sport is Martial Arts then recommendation is to change the current learning pathway.

Rule 4: If the selection of current learning pathway is

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happened due to family recommendation, there is no physical disability, and there is no any problem occurred during facing the selection of current learning pathway, and the mother does not has monthly income, then recommendation is do not change the current learning pathway.

R1: ((Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs > 0.5) and (Mother_income > -0.5) and (Smoking > 0.5)) ⟶ Yes

R2: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs > 0.5) and (Mother_income > -0.5) and (Smoking ≤ 0.5) and (sport_Outside))= 0.0 ⟶ No

R3: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs > 0.5) and (Mother_income > -0.5) and (Smoking ≤ 0.5)and (sport_Outside))= 5.0 ⟶ Yes

R4: ((Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs > 0.5) and (Mother_income ≤ -0.5)) ⟶ No

R5: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs ≤ 0.5) and (Lect_attend_avg > 1.5) and (Mother_job > 1)) ⟶ No

R6: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs ≤ 0.5) and (Lect_attend_avg > 1.5) and (Mother_job ≤ 1) and (current_housing > 0.500)) ⟶ No

R7: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs ≤ 0.5) and (Lect_attend_avg > 1.5) and (Mother_job ≤ 1) and (current_housing current_housing ≤ 0.500) and (Father_qual > 3.500) ⟶ Yes

R8: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs ≤ 0.5) and (Lect_attend_avg > 1.5) and (Mother_job ≤ 1) and (current_housing current_housing ≤ 0.500) and (Father_qual ≤ 3.5) and (Marital_status > 0.5)) ⟶ No

R9: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs ≤ 0.5) and (Lect_attend_avg > 1.5) and (Mother_job ≤ 1) and (current_housing current_housing ≤ 0.500) and (Father_qual ≤ 3.5) and (Marital_status ≤ 0.5)) ⟶ Yes

R10: (Sele_maj_info ≤ 0.5) and (Physical_disability > 0.5) and (sel_Maj_obs ≤ 0.5) and (Lect_attend_avg ≤ 1.5)) ⟶ Yes

R11: (Sele_maj_info ≤ 0.5) and (Physical_disability ≤ 0.5)) ⟶ Yes

R12: (Sele_maj_info > 0.5) ⟶ No

Fig. 2 the extracted rules

Rule 5: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is a problem occurred during facing the selection of current learning pathway, and average attendance of lecturer is very good, and the mother has a job then recommendation is do not change the current learning pathway.

Rule 6: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is a problem occurred during facing the selection of current learning pathway, and average attendance of lecturer is very good, and the mother has a job, and current accommodation is single then recommendation is do not change the current learning pathway.

Rule 7: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is a problem occurred during facing the selection of current learning pathway, and average attendance of lecturer is very good, and the mother has a job, and current accommodation is with family, and the father qualification is at least university degree then recommendation is to change the current learning pathway.

Rule 8: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is a problem occurred during facing the selection of current learning pathway, and average attendance of lecturer is very good, and the mother has a job, and current accommodation is with family, and the father qualification is less than university degree, and marital status is not married then recommendation is do not change the current learning pathway.

Rule 9: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is a problem occurred during facing the selection of current learning pathway, and average attendance of lecturer is very good, and the mother has a job, and current

accommodation is with family, and the father qualification is less than university degree, and marital status is married then recommendation is to change the current learning pathway.

Rule 10: If the selection of current learning pathway is happened due to family recommendation, there is no physical disability, and there is a problem occurred during facing the selection of current learning pathway, and average attendance of lecturers is not good then recommendation is to change the current learning pathway.

Rule 11: If the selection of current learning pathway is happened due to family recommendation, there is a physical disability then recommendation is to change the current learning pathway.

Rule 12: If the selection of current learning pathway is happened due to other factors and there is no influence of the family then recommendation is do not change the current learning pathway.

Figure 3 shows the algorithm of our proposed recommendation. This algorithm shows that the student should choose first his learning pathway then student needs to answer recommendation's questions to get the advice.

```
Start
Current learning pathway = empty;
Students choose his learning pathway;
Current learning pathway = student's choice;
Loop:
Students answer the recommendation's question;
Until  end of recommendation's questions;
If the output(recommendation) = "Yes" then
Recommendation = Change (Current learning pathway);
Else
If  the output(recommendation) = "No" then
Recommendation = not(Change (Current learning pathway));
End;
```

Fig.3 algorithm of the proposed recommendation

IV. Validation

The proposed recommendation model has been tested by using questionnaire papers that have been saved a way and kept as testing samples. The collected questionnaire papers have been divided into two groups, developing and testing groups with ratio of 70% and 30% respectively. The results show that the accuracy of the proposed recommendation model is accepted and applicable.

V. Results discussion and Future work

Here is this section, the obtained results have been discussed and future work is presented. Analysing the extracted rules the following findings have been notice:

- There is a high risk to choose the learning pathway based on family recommendations;
- There is no any influence for the mother's income in satisfaction of choosing learning pathway. Although mother's income has been mentioned but it include all the choices of mother's income;
- Smoking habit and play Martial Arts is a sign of dissatisfaction of learning pathway;
- Parents with high qualifications have negative influence in choosing learning pathway for their kids;
- Attendance is a good sign of learning pathway satisfaction;
- Physical Disability has strong influence of choosing unsuitable learning pathway.

Each point of the above findings could easy produce more than one recommendation. These findings are very interesting and are match and cope with real life facts.

As a future work, we are planning to extend the scope of the proposed recommendation by including all the student from University of Tabuk and we are plan to go more deep by adding new perspectives in developing recommendation. We will evaluate our propose system by test it with the current graduates.

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Twenty years of informatics teaching methods in Slovakia

Ivan BRODENEC

***Abstract*—**The article gives summary on ideas and methods used in teacher training programs in Slovakia. We present our national conference which lasts already twenty years, the cognitive process in informatics and one of the practical approaches in didactics of informatics.

***Keywords*—**cognitive process, didactics of informatics, open-book exam, problem solving, teacher training

I. INTRODUCTION

The annual twentieth conference on teaching informatics at all types of schools *DIDINFO* which was held this year at our university gives us possibility to look back at all traps that had to be solved in introducing informatics as a school subject in primary and secondary education in Slovak republic. These give us also ideas for future where we see informatics as one of the important parts of knowledge.

Fig.1 Conference logo [1]

The idea of platform where teachers from primary and secondary schools can exchange their experience with researchers from the area of theory of informatics education arose in 1993. Our *Department of Informatics* in cooperation with *Methodology and Pedagogy Centre* (institution which gives methodical support for teachers of different school subjects) and *Centre for Scientific and Technical Information* (institution which gives technical support and training in using information technologies in all subjects) created an event which started as *Colloquium on teaching of informatics* in 1994 and from 2000 is known as *DIDINFO*.

This idea came in time when informatics was in its early years as the school subject at secondary schools and discussions were held on what should be its contents. Also thoughts of introducing informatics at primary schools started at these times.

Historically it is also a place for annual meeting of members of the subject committee for informatics which is an advisory body of *National Institute for Pedagogy* which creates all necessary documents and support for the contents of the subject.

II. TEACHING OF INFORMATICS IN SLOVAKIA

History of teaching informatics is strongly connected with teaching of mathematics where small part dedicated to algorithms was reserved in last year of primary school.

Two different approaches were used and taught at some schools in the beginnings.

Fig.2 Few equations about informatics [2]

First has put an equal sign between informatics and programming which means that the entire contents of subject was made of algorithms based on either algorithmic language or programming in BASIC or Pascal. Second was influenced by ideas of informatisation and has put a different equal sign between informatics and use of computer.

The discussion on what should be the contents did not stop until now but the community has found the compromise, which satisfies both groups.

This compromise is stated in the *State Educational Program* [3] which has put informatics together with mathematics into one group of subjects called *Mathematics and Information processing*. It also gives the minimal number of lessons which should be taught at every level of school (ISCED1, ISCED2 and ISCED3). The program also offers optional hours for the school which can be used to increase number of lessons in some subjects.

III. COGNITIVE PROCESS IN TEACHING INFORMATICS

Cognitive process in informatics is also connected with cognitive process in mathematics and the theory we are following is the theory of professor Hejný which was

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modified to the use of knowledge in informatics by professor Kalaš [4]. It shows four steps with one would say "intermediate state":

- motivation
- collecting experience
- … generalization …
- formation of the knowledge
- training of the knowledge

Motivation and collecting of experience is the crucial part of this process. Correct use of different methods increases the chance that at the end the knowledge will be correctly used by the student and properly connected with other knowledge that the student gets.

We try to avoid so called *empty room cleaning* situation where the student with no experience gets too much information which is not necessary for him/her at that time because one can find it by collecting more experience. These include for example:

- teaching of directory structure at the first lesson of informatics
- going through all menu parts in an application before even working with it
- shortcut keys to be known by heart
- 3D table in spreadsheet editor
- etc.

The other way we try to look at the cognitive process is the so called *historical vs. human point of view*. In many parts of informatics one can look at the process of getting the knowledge in the history. Historical experience is one possibility how teachers bring the knowledge to the student. They follow the steps which have been done in the history to achieve the knowledge.

On the other hand we prefer to look at the knowledge from *man´s point of view*. This allows us to show only necessary information to solve some problem, anything else can be found by collecting some other experience and this way the student gets the knowledge on his own.

One example for this can be already mentioned directory structure of the operating system. From the historical point of view it was necessary to know all the commands of the operating system just from the beginning but nowadays we don´t have to know what happens inside the computer when we save something and what commands are executed when we copy something from one place to another.

Another example is our favorite and is connected with teaching of programming and different paradigms that can be used. The discussion about *correct paradigm for teaching programming* is being held not only in the Slovak republic. We can see many ideas which again follow up our look at the cognitive process in teaching programming.

The figure shows that if we want to start from the nearest field of human being we should start thinking in object-oriented way. This does not necessary mean that we should learn everything from object-oriented programming, but using its concepts we can achieve different approach than one which starts teaching programming using structured way. More about this concept can be found in [5].

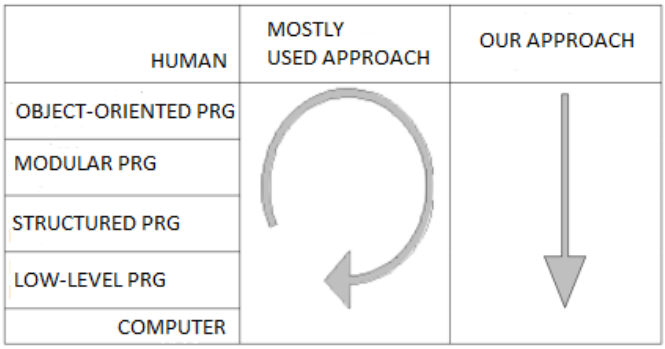

Fig. 3 Different approaches in teaching programming

IV. The Seminar about OOP

This activity which has taken place at a secondary grammar school in our town was not only opening of door to object-oriented programming but also a possibility to present and verify some of our topics which are done as part of our research in this field.

The main idea of this model of teaching programming is to show a paradigm which works in practice many years. Object oriented programming does not seem to be just fashion wave like other approaches in history of programming.

If we talk about topics of this seminar, the main objective was to learn the principles of OOP in the development environment Delphi. The skeleton of the seminar is formed by these topics:

- Basic prepared components
- Own basic object, encapsulation
- Use of basic object in more complex object
- Inheritance, hierarchy of objects
- Polymorphism

The idea of objects and their behavior is very close to the man. There are many objects around us that have their basic properties, can respond to different events, and send us or to each other different messages. Doing so, in many cases we do not need to know how exactly the object works, how it's implemented. For us it's enough to know what options we have to control the object. Remaining parts can work for us as a black box. This is the first of the object-oriented programming properties (encapsulation), which is to be learned in this approach.

In our model we look at this concept from two aspects when teaching programming. First is the object manipulation, use of their properties and execution of methods which will solve the problem we are given. Second one is the design of simple object in the real world which will be later extended with other OOP properties.

We used integrated development environments for the first aspect. In this way we have two possibilities to work with it. We can have a set of objects which is given to us by this environment, or the teacher can create his own micro world,

which is an interesting motivation when used with a theme which students like. Regardless of which programming language we use and what kind of supporting software is used, it is the way to learn the basics of object creation and manipulation. Because the students which were part of this seminar were interested in understanding the Delphi environment, we used this one for it. As we already mentioned, we combined the two aspects. First we used the components which are available through visual components library where we use basic objects which support easy input and output of values and graphical representation (TButton, TEdit, TCanvas, TLabel). We need to understand just behavior of them, knowing the properties and methods which are available. One of the most important objects from these is in our opinion the canvas which gives the motivation that we see what we create graphically.

Object that we started to design after getting the experience with object manipulation was a simple traffic light at the junction, which consists of three lights. The first object was therefore TLight, with basic properties and methods which were discussed with students. Implementation of them is of course the way to familiarize with the basic rules of language syntax, which we started to use. It's useful to say that learning the syntax should not overshadow the object design. It is the same as the object manipulation in the previous step. We do not need to know the background of the object, we need to know just how it works. The same idea works also with design of object, so we will discover the properties and rules of syntax gradually.

Fig.4 Simple TLight object

Students can manipulate with this object, create more instances of the class with different colors and prepare themselves for creating a streetlight. They of course don't just design this more complex object but they also implement it.

The same application is done in two ways. A sequence of commands is performed at first by pressing the buttons. These actions work with original TLight objects. After transforming these commands into a new object methods of TStreetLight, buttons serve only to carry out a specific method. I can say that this form of design worked well at the seminar. Student has the option to directly manipulate objects and solve the specific problem. The problem is then transformed into methods of the new object without the need to deal with complex issue from beginning, which could be difficult for him to handle.

Fig. 5 TStreetLight object

Inheritance is the next important property in object-oriented programming. Again there are two ways of implementing it into the informatics lessons, each of which may focus on specific skills we want the student to learn. This handles either creating a hierarchy of objects starting with our base object which was already defined or extending the functionality of prepared object which can be used for learning some other techniques and algorithms.

Polymorphism is a property which is very closely related with inheritance. You can really quickly find it's functionality in the presented streetlight example. If the students creates a new light with different shape for example, he can use it in the same TStreetLight object and it will work with no problem. The concept of polymorphism differs a little bit depending on language we use. Again there is idea not to *clean the empty room*. It means not to concentrate on specific restrictions which are in the language but use generally used properties which are applicable anywhere.

V. Open-book exam at informatics lesson

The other practical approach is our experience from teaching informatics at primary school. This activity took place in the 8th year (13 year old children) at one basic school in our region. We used the method of open book exam to talk about most important definition in the informatics, basic unit of information i.e. 1 bit. The idea was to not only teach the students definition of this unit, which would cover just lowest level of any taxonomy of cognitive skills but to have idea of how can we represent such amount of information.

Figures 6 and 7 show original documents which were given to students and also created by them. First gives brief information on what is one bit. It is compared to other units like gram or meter and few examples are given (light is on/off, I sit/don´t sit on chair, phone is ringing/not ringing). If we know what is one bit, we can ask for more bits and create some tables which show us relation between numbers of bits, number of yes/no questions and number of possibilities we get. This was also a task in which students could improve their skills in text editor when creating tables.

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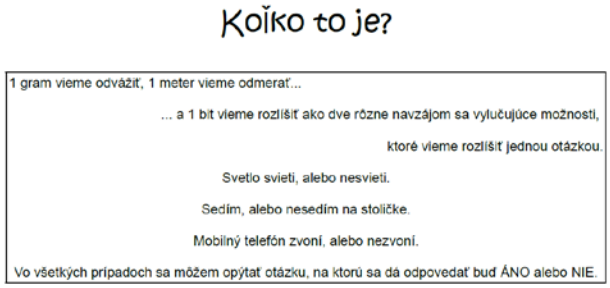

Fig. 6 How much is one bit

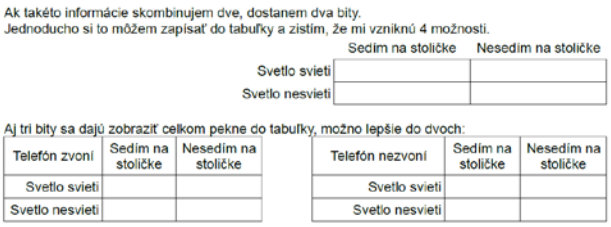

Fig. 7 Two and three bits

Other tasks involved with this topic were:

- the correspondence between number of characters in text file and the size of the file on the disk
- representation of the color using RGB, coloring transition effect made by hand
- information in graphics, pixels and their correspondence to the amount of information

The final part was the open book exam. Our motivation to use it was the curiosity about this type of examination with this group of students and to answer the question if they can use created notes in the form of documents in the computer to solve the problems in the test.

First question asked about eight types of fruit (apple, pear, blueberry, gooseberry, plum, peach, strawberry, and raspberry). We wanted to know how many questions we need to differ between them and how many bits they represent. From the 18 tests I put 100% to 4 answers. Other answers ended just with some number of questions (and bits) but the questions did not correspond very much.

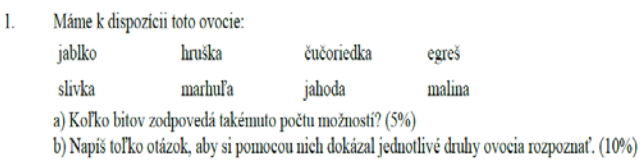

Fig. 8 First task of exam

Second question was easier. Using internet students had to find smallest and tallest man on planet. From this information they had to find out what is the difference between these heights and also find number of possibilities for heights in this situation. This was the trickiest part of the task, as these two numbers differ by one.

Third question used the practical knowledge that students should have from the previous lesson where they did coloring effect. This time they had to fill the table with numbers representing RGB to go from green to red color. Few students created table with decimal numbers.

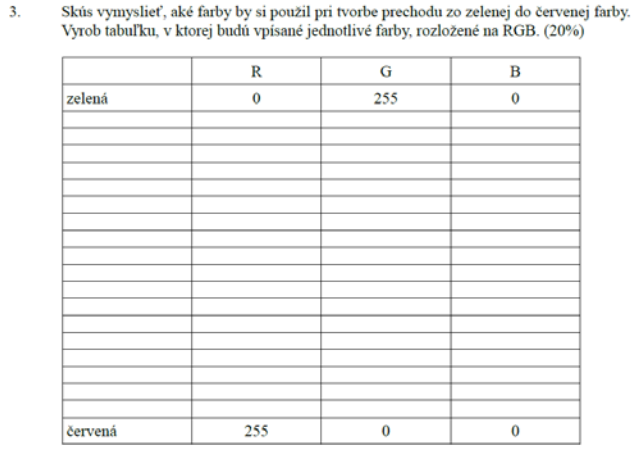

Fig. 9 Third task of exam

Fourth question asked about 1GPix as the students had the information about 1MPix when talking about pictures, pixels and photo-camera. Sub-task was to give resolution of picture with ratio 4:3 which does not fit into 1GPix.

Fifth question was a "feedback" question. I asked for term which was not clear for the student. I wanted also to have a sentence or two about why the student thinks so. Few of the answers were left without this reasoning.

Final question was about practical skills with pictures. Students had to find picture with given resolution, save to disk then copy to text editor, save the document and compare sizes. They should also write why they think that there is a difference.

When we evaluate this type of examination we get two results. One is the assessment given to the children. The other one and more important for us is how students (and indirectly also parents) react on it. The feedback I have is that students should be more prepared for this kind of testing. Also the use of digital technologies for storing the notes and using them again in the future is an area where we can do more.

VI. Conclusion

We wanted to give brief information on some of our activities which are being held in teaching informatics in Slovakia. Informatics as one of the youngest school subjects offers many possibilities to use new approaches in teaching and to show that these can be used also in other subjects. The methods used in preparation of future teachers of informatics should adapt to what is closest to man´s thinking.

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Comparative analysis of web animation creation methods

V. Veselá, M. Krbeček, and Z. Prokopová

***Abstract*—** In this paper differences between HTML5/CSS3 and Flash are described. By using these two technologies animations can be created. Animations are great way to bring website to life. With animations interactive elements on the web pages can be created for both desktop and mobile devices. Paper describes both of these technologies in detail. A simple animations were created by HTML5/CSS3 and Flash in order to compare this process. All discovered data are presented in a comparative table and a conclusion was formed from them.

***Keywords*—** Animation, Web Animation, Flash, HTML5, CSS3, ActionScript®

I. Introduction

ANIMATIONS are one of most frequent types of multimedia data, which the users can meet as a promotional material, learning materials, gaming industry, but also an audio and video record on web pages. HTML5/CSS3 is the fifth revision of the HTML standard published by W3C. It is a well known markup language used to developing the web pages. HTML5/CSS3 was created to improve support for the latest multimedia technology. [1]. The second type is Flash and it is a multimedia and software platform from Adobe, that is mainly uses for creating vector graphics, animation, games and Rich Internet Applications (RIAs). Flash uses ActionScript® to code their animations. For playing of Flash animations Flash Player is uses, it is a plug-in for web browsers [2]. On the other hand an advantage of HTML5/CSS3 is a support of nearly all web browsers, it does not require an additional plugin to be installed. Flash is an older technology, as compared to HTML5/CSS3. It was one of the most popular ways to add interactivity, video and animations to the web sites. It is a question that is so popular to stay in tune.

II. Animation

Animations can be considered as a part of the video format. Computer animation is a combination of static and moving images. Each frame of the animation is static image. Animation is a sequence of images that are slightly different from each other and also must be displayed correctly which means in a pre-determined order and with proper frame rate. Animation is uses on web and web applications for creating of better and more pleasant users interface and also as a faster transmition of information than for example written text. There are several ways for creation of animations for the web. In this paper two ways will be descripted. [3].

A. Flash

Flash is a vector graphics tool that is uses mostly for creating of interactive web animations, presentations and games. Flash animations are representing by small file size because they are saved in vector format called SWF (Small Web Format). The Frame Rate should be set around 20 - 25 fps to gain nice and fluent animation.

Flash uses the XML format to communicate with the server-side script (such as ASPX, PHP etc.). Programming language of Flash is an ActionScript®. There are several libraries (classes) in order to simplify creation of animation in Flash repository. Main classes are:

1) ActionScript's® *LoadVars* class is used to work with smaller text files as user passwords or contacts. This class stores the data into the format which is sent to the server. It can be easily read or used to communicate with the server via SQL queries. [4]
2) Flash can play external MP3 files saved on the server. That is performed Streaming – the data are read from the server and played in the same time. The *Sound* class is used for music playing. The class controls the phase in the moment of playing. Due to its attributes it is possible to create a small sized animation with external music or voice. Flash can also play an external video. The playing of FLV videos is similar to playing of MP3 files. These video files are also stored and played from the server. [5]
3) Next two classes used by Flash are *NetSteam* and *NetConnection*. These classes provide connection between the player and source of the animation (camera, FLV file). Another external data that can be used in Flash animation are images. [6]
4) The Flash uses the MovieClipLoader ActionScript® class for loading of images and for controlling of their attributes. [7]

B. HTML5/CSS3

There are Animation, Transition and Transform modules in this tool. These modules are an extension of CSS syntaxes that are supporting in all modern browsers, replacing the traditional roles of JavaScript and Flash. Animations are making your

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websites more visually attractive and CSS3 is one of the best ways to create this animation. All three modules will be described in detail below. [8]

1) CSS Animation

With these kinds of animations, you can define not only the beginning and the end state but also any intermediate states lovingly known as keyframes (see Fig. 1). These intermediate states enable higher control over the motion of images [8], [9].

Keyframes animation starts with animation name, which must be unique. The animation is divided to sequences and these sequences may be specified in two ways [9]. The first is given by declaration:

```
@keyframes animation_name
{
from {left:0px;}
to {left:200px;}
}
```

Second way is specified as percentage in time [9].

```
@keyframes animation_name
{
0%   {left:0px;}
25%  {left:200px;}
50%  {down:100px;}
75%  {right:200px;}
100% {top:100px;}
}
```

If you do not define the start or the end states, it will be interpolate from other states.
You can change many CSS parameters in one animation [9], [10].

```
@keyframes animation_name
{
0%   {left:0px; background:green;
width:150px;}
100% {left:200px; background:yellow;
width:300px;}
}
```

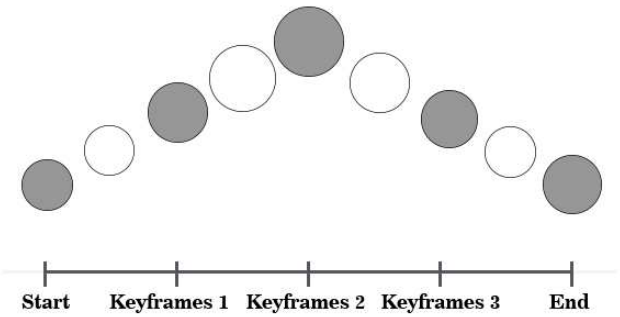

Fig. 1 CSS Animation

2) CSS Transitions

For this type of animation only starting and final state is defined and all movements between these two states is interpolated, see Fig. 2. This method is frequently used for simple animation such as entering of the various objects into the site [11].

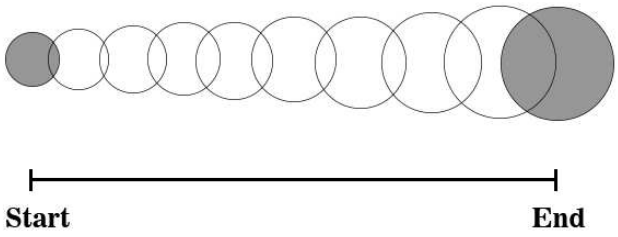

Fig. 2 CSS Transitions

3) CSS Transfrom

A transformation is an effect performing an element shape, size and position change. The CSS transform property allows you to visually manipulate element. There are several different transform functions which applies a different visual effects [11],[12]. These functions are described below:

1) Rotate - The origin of the rotation is at the centre of the element. Positive value of angle rotates the element clockwise, negative value counter-clockwise, see Fig. 3.

```
transform: rotate(angle);
```

2) Scale - This method is used to adjust the size of the element which can be adjusted horizontally, vertically or as a combination of these, see Fig. 3.

```
transform: scaleX(value);
transform: scaleY(value);
```

3) Screw - With the *skew* method the element turns around the X and Y axes by the specified angles, see Fig. 3.

```
transform:  skewX(angle);
transform:  skewY(angle);
```

4) Translate - With the translate method, the element is moved from its current position to a new one determined by the X and Y axes parameters, see Fig. 3.

```
transform:translateX(tx)
transform:translateY(ty)
```

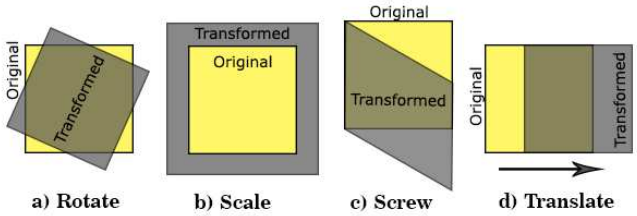

Fig. 3 Transform method

III. COMPARISON OF HTML5/CSS3 AND FLASH

Since Adobe announced the end of support of Flash for mobile devices, the debate has begun whether exists another way to create animations. One of the possible successors is HTML5/CSS3. But this technology has a lot of opponents who do not believe in its potential. Flash does not lose popularity from day to day. On the other hand, HTML5/CSS3 specifications are gaining popularity during a last few years. A huge progress and inclusion of new features allow solving of parts which was addressed by Flash in the past. HTML5/CSS3 has a large advantage in W3C specifications which are implemented in all web browsers. In order to remain main format for web animations Adobe's SWF must adapt market trends. There is growing number of devices running on iOS operating system where the format SWG is not supported. Because of that animation in SWG format must be converted into HTML code. Helpful tool is Adobe Wallaby that are able to converts SWF files into HTML5 format. Same functions is provided by Google Swiff which is a web-based tool developed by Google. Their main goal is to display SWF content on devices that does not support Flash, such as iPhone, iPad, and Android Tablets [13].

Some differences between HTML5/ CSS3 and Flash:

- HTML5/CSS3 does not need plug-in compared to Flash which need an external plug-in.
- Flash does not support from Apple mobile devices, but HTML5/CSS3 runs on Apple mobile devices.
- Flash is more popular for creating animation than HTML5/CSS3.
- Flash uses more CPU power than HTML5/CSS3.
- Most of web-based games are built using Flash.
- The vast majority of browser market now supports HTML5/CSS3 video and animations. [14]

TABLE 1. COMPARISON TABLE OF HTML5/CSS3 AND FLASH [8]

Comparison table		
	HTML5/CSS 3	**Flash**
Desktop operating systems	Microsoft Windows, Apple Mac OS X, Linux	Microsoft Windows, Apple Mac OS X, Linux, Solaris
Mobile operating systems	Windows Phone 8+, Android 2.3+, Apple iOS 6+, Symbian Belle+, BlackBerry OS 7+	Up to Android 4.0, Windows RT
Vector graphics formats	Vector Graphic (SVG)	Small Web Format (SWF) with embedded graphics
Programmig languages	JavaScript	ActionScript®, Pixel Bender
Data formats	CSS3, HTML, XML, JSON	JSON, XML, Subset of CSS1
Data compression	GZIP compression for HTML, JS and CSS files	LZMA or DEFLATE for SWF files
Image formats	PNG, JPEG, Animated GIF	PNG, JPEG, JPEG - XR, Single-frame GIF
Video codecs	H.264 (MP4), ogg/Theora and VP8 (WebM)	Sorenson Spark, On2 VP6, H.264 (MPEG-4 Part 10)
Audio codecs	MP3, Ogg Vorbis, WAV, AAC and WebM Vorbis	ADPCM, MP3, HE-AAC (MPEG-4 Part 3)

A. Analysis of HTML5/CSS3 and Flash animations effectivity

Same simple animations were created in both technologies in order to comparison of their effectivity. A person with ordinary experience in HTML5/CSS3 and Flash was chosen for test performing. This person made this simple animation and after that the particular points was evaluated.

TABLE 2. VIEWPOINTS OF THE TEST

Viewpoints of the test		
	HTML5/ CSS3	**Flash**
File size	36,4 kB	11,9 kB
Time of creation	7 min	4 min
Number of lines	45	15
Knowledge	Knowledge of HTML5 and CSS3	Knowledge of ActionScript® language

The animations were created in two development environments. Adobe Flash Professional CC was used for Flash developing and Microsoft Expression Web for creating of HTML5 code. The total size of the HTML and CSS files is bigger than Flash files. Flash generates only one file (SWF) including source images which is compressed. On the other hand in HTML5/CSS3 the images are stored in original format. Their size is counted in the total size of animation. With other files like CSS styles the total size is considerably bigger. Also HTML5 code is twice longer then the Flash code. Images in HTML5/CSS3 have to be positioned manually, therefore it takes much more lines of code. This positioning of the particular elements in HTML5/CSS3 is more difficult than positioning in Flash. In Flash elements are just pulled on the

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right place from library of sources. It is a possible way to create image with SVG. It is a vector graphic format which generated image with HTML5 code. SVG is a technology, which can enable images to express mathematically. Linear motion is adjustable very simple in HTML5/CSS3 but complicated movement along curve is more difficult.

Also keyframes are added to the animation by CSS3 code as a percentage parameter of animation duration. The testing suggests that HTML5/CSS3 technology is good choice for creation of basic web animations both for desktop and mobile devices. On the other hand Flash stays best choice for advance animations and game developing.

IV. Conclusion and Future Work

Animations can quickly grab attention and increase the visual catchiness. Web animations can be created in several ways. Flash does not lose popularity from day to day. This is a big system that does not include only Flash and Flash player, which are used for creation and playing of animations. There are others software like Flash Builder for the development of games and applications using *ActionScript*® and the open source Flex framework. Adobe AIR (Adobe Integrated Runtime) is a cross-platform environment to facilitate developing applications based on HTML, Flash, Flex and AJAX. Adobe AIR enables developers to package the same code into native applications and games for Windows and Mac OS desktops as well as iOS and Android devices. In all the previous software Flex platform is used which is highly productive application framework intended for creation of expressive web applications that are consistently supported across all major browsers and devices.

By using of HTML5 an appearance of the elements in animation can be changed. In HTML5 are more options for easy animations creation. It can be created by using of the animation transitions to move the element from one place to another. It is also possible to set keyframes for determining of the animation course or transitions between individual keyframes by one of the CSS3 parameters.

Using of Flash is still irreplaceable in this area. But it has to adapt according to a market development mainly represented by mobile devices running on iOS and Android which does not support Flash files. Therefore Adobe is more focusing on usage of HTML5 and CSS3 technologies. Several software programs for transferring of Flash files into HTML5 code were developed.

This paper is focused on the differences between animations creating by using two technologies (HTML5 and Flash). Tests were made with a simple animation which was assessed in several points of view. This study will continue as a deeper research of these technologies for complex animation. There also will be more technologies include in further testing such a JavaScript etc.

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Handel-C Implementation On FPGA Of Real Time Motion Detection

K. Sehairi, C. Benbouchama, and F. Chouireb

***Abstract*—**This paper proposes real time implementation on FPGA of motion detection algorithm using Handel-C language; the results are shown in RGB video format. In the first part of our work, we propose a GUI interface programmed using the Visual C++ that facilitates the implementation to non-initiate users; from this GUI, the user can program/erase the FPGA or change parameters of filters or the threshold filter. The second part of this work details the hardware implementation of real-time motion detection algorithm on a FPGA including the capture, processing and display stages using DK IDE. The targeted circuit was an XC2v1000FPGA embedded on the Agility RC200E board. A PixelStream-based implementation has been successfully performed and completed with a test validation on real-time motion detection.

***Keywords*—** Frame difference, FPGA, Handel-C, Motion detection, Real Time, video surveillance.

I. Introduction

Detection of moving objects in video streams is known to be a significant and difficult research problem [1].There are many methods dealing with this problem, Temporal difference [2][3][4][5][6][7],Background subtraction [8][9][10] and optical flow[11][12] .Accurate moving object detection in RGB will greatly improve the performance of object recognition, classification, identification and motion analysis. However, the computational complexity and the huge information for RGB video involved in object detection and segmentation makes it difficult to achieve real-time performance on a general purpose CPU or DSP. There exist three main architectural approaches to this challenge: 1) Application Specific Integrated Circuit (ASIC), 2) parallel computing, and 3) FPGAs. Evolving high density FPGA architectures such as those with embedded multipliers, memory blocks and high I/O (input/ output) pin count make FPGAs an ideal solution in video processing applications [3].

The detection of objects in motion is based on the image thresholding, realized by calculating a differential image of two consecutive frames [2][3][7]. In order to detect the object in motion, the flow of data acquired from camera will be split in two parallel sub-blocks; the first one will be converted from YCbCr to gray-scale and will be used as an analysis block. The second sub-block will be converted from YCbCr to RGB and merged with the result of the analysis sub-block. The video has a resolution of 720x576 and the object in motion will be presented in a bounding box around it. For this implementation, we should respect two main constraints: the real time processing and the resources of the targeted FPGA. In addition to that, we were interested in developing a Graphical User Interface in order to send the bit-file that configures our FPGA, erases it or changes a parameter in filter, like the threshold parameter. This helps non initiate users to use the program without the necessity to know the hardware architecture. A similar work is done by E.Kobziliet al.[13]in which they used this design for an FPGA implementation of several types of edge detection; the targeted circuit was an FPGA VirtexII embedded on the RC200 board.

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II. Related works

Many methods and techniques for motion detection have already been proposed, in [14] they have been classified in three large categories: Background subtraction, temporal difference, optical flow. K.Ratnayake and A.Aishy [3] developed an algorithm for object segmentation and implement it in Xilinx XC2VP20 using VHDL, they used frame difference algorithm with a spatio-temporal threshold, the design runs at 133Mpixel/s. In another work presented by M.Gorgon, P.Pawliket al.[8]in which they used the method of Sum of the Absolute value of Difference to detect vehicles for road traffic, the language used is the Handel-C with the PixelStream library of DK Agility, the implementation was done on RC300 board fitted with an FPGA VirtexIIV6000. The results show that this implementation process 25 standard PAL images in gray scale with resolution of 576x768 in every second, the number of CLBs used is 11%, 5% block RAMs, and 32% of I/O blocks.

Another work presented by Wen [4], in which he developed an algorithm to detect and track human motion using the frame difference method with an adaptive threshold whose parameter is calculated from the difference of smoothed image by Gaussian filter and the original image, the algorithm shows a good result in detecting motion but errors still appear due to change of brightness or shadow problem. A recent work on frame difference method presented by Wei and al. [7],in which they propose improving this algorithm by using an

arithmetic operation on pixels between the image of frame difference filtered with a low pass filter (Gauss low filter) and the number of binary images are calculated by some gray images in the image sequences. This work was not implemented on FPGA, but the result of this algorithm shows that the moving object can be detected precisely. Similarly, Widwayanet al. [15] work on motion detection by combining the frame difference method and Dynamic and adaptive template matching in order to increase accuracy; the image was captured every second from an IP camera and with a resolution of 256x192.The results show that the algorithm provides detection accuracy of 95,5%.

Menezes, Silva-Filho[2]implemented on FPGA the method of background subtraction using a new motion detection architecture ;the goal was the comparison between a software implementation (on an Intel Celeron2.66Ghz) and a hardware implementation on SpartanII, the resolution of the video was 126x76, the results show that the hardware implementation is 7.5 times faster than a software implementation. In [9]L. Ovseniket al. designed a system of video surveillance in which they used the background subtraction as a first step to detect motion and then track and identify the subject in motion using optical correlator (based on comparing two signals by utilizing the Fourier transforming properties of a lens), the results were applied on detecting an abandoned luggage.

III. The Software-Hardware Mixed Design

To make our implementation more flexible, we use the software-hardware platform approach; it simplifies the use of the hardware side and also simplifies the change of data between the soft and the hard, especially for image processing applications that need many parameters to be changed for example the parameters of convolution filter. In our conception we used the Handel-C language for the hardware part; Handel-C is a behavioral oriented programming language for FPGA HW synthesis and it is adapted to the co-design concept[13].

The software side was developed using the VisualC++ language. After generating the bit file using the Agility DK[17]; we will use the software interface which we have developed to charge this bit file via the parallel port (with a frequency of 50Mhz) on the RC200E board to configure the FPGA.The algorithm parameters are transferred using this port with the same frequency with 8 bits data length. For the user, these operations are hidden and the graphical user interface allows him to configure or erase the FPGA and to change the algorithm parameters, as an example in our case, we can change the thresholding according to the brightness of the scene.

IV. Outline of the Algorithm

A. PixelStrams library [18]

Before we detail and explain our algorithm and the method used to achieve our goals, we should speak about the tools used for this implementation. The board used is RC200E board fitted with an FPGA XC2V1000[19], this board has multiple video Input such as (S-video, Cameran video and composite video) and Video output (VGA, Svideo, composite video) and two ZBT SRAM with a 2Mb capacity. The language used is Handel-C [20], and the Integrated Development Environment is DK5 of Agility, and this environment is equipped with different Platform development kits (PDK) that contain the Pixel Stream.

Pixel Stream is a library used to develop a system for image and video processing. It comes with many blocks, named filters, that do a primary video processing like acquisition, streams conversion and filtering. The user has to associate these blocks carefully indicating the type of the stream (Pixel type, coordinates type, synchronization type). Then he can generate the algorithm in Handel-C, and then he has to add or modify the blocks to program his method and he must finally merge the results. It is worth mentioning that these blocks are parameterizable. That means we can modify the parameters of image processing, for example the size of the acquired image or the parameter of threshold and these blocks are fully optimized and parallelized. Fig. 1 shows the GUI of Pixel Stream.

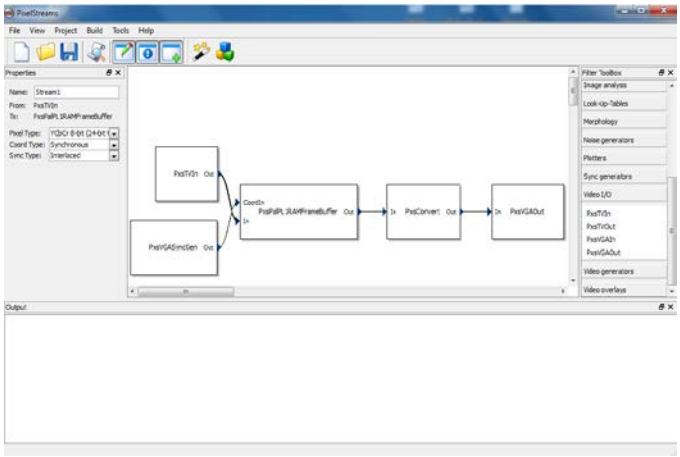

Fig. 1 PixelStream GUI

As mentioned in the introduction, the flow of data will be split in two parallel sub-blocks: an analysis sub-block and a display sub-block. Fig. 2 shows a basic block diagram outlining the algorithmic structure of the object detection process of the system already developed.

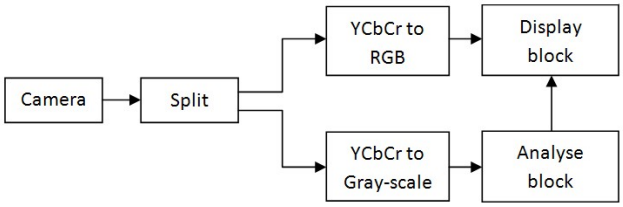

Fig. 2 Object detection process algorithmic basic block diagram

The object detection process can be broken down into the

following stages:

B. Image acquisition and splitting

The images acquired from the RC200E board camera, fitted with a Philips SAA7113H video input processor, are in YCbCr color format. These images will be split using the Pixel Stream library of Agility DK into 2 streams that feed our two sub-blocks. In the display block, we convert the stream from YCbCr to RGB to be able to display it in VGA screen. In the analysis block, we convert the second stream to Gray-scale level to reduce the amount of data analyzed, this will help us reach the real time constraint and reduce clearly the resource consumed of the FPGA.

There are two ways to do the conversion, either before or after split. If we choose to do the conversion before split, we have to convert the stream from YCbCr to RGB (such conversion is lossy and should be avoided wherever possible [15]), after that in the analysis block we convert the stream from RGB to gray scale level. But in this case we will increase the number of multiplication to convert the stream from YCbCr to RGB then from RGB to gray-scale level, knowing that this conversion can be done by different methods and all these methods use the division, but it is better to avoid any use of division especially in FPGA (the average method: divide the sum of three RGB components by three. The lightness method: divide the difference between max and min of the three components for each pixel by two. The luminosity method implies taking 30% of the red component plus 60% of the green component and 10% of the third component) (Fig. 3-a).

In the second case, if we choose to do the conversion after splitting, we have to convert the stream in every sub-block (Fig. 3-b). In the display block we convert the stream from YCbCr to RGB and in the analysis block we convert it from YCbCr to gray-scale, knowing that to do this conversion we just take the component Y because it represents the Gray-scale level in the YCbCr format. So we see clearly that we use less resource by avoiding many multiplication operations or division (to convert RGB to gray Scale, case one). More than that, we are obliged to do approximations in the conversion from YCbCr to RGB, and this conversion is not suitable for the analysis block, that needs all the information captured from the camera. So we choose to let the conversion after split in every branch of sub-blocks. Fig. 3 shows the possible ways to do the conversion; the preferred one is that presented at the bottom of this figure.

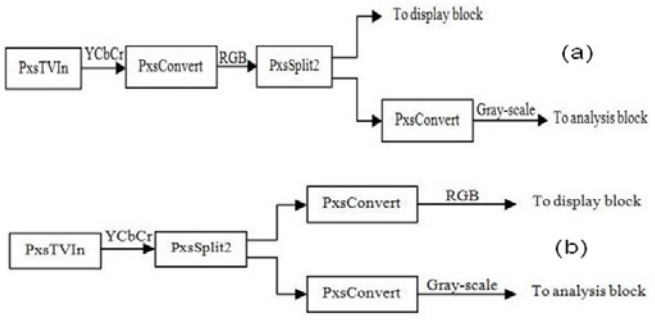

Fig. 3 Possible ways to do the conversion, (a) before splitting, (b) after splitting

C. Analysis block

1. Temporal difference

Temporal difference is a simple method to extract moving objects. It presents an advantage in dynamic environments (ex: sun rise). The technique is simple, consisting of saving the first image acquired in frame-buffer It-1(x, y) and acquiring a second frame It(x, y). This second frame will activate the delay cell to diffuse the image stored in the frame buffer according to the coordinate of the pixel. Then the two streams will be synchronized and subtracted (Eq.1). Fig. 4 shows the delay cell and difference diagram.

$$\zeta(x,y)=\left|\frac{dI(x,y)}{dt}\right|=\left|\Delta I_{t,t-1}(x,y)\right|=\left|I_t(x,y)-I_{t-1}(x,y)\right| \quad (1)$$

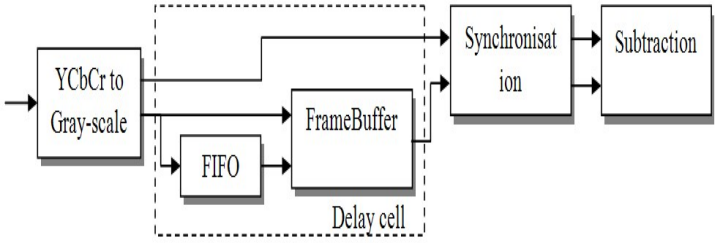

Fig. 4 The delay cell and difference diagram

After, to get the region of changes, the difference image is thresholded to remove the small changes of luminosity between the two instants (Eq.2).

$$\Psi(x,y)=\begin{cases}0 & \text{if } \zeta(x,y)<Th\\ 1 & \text{otherwise}\end{cases} \quad (2)$$

We should note that we mean by a frame buffer the external SRAM in our board RC200E and we have not used the blockRAMs of our FPGA because their capacity is 720Kbits, and this amount lets us deal with an RGB image with a resolution of just 240*128.

2. Block of analysis and statistic

After we get the region of changes from the thresholded difference image, we search in this block the min and max along X and Y image axes. Table I shows the code for calculating the Min and Max in Handel-C to give an idea and comparison with the standard C language. In this code, we have used the parallelism instruction (par{}) to calculate these

values in one cycle.

Table I. Handel-C program to calculate the Min and Max along the axes X and Y

```
unsigned Minx, Miny, Maxx, Maxy;
Minx=720;Miny=576;Maxx=0;Maxy=0;
If (Value==255) {
par{
Minx=((unsigned 16)xx<= Minx0)?((unsigned 16)xx):Minx;
Miny=((unsigned 16)yy<= Miny0)?((unsigned 16)yy):Miny;
Maxx=((unsigned 16)xx>= Maxx1)?((unsigned 16)xx):Maxx;
Maxy=((unsigned 16)yy>= Maxy1)?((unsigned 16)yy):Maxy;
    }
                }
else {delay;}
Copy the values
Reset all the values
```

It is better to apply a filter before calculating these values to remove the noise, we generally use a median filter or a morphological filter.

Then to find the center of gravity (COG), we calculate the sum of the coordinate of pixels non zero along X and Y axes, and divide this sum by its number; and to avoid division we can easily approximate the COG of the object by calculating the COG of the surrounding box, and for that we take the difference between the min and the max in each image axis and shift right one bit to produce the division by two, to which we add the min value (Table II).

Table II. Handel-C program to calculate the COG

```
if (Value ==255) {
   par{N+=1; sumX+= Coord.X;sumY+= Coord.Y;}
                }
else{delay;}
then
xg=sumX/N;
yg=sumY/N;
```

```
The MaxX, minx, MaxY, miny has been already
calculated.
xg=minx+(MaxX-minx>>1)
yg=miny+(MaxY-miny>>1)
```

Once coordinates of the center of gravity are obtained, we copy the values to specific block in the display sub-block where we can plot a rectangle around the detected object. Finally we reset the values of min and max in the two axes.

Fig. 5 shows the result of a temporal difference in our scene obtained using Matlab to visualize the result. We see clearly that the temporal difference gives a non-closed edge of the mobile object. If we search the max and the min along the X and Y axes, we can easily obtain the points to make a bounding box on the object in motion.

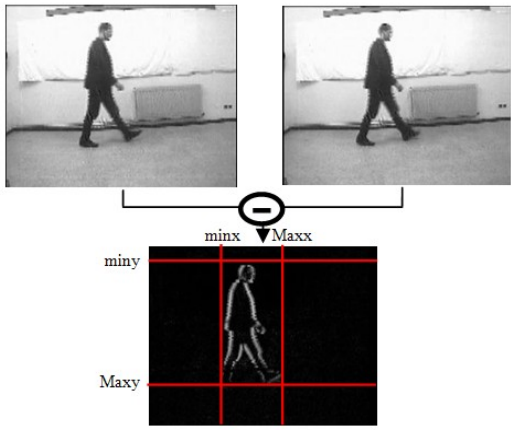

Fig. 5 Temporal difference and the Min and Max in X and Y axis

D. Display block

As stated above, the stream in the display block is converted to RGB. Next we store the image in Frame buffer and wait for the block of analysis to deliver the coordinate of the center of gravity or the four points of the rectangle calculated from the min and max along the two axes X and Y. These points serve us as an input to the block that draws the rectangle.

Using the PxsCursor and PxsConsole we can add a cursor in the center of gravity of the object and add a warning text like "Warning there is motion". For two objects we use two blocks to draw a rectangle around each object.Finally we can copy stream to VGA output to visualize in a screen. Fig. 6 shows all the diagram of motion detection in RGB.

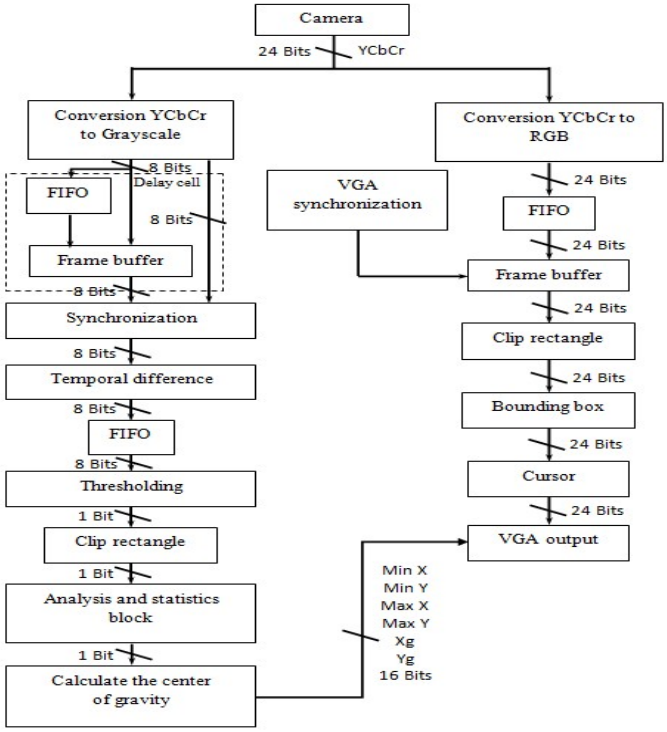

Fig. 6 Diagram of motion detection

V. IMPLEMENTATION RESULTS

In this section, we demonstrate the effectiveness of the proposed algorithm to work in real time and do the detection in RGB with minimum resources consumed.

Fig. 7 shows the graphical user interface (GUI) that represents the mixed Software/Hardware tool.

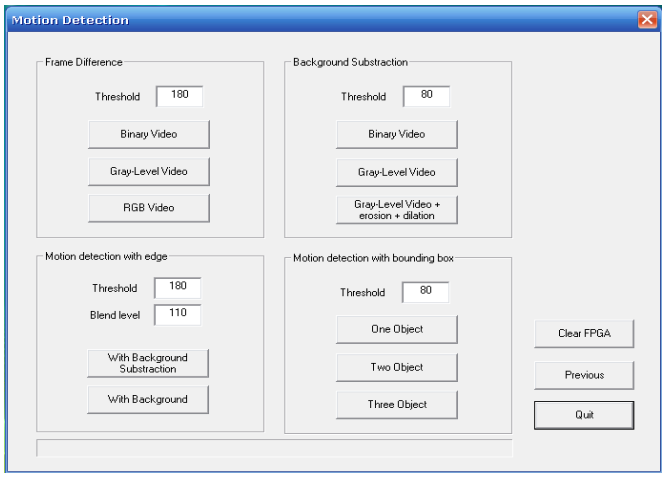

Fig. 7 The graphical user interface

Fig. 8 illustrates the results of our algorithm in figures, captured from the video result, in which a person walks around. The result shows that the person is well detected. The resource used for the detection is demonstrated in table III. The table shows also the maximal frequency for this implementation. We see clearly that the two major constraints, the technological limits and the real-time aspect (40 ms/image), are respected. This algorithm can treat 70 MPixels per second, it can treat approximately ~170images/s for video size of 720x576 (and it is very far than time constraints 25images/s).

Table III. Implementation results for one object

Resources	Total	Resources used
Input/output	324	179 (55%)
LUTs	10240	2,074 (20%)
Slices Flips Flops	10240	2,817 (27%)
CLB Slices	5120	2,844 (55%)
Block RAM	40	9 (22%)
Frequency	/	70.55Mhz (5.88ms/image)

Fig. 9 shows the results for two objects in motion. We can see that the two persons are well detected but when the two objects get closer, the occlusion problem appears and the algorithm considers them as one object.

Fig. 8 Motion detection in RGB for one object.

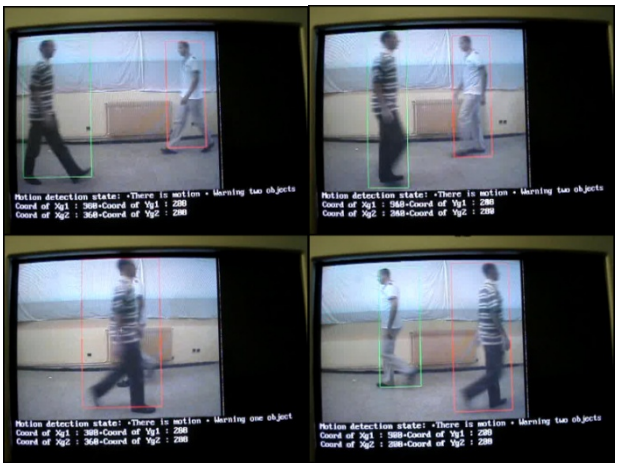

Fig. 9 Motion detection in RGB for two objects.

VI. CONCLUSION

In this paper, we presented a simple method for the detection of motion in RGB for real time surveillance application using Handel-C language. Our program was just about 300 lines and this shows the ease and rapidity of the Handel-C language and the DK integrated development environment and its libraries on reducing the time of development. In our work we used the most important characteristic in FPGA, the parallelism in data and design. Using two parallel sub-blocks helps us to reach the constraints of real time and visualize the detection in RGB, that is very important for more recognizing the object in motion and unlikely other methods that give the result of detection in binary image. For non-initiate users in programming FPGA, the interface was a perfect tool to implement FPGA and it helps the user change the threshold parameter according to the brightness of the scene.

We have obtained satisfying results, but in the case of two objects the problem of occlusion appears (major problem in all video surveillance applications) and the method is limited; the accuracy of detection changes according to the scene (in indoor areas, the accuracy is better than in outdoor areas,

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change of luminance, slight motion, tree branch movement). As a future work, we propose to develop the algorithm of motion detection to detect many objects and try to recognize these movements and gestures using learning methods.

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Remote control of a positioning system

Florin Ravigan, Niculae Boteanu, Laurentiu Alboteanu and Eugen Gheorghe Subțirelu

Abstract— Complexity of positioning systems depends on the nature of the application and the hardware used. Thus, the information processing unit is strong, the system may be more accurate and flexible. Moreover, the development of Internet network in recent years, the bandwidth can implement remote control of these systems. A type of microprocessor that has developed a lot is based on ARM architecture. ARM represents a family of instruction set architectures for computer processors based on a reduced instruction set computing (RISC) architecture. Performance numerical processing devices based on this architecture we recommend for use in command and control systems of processes with small time constants that simultaneously provide graphical user interfaces. The present paper wants to presents a positioning system controlled by a microcontroller with 32-bit ARM architecture developed by ST Microelectronics with remote interface.

Keywords— microcontroller; ARM; positioning; servo; graphical interfaces, Ethernet.

I. Introduction

IN that paper, the authors wants to present efficient realization of a remote positioning system developed by a servomotor controlled by a ARM architecture microcontroller with Ethernet interface. System applications are numerous, covering a wide range of areas.

The ARM architecture was developed by British company ARM Holding. This company develops the instruction set and architecture for ARM-based products, but does not manufacture products. The company releases just updates to its cores. Current cores version supports a 32-bit address space and 32-bit arithmetic.

This architecture offers outstanding performance cee needles made possible the development of many information processing devices. Along with system-on-chip (SOC), multicore cpu's, they appeared microcontrollers based on the ARM architecture.

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These microcontrollers have a hardware architecture that allows development of command and control systems performance through both processing power and the stability.

This paper aims to present an automation system to control an actuator made of a development system with a 32-bit microcontroller STM32F407 ARM Cortex-M4 architecture. This system is also equipped with a resistive touch screen, which facilitates interaction more user friendly.

Also, the system allows remote communication using the Internet. For this purpose, designed and Ethernet communication interface.

System block diagram is shown in figure below.

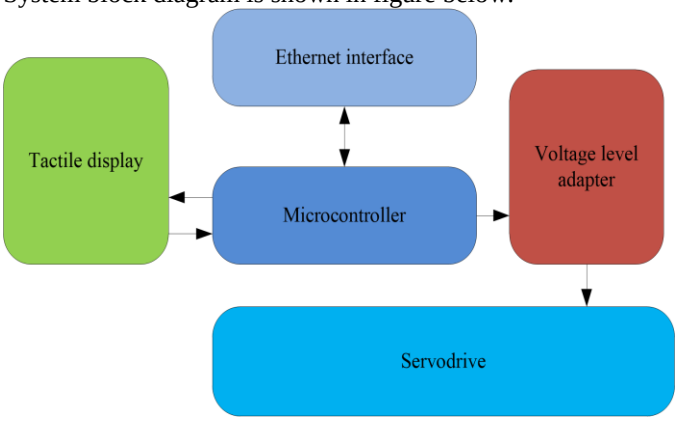

Fig.1 Block diagram of the system.

II. The Presentation of the Positioning System

A. The microcontroller

Automation system used is compact development system developed around a microprocessor ARM Cortex M4 STM32F407VGT6 family produced by ST Microelectronics. That board is produced by MikroElektronika D.O.O. being named Mikromedia for STM32 M4.

This system also has integrated:

• mp3 decoder that can be used for playing various acoustic warning signals;

• resistive touch screen with a resolution of 320x240 pixels;

• accelerometer that can be used for detecting vibrations in applications;

• a slot for a micro-sd card usefull to store log files or media resources;

• USB interface for programming or serial communication with another device;

• 8-bit flash memory;

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- Two connectors with 26 de pini.

An image of this system is presented below.

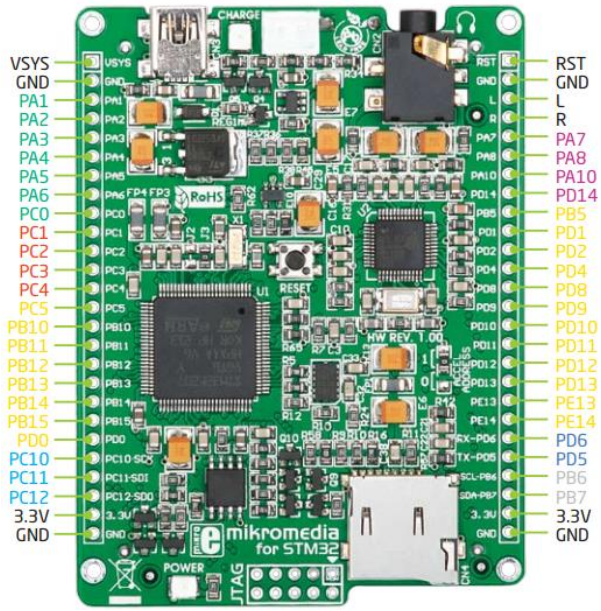

Fig.2 The microcontroller board pinouts

Microcontroller's 32-bit STM32F407VGT6 model being produced by ST Microelectronics and is part of the ARM Cortex-M4.

This microcontroller dispose of:

- 32-bit kernel capable of 1.25 million instructions per megahertz;
- 196 kB RAM; 83-pin input / output;
- SPI interface, I2C, CAN, USB, Ethernet;
- USART, UART;
- Timers 16 and 32 bits up to 168MHz;
- 16MHz internal oscillator, 32 kHz, PLL;

B. The servo drive

To achieve positioning has been chosen a servo drive manufactured by Parallax Inc. with the following specifications provided by product documentation:

- It can hold any position between 0 and 180 degrees;
- It can be powered by DC 4-6V;
- Torque of 0.268 Nm at a supply voltage of 6V;
- Maximum current draw is 140 +/- 50 mA at 6 VDC when operating in no load conditions, 15 mA when in static state.
- Position control by pulse-width modulation, 0.75–2.25 ms high pulse at 20 ms intervals.

Below is presented the servo drive and the electrical circuit.

Fig.3 The servo drive

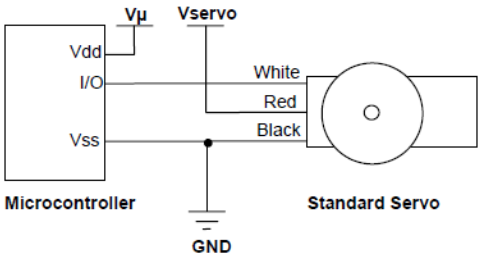

Fig.4 The quick-start circuit

The I/O can be TTL or CMOS signal from microcontroller from 3.3 to 5 V, but the recommendation is not to exceed Vservo + 0.2 V.

As shown in the specifications, the actuator can be controlled by means of pulse width between 0.75-2.25 ms with every 20ms.

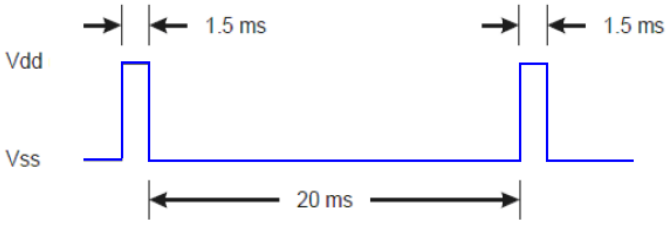

Fig.5 Sample timing diagram for the center position.

C. The Ethernet Interface

To provide the remote control for that system , it was designed an Ethernet interface. It features ENC28J60, a 28-pin, 10BASE-T stand alone Ethernet Controller with an on-board MAC & PHY, 8K Bytes of Buffer RAM and SPI serial interface. Chip supports programmable automatic retransmit on collision and automatic rejection of erroneous packets. Board contains standard RJ-45 connector, transmit, receive and power LEDs. The usage of an on-board crystal oscillator ensures a very stable operation.

The schematic of interface is presented bellow.

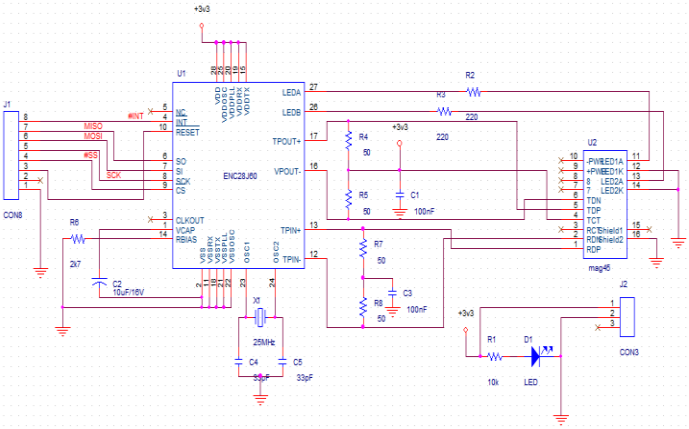

Fig.6 The Ethernet interface schematic

The connection with microcontroller board is mage using the following schematic the communication being carried out by SPI serial interface. On the left side are Ethernet interface pins and the right of the microcontroller board.

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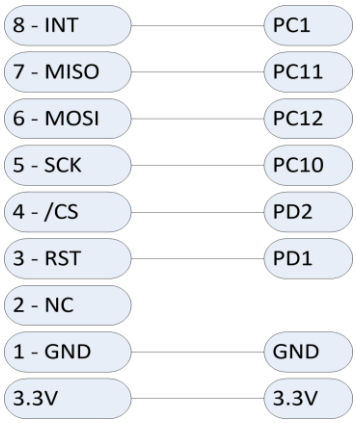

Fig.7 Connections between microcontroller board and the Ethernet interface.

To connect the circuit to a computer network requires a circuit consisting of coils, diodes and resistors to ensure the electrical parameters of the line, controller protection and the possibility of using PoE (Power-Over-Ethernet).

For this, it has been identified the connector that has integrated magnetic system and can use Power over Ethernet technology, providing speeds of 10/100Mbps.

The connector has built-in two green LEDs that can be used to display various information ENC28J60 controller (using the register PHLCON: PHY control register LED modules): transmit activity; receive activity; collision activity; link status; transmit and receive activity; link status and receive activity; link status and transmit activity; duplex status and collision activity.

D. Supply circuit of the actuator

For transmission of impulses from the microcontroller to the actuator was designed a simple scheme for adapting voltage levels from 3.3V to 5V.

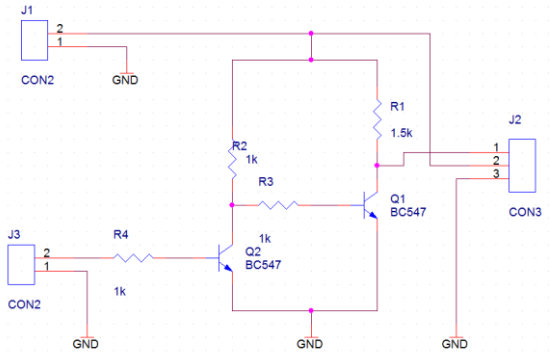

Fig.8 Voltage levels adapter

Connector J1 is dedicated 5V supply voltage and J3 connector connects to the microcontroller. The J2 is connected to the actuator.

Fig.9 The whole system

The whole system is presented for the previous image where you can see the following:

1-microcontroller and touch screen system; 2-Parallax actuator; 3-Adapter 3.3V to 5V voltage levels; 4 Ethernet interface; 5-programmer STM32 family of microcontrollers; 6th network router; 7 to 1 smartphone used for testing.

III. THE DESIGN OF THE SOFTWARE PACKAGES

Software run by microcontroller is written completely in C language and must fulfill the following tasks:

- Graphical user interface running on the touch screen;
- generate the necessary pulse positioning actuator;
- setting up and maintaining Internet communications network.

To achieve these tasks were developed separate software routines. So that makes the graphical user interface consists of five screens.

The first screen is primarily designed as a menu through which the user can set the operation of the system and view the screen with information about the application.

From this screen the user can choose three modes of operation using the tactile display: step-by-step, auto and remote.

Tactile surface is read as an interruption. Every interruption coordinates and evaluates whether they coincide with areas declared handler is called. This routine will load a simple function call another graphical display or change a variable in the Main program.

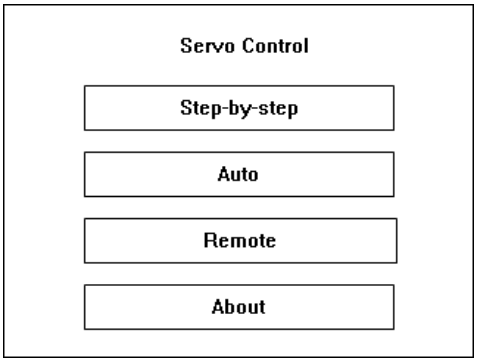

Fig.10 The main screen

Step-by-step mode allows the user to rotate the actuator in both directions with a step of 5 degrees constant defined in the application. This value can be changed in the source code of the application.

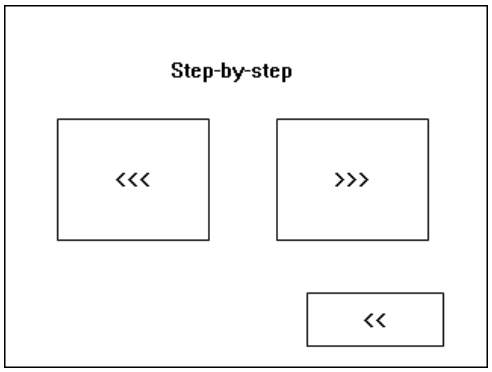

Fig.11 The screen of Step-by-step mode

The next screen enables automatic movement of the actuator in some positions predefined: 0, 45, 90, 135 and 180 degrees. These software buttons do nothing to change the parameter generation function modulated pulse duration.

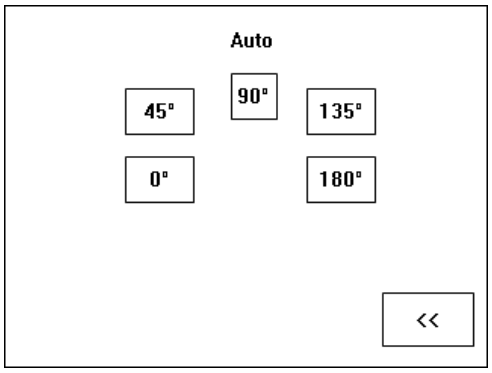

Fig.12. Auto positioning screen

When you want to pass remote control system remote mode. When the next screen appears, the system will run a web server consists of a special routine.

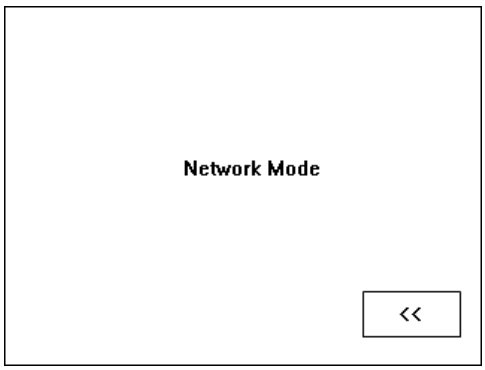

Fig.13 Network mode screen

This routine will serve an HTML page that was captured in the Chrome browser on an Android device, as shown the following figure.

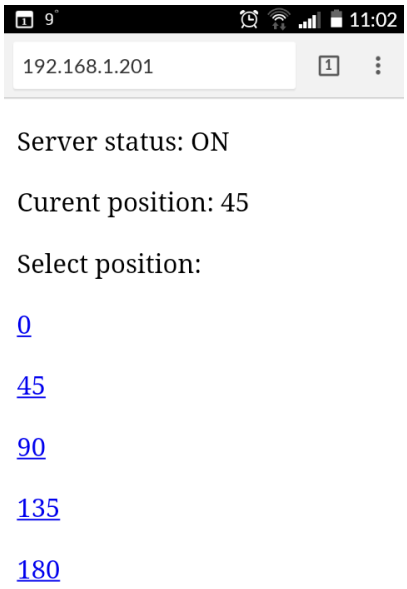

Fig.14 The remote interface provided by microcontroller

The interface displays the current position and offers 5 links witch communicate to microcontroller the required position.

The graphical interface was maintained very simple to boost the performance of whole software package, that part being the largest consumer of processor time.

The next module of software was the generator of pulses. Since it was very difficult to generate PWM pulses using modules of microntroller, on the grounds that the period is not constant, we implemented a function that receives as a parameter the pulse duration in microseconds.

For generation was experimentally determined during a while loop that runs assembly language instruction NOP.

In performing this function to take into account processor clock frequency of 168MHZ, which results in a clock period of about 6ns.

It is difficult to write o precise routine to generate a variable pulse width because calculating takes some time (with floating point unit activated), then calling function and returning back also takes some time. Making some tests the resulted function are below.

```
void delay_us(unsigned us)
{
  unsigned i = us * 17;
  while (i-- > 0) {
    asm nop;
  }
}
```

This feature is specific to the microcontroller STM32F407 frequency which is set to 168MHz and depends on the compiler optimizations applied.

Below are two shots taken using a digital osciloscope for pulses of 750 microseconds and 2.250 miliseconds.

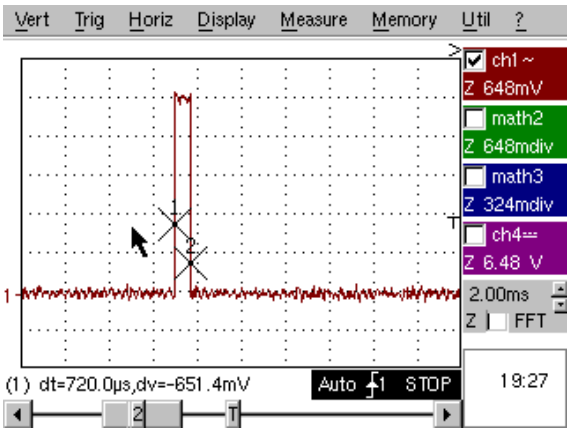

Fig.15 Pulse of 750 microseconds on oscilloscope

One can notice small differences that may be due to both precision pulse generation and the possible measurement errors. Although the actuator placed in the positions which proves that all routines work well.

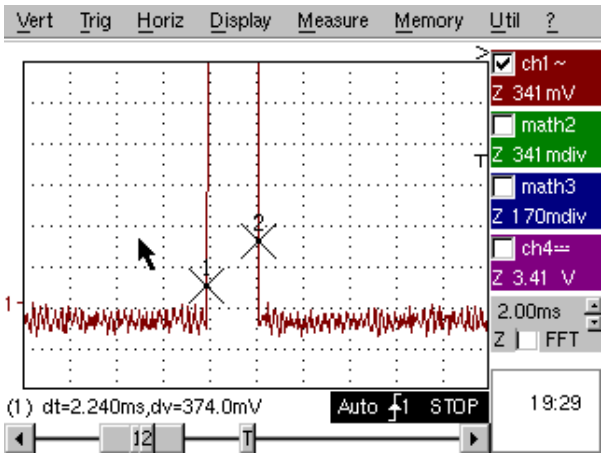

Fig.16 Pulse of 2250 microseconds on oscilloscope

The next part of software is dedicated to network communication. Here are the steps algorithm to achieve that task:

- microcontroller configure SPI communication;
- to set the configuration registers of the circuit ENC28J60(addresses, mask, gateway, port);
- is expected to receive a network packet;
- Package type is detected;
- If the protocol is IP header is extracted it;
- if the type is TCP packet handler is calling the package.

Web page served by the microcontroller is designed as a constant string containing HTML and Java scripts calling variables in program code.

The main function repeats in a while loop 3 functions :

- it generates the graphical user interface and reads the user interaction;
- it generates pulses necessary to achieve and maintain position actuator;
- listen interrupts generated by SPI interface used for communication over the network.

IV. Conclusion

The presented system offers an effective solution, at a low-cost, robust in operation. Following tests were carried out revealed the following conclusions:

- The system is relatively inexpensive offering outstanding performance; the graphical interface is very responsive;
- Propagation delays through the network, both locally and over the Internet are very small, being under 2KB packets; performances were excellent microcontroller behind a 10Mbps ADSL connection and access on an Android device connected to a 3G mobile network.
- Written routines are optimized for driving speed is easily ported to other microcontrollers in the family STM32F4xx.
- The system can be used to control various mechanisms using a feedback from a sensorial system.

The application can be developed as needed by making the following additions:

- in order step by step to make a screen through which the user can set the step size;
- it can achieve an interface through which you can specify up previously defined;
- it can implement a routine communication with other information processing devices are on a higher level and relieving the microcontroller to achieve the graphical interface;
- EEPROM memory usage of the system microcontroller to save various settings;
- design of graphical user interfaces for Windows to configure parameters such as the IP address;
- use micro-sd slot for saving log files.

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Approach based on multi-agent systems and ontologies for interoperability between different systems of port information

Mehdi ABID, Benayad NSIRI and Yassine SERHANE

Abstract— The objective of our work is to propose a mediation architecture in order to solve the majority of interoperability issues (incorrect interpretation, semantic ambiguity, linguistic differences, overlapping information etc.) during a collaboration between different ports information systems. To achieve this objective we present more precisely a solution relying on a distributed architecture based on mediators, and thus adopt a system that relies on Multi Agents Systems (MAS) based on local and global ontologies, in order to provide these heterogeneous ports systems' users a friendly interactive and homogeneous environment which guarantees solving these semantic conflict issues, and helps these systems to establish a collaboration and facilitate the sharing of consistent information with the goal of accelerating the flow of information in the internal system, then across the entire port network.

***Keywords*—** Mediation, interoperability, port information system, global ontology, local ontology, multi agent system, heterogeneous system.

I. Introduction

Nowadays technological developments have pushed the sectors related to ports areas to develop a variety of information systems, this tendency has resulted in a mosaic creation of ports heterogeneous information systems. Collaboration between the various ports systems becomes necessary in case there is a need to use their internal resources and all the networks' collective resources.

Due to obstacles, the exchange and management of various information in a collaboration between the ports information systems becomes increasingly complicated: automated exchange, overlapping information and presentation of data in different languages etc. These linguistic differences can be one of the main causes that generates name conflicts issues [1] where each business or system may designate an entity according to its local area, these naming conflicts can be synonyms conflicts, homonyms conflicts or polysemy conflicts.

Synonyms conflict [9]: different words expressing the same information, for example the word « lift» (American English) and « elevator» (British English) are two different words referring to the same information.

Homonyms conflict [8]: same word different origin with the same pronunciation that have different meaning, eg. if two different systems exchange data, while the data exchanged is « left », the probable conflict is presented in a sentence « left » can refer to the past of the verb « leave » or the opposite of « right ».

Polysemy conflict [10]: same word of the same origin changes meaning depending on the context. For example the word « Get » can be used as « we get money » in this sense the word « Get » means the amount obtained, whereas if we use « we get it » in this case the term « get » means to understand.

The data can then be presented differently from one system to another, this heterogeneity involves communication and knowledge sharing between these systems which have not been designed to collaborate with each other from the beginning. Ontologies have been commonly used to solve two important and related problems that occur in large organizations: information integration and knowledge representation [2], in order to solve these problems several approaches have been proposed such as « mapping ontology » [3] « unification ontologies » [4] for sharing and reusing various information between these heterogeneous information systems' databases.

In this article we address the problem of providing a solution to solve semantic, technical and structural conflicts using ontologies, and an architecture based on multi-agent systems. The reason behind the use of multi-agent systems technology is to facilitate semantic interoperability [11] after any interaction task between existing ontologies and then enrich the knowledge of all the different agents of information systems, the use of agents in our system is designed so that any agent can satisfy our goals exploiting its own resources and skills, it may even be interacting in an environment where other existing agents interact on shared knowledge.

II. Background

In the port sector several studies have been developed to solve any interoperability problems during a collaboration or data

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exchange between several firms, where these ports information systems development organizations work autonomously. This process requires high costs due to software maintenance of each port information systems, in the early 2000s different port firms wished to impose the use of a common centralized storage of all information (Docker, date in, date out, broker, commodity-type, palette, register, stevedore … etc.) between each heterogeneous information system. In addition, this approach involves several financial, strategic and technical problems, like misinterpretations due to linguistic differences between the information systems and the delay of data updates due to data redundancy (same data stored in different databases). Also with technological evolution several approaches have been proposed to establish a common interface between each port information system and hide the heterogeneity of these systems during a collaboration.

M. Miranda and Al [5] propose a multi-agent system (SMA) based on ontologies that provide data access to various information systems, this approach can receive messages from multiple clients, and specify the data that may be provided by a specific agent.

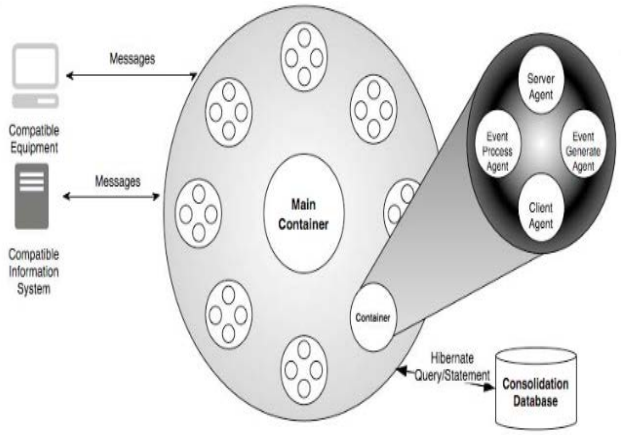

Fig 1 : Communication using a multi-agent system

As shown in **Fig.1**, the system contains several parts based on agents that receive and process the various requests. Depending on the setting of multi-agent system, an agent acts only with the transmission of a specific message, messages are transmitted to agents in charge to process the service sent. Thanks to the use of a global ontology which defines the communication between these agents, they become easier to find, so that the server agent can easily find the specific agent to which the message will be sent systematically. This dynamic flow of information allows to have set of general processing agents as well as the ability to add and remove specific agents when needed for an interoperability service [5].

III. METHOD

The proposed architecture is based on a context mediation system, it helps to rely on structured data such as OWL, in order to solve heterogeneity issues, however several misinterpretations can occur with different OWL versions because of linguistic differences [6] or interpretation differences that change from one domain to another.

Our approach is based then on a multi agent system which is made up of several agents (local agent, mediation agent, manager agent and human agent) with an architecture based on a context mediation concept, to exploit any semantic homogeneity which consists of 3-levels: 1) user level 2) mediation level, 3) source level. **Fig 3**.

The first level: User level, is constituted of different port information systems equipped with an architecture that is based on multi-agent systems to manage the semantic heterogeneity between internal components and to ensure a good understanding of data exchanged during a collaboration with a heterogeneous port information system. This level contains four types of agents: manager agent, mediation agent, local agent and human agent.

Once the local agent faces a problem of incomprehensible or ambiguous term, it reports to the mediation agent by sending the list of incomprehensible data.

The mediation agent treats any technical issue of ambiguous data and ensure that they are consistent with the data structure by solving structural conflicts. **Fig 2**

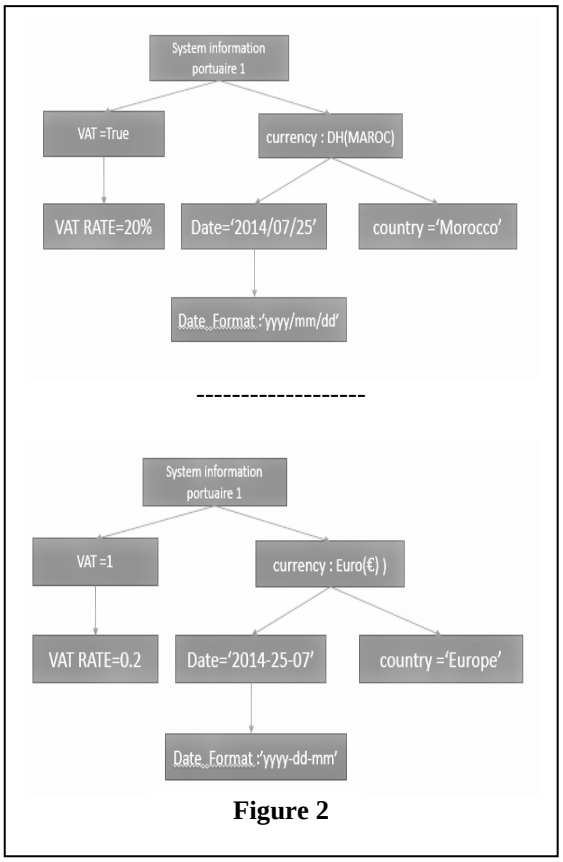

Figure 2

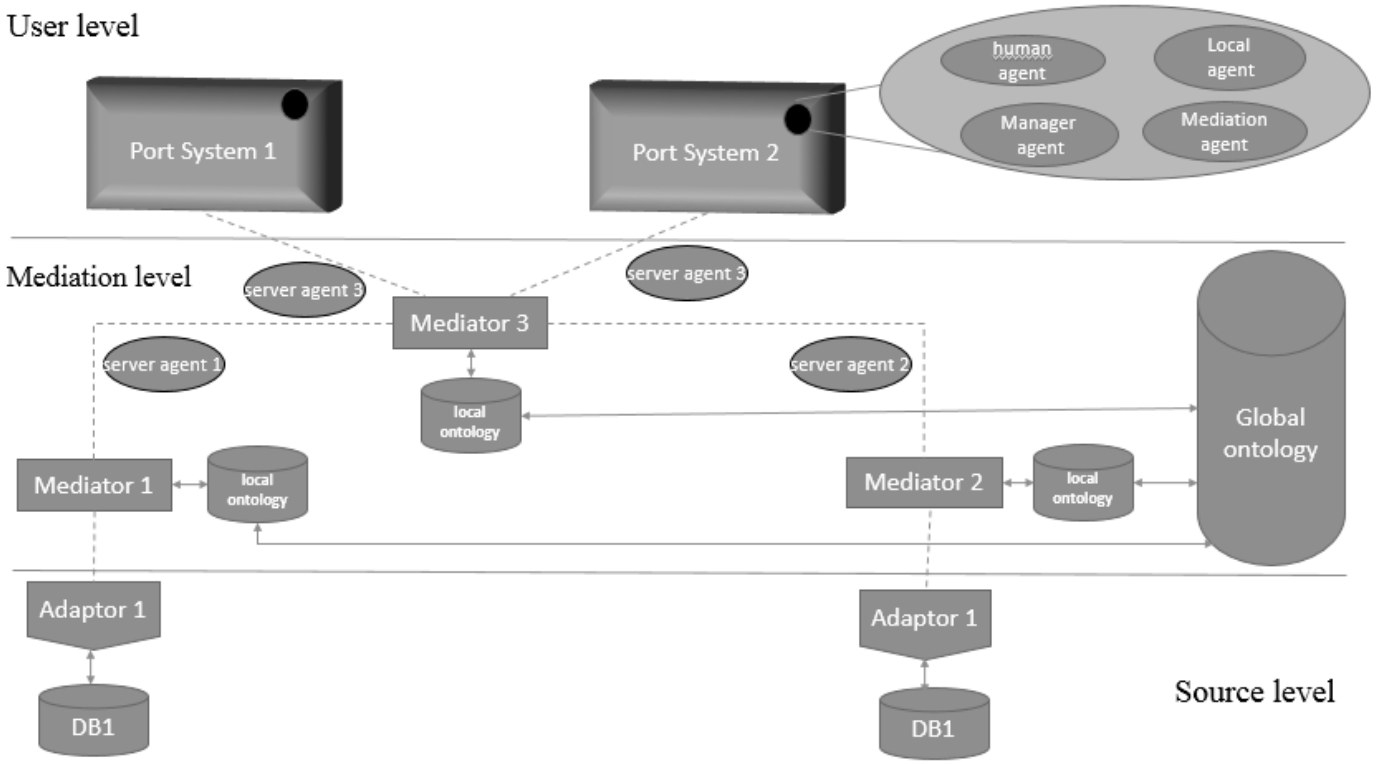

Figure 3

Manager Agent treats all semantic problem by checking the semantic consistency of data, it also contains a list of all the ambiguous data previously processed in order to transmit to the human agent, only new cases where a misunderstanding cannot be resolved without human intervention. **Fig 4**

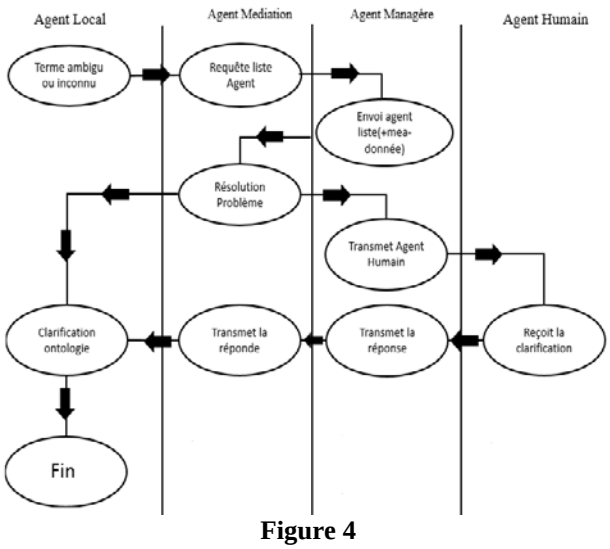

Figure 4

The second level: Mediation level, consists of server agents mediator agents and a global ontology that includes local ontologies.

The mediator simplifies, abstracts, combines and describes the data [7] using to the server agent to process and transmit different data issued by the ports information systems' various requests. Several mediators can be structured in an organized and structured hierarchy between any information systems [1].

The local ontology contains a repository of different data knowledge of each mediator, and describes the context of the internal data of each port information system, it also contains generic knowledge of each port system less abstract than a global ontology one in order to facilitate internal data exchanges between users of a particular information system.

The global ontology is the result of a merger between all the different local ontologies to ensure semantic interoperability and cooperation between them, and share various data information between any knowledge base of each port information system. This ontology (global ontology) replaces the local ontology when it comes to data exchange between the different port systems, to exploit the internal resources and the collective resources of all the different ports information systems [1].

The third level: Source level, is composed of data agents, adapters and various databases of each port information system.

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The adapter is positioned between the mediators and the database, it is thus responsible for providing the results in a unified interface in order to hide the heterogeneity of the associated source, the role of the data agent is to control the access privileges assigned to various external of information systems users.

IV. R ESULTS

In this perspective we decided to apply the different approaches presented in the previous section, on an example of data exchange in a collaboration between heterogeneous port information systems, to facilitate the exchange and communication between them and to enable interoperability of exchanged data by solving conflict issues (Structural, technical and semantic) where each system shares information according to its own data model, which is different at the database system management, design and modeling level.

Based on our study, we introduced an architecture which relies on 3 levels. User level which contains the ports information systems users. Mediation level which contains a set of server agents, mediator agents and a global ontology that includes the different local ontologies in order to process requests from different users and thus solve problems of heterogeneity.

We also implemented a knowledge base that depends on various ports information systems designed with the open source Framework « Protégé » (see **Fig 5**) in order to define logical characteristics for classes as OWL expressions, we decided to create this port ontology which is based on EDIFACT-ONU standards (UN rules for the exchange of administration, commerce and transport computerized data), a set of international standards, directories and manuals for the exchange of computerized data [12].

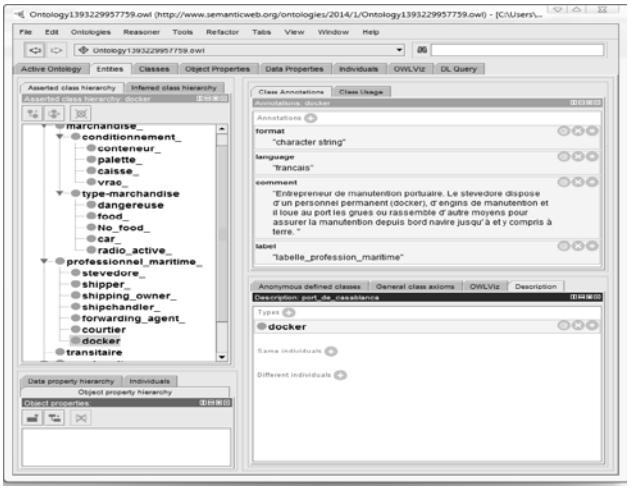

Figure 5

Source level: is composed of adapters, data agents as well as various types of databases system management (PostgresSQL, Informix, Oracle Database, Sql,)

The **Fig.6** shows the process of a request sent by a port information system to an external user.

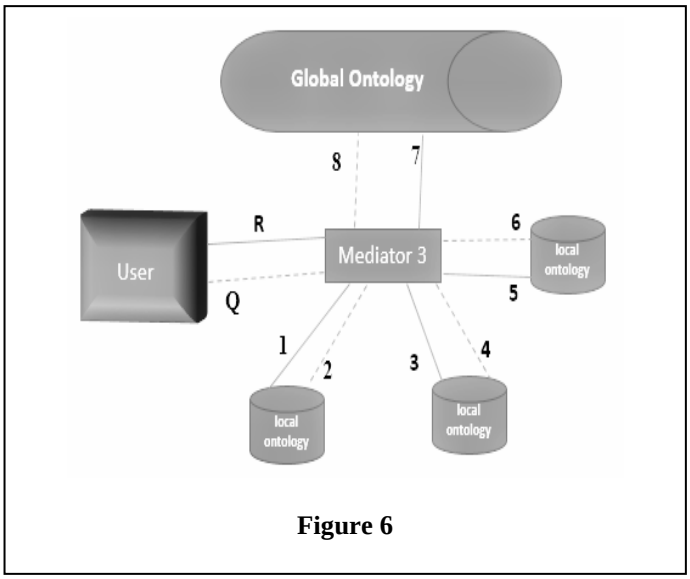

Figure 6

Once a user sends a request to an external system, this request will be automatically processed by mediators at mediation level, these mediators send their requests to their appropriate local ontology, if in this phase a null response is returned, the mediator sends the request to the global ontology resulting from the coalition of all local ontologies in order to ensure the a response for the request issued by the user.

The merger process of all local ontologies ensures interoperability between these ports information systems and as well enriching the exchanged data vocabulary to reduce the problems of data loss during the exchange between systems. This process involves the task of grouping all local ontologies, and it's based on 3 levels: Selection level where each system selects the ontologies to unify (see **Fig.7)**.

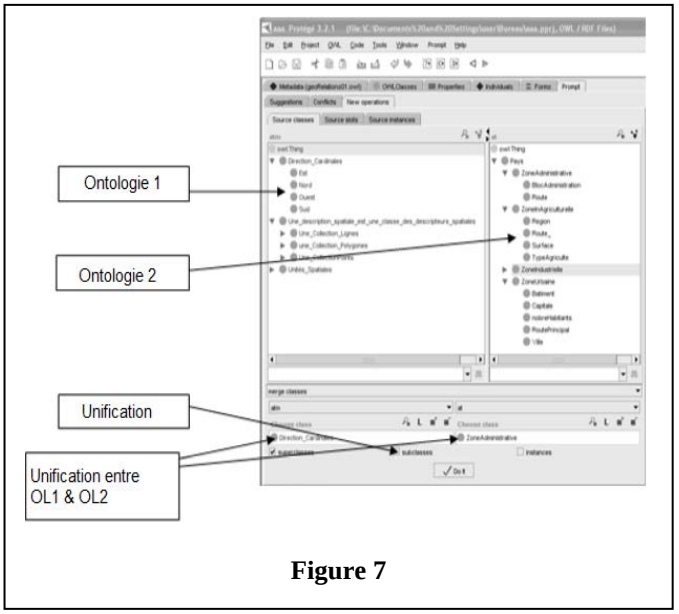

Figure 7

Standardization level is based on the determination of instances or subclasses of each local ontology to unify in order to create a global ontology (sharing level), this ontology (global ontology) collects information from various data and

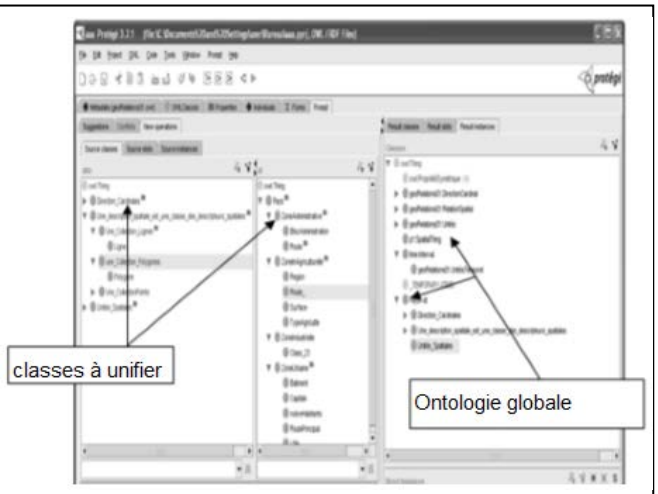

Figure 5

creates a shared vocabulary between all the ports information systems (see **Fig 8**).

V. Conclusion

In this article we have developed a mechanism to solve the problems of misinterpretation as well as technical and structural conflicts in an information exchange between multiple ports information systems, and to present this data in a common interface in order to hide any heterogeneity issues.
We decided to use a 3-level architecture. User level, mediation level, source level. The user part relies on multi-agent systems, where these agents interact with each other in order to solve ambiguities without human intervention, this process will thus establish a collaboration based on the inter-exchange between different ports systems.

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Microembolus Classification Using MFCC and LPC Feature Extractions

Najah Ghazali, Haryati Jaafar and Dzati Athiar Ramli

***Abstract*—** Occurrence of embolism from the patients who are suffering from carotid artery stenosis may lead to the onset of stroke once it becomes more severe. The Doppler ultrasound technique is commonly used to detect emboli in the cerebral circulation. However, the detection of emboli is still relying on human as an observer as a gold standard. A classification system was proposed in this study to detect emboli based on principle of ultrasound signal. There were 12 coefficients from Mel Frequency Cepstral Coefficient (MFCC) and 14 coefficients from Linear Prediction Coefficient (LPC) were extracted as the emboli features of the investigation. The classification of microembolus was performed by using the Support Vector Machine (SVM) classifier. The experiments were done on 3 patients with different number of training and testing samples. It is shown that the features extracted from the LPC method achieved better classification performance of 83.04% than those of MFCC method with only 81.95%. Therefore it revealed the feasibility of an automated detection of emboli feature from ultrasound signal.

***Keywords*—**Carotid Artery Stenosis, Emboli detection, LPC, MFCC, Transcranial Doppler.

I. Introduction

IDEALLY, a healthy person will have a blood flow system suspension with no larger particles, aggregates or bubbles. However, in some circumstances the particles known as emboli may appear in the human vessel. Macroembolism or emboli are the particles consist of the solid emboli such as platelets, fibrinogen, cholesterol, fat, disrupted plaque (thrombus) or gas emboli such as the gas bubbles which travel through blood circulation [1]. An embolization can occur in various situations such as carotid stenosis as shown in Figure 1. Stenosis is an abnormal narrowing condition in the inner surface of the carotid artery. It is caused by plaque or blood clot which is formed near the artery wall [2]. The plaque or blood clot can be formed in the emboli if it is disintegrated from the wall which eventually blocks the small arteries in the brain and leads to stroke. There are different levels of severity of stenosis which rely on the ratio of diameter of the blood vessel to the diameter of the plaque formation in the internal carotid artery. When the plaque collapses from the wall, it will travel along the blood flow which is overloaded with emboli. In a long run, it will lead to the onset of stroke. In this paper, an investigation was done on the emboli detection that occurred in patients suffering carotid artery stenosis.

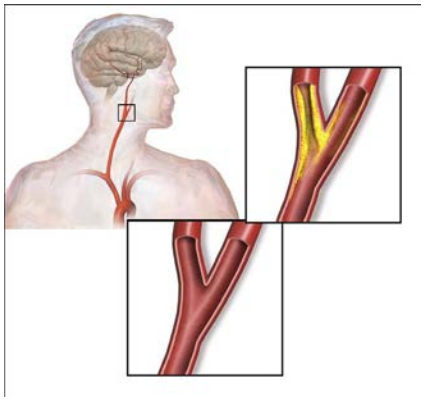

Fig. 1. Carotid artery stenosis.

Generally, the characteristics of the microemboli signal (MES) can be summarized as below :

(1) MES has high-intensity which usually generates power that increases between 3-9 dB or higher than the signal from normal blood flow (referred to Doppler speckle). It is due to the size of emboli which is bigger than the red blood cells [3].

(2)Short duration of transient (less than or equal to 300 *ms* [4].

(3)Real emboli signals may also produce bidirectional signals. There will also be a time delay between two depths of insonation and characteristic of chirping sound.[3]

(4)Microembolization is more likely consist of plaque debris rather than thrombotic material,[5].

The detection of emboli is still relying on human observer as a gold standard. Based on characteristics of emboli discussed before, it is possible to detect emboli without human intervention.

This study is mainly aimed to investigate the possibility in discriminating the microembolus from the background signal. The signals were obtained by using a transcranial Doppler (TCD) system simulator which the transducer was insonated through thinner region of the skull of a virtual patient known as an acoustic window. An embolic condition can be found out via sonogram with the sound like ‘chirping’, ‘moaning’ or ‘ripping’. The sonogram has been used widely in clinical practices for embolism detection and velocity profile. The

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detailed discussion on the transcranial Doppler system and simulator are elaborated below.

A. Transcranial Doppler System

TCD detection is an essential tool in clinical diagnosis mainly in the MES detection. It also gives a good indication of particle velocity by providing real-time information about the changes in velocity and very sensitive to any occurrence of the microemboli or foreign particle that come across the blood vessel. It is essential to obtain good quality signals in order to be able to extract the information from TCD. Next topic will explain more details on how the transcranial Doppler operates.

1) Doppler Shift.

When the ultrasound is scattered or reflected at a moving structure within the body, it experiences a Doppler shift in its frequency and returns to the receiving transducer. When the line of movement of the reflector is at an angle, θ to the transducer beam, then the Doppler shift, f_D is given by :

$$f_D = f_t - f_r = \frac{f_t 2u\cos\theta}{c}$$

where f_t is the transmitted frequency, f_r is received frequency, c is the speed of ultrasound and $ucos\theta$ is merely the component of the velocity of the reflecting agent along the ultrasonic beam direction [6]. Table I shows a typical case of blood flow in a superficial vessel :

Table I. Calculation of Doppler Shift

Characteristic	Measurement
Transmitted frequency, f_t	2 MHz = 2 x 10^6 Hz
Velocity of sound in soft tissue, c	1540 ms^{-1}
Angle between ultrasonic beam and direction of flow, θ	45^o
Doppler shift, f_D	551 Hz

The shift in frequency is usually small and within the audible range. In an ultrasonic Doppler instrument, the electronics are designed to extract the difference in frequency, f_D. The ultrasound signal returns to the detector from different cells and therefore suffers different Doppler shifts. They are added together to give a complex signal and later fed to a loudspeaker where they can be interpreted by listening. A strong signal such as emboli detection corresponds to strong echoes that have received a Doppler shift.

2) Spectrum Analyzer

The Doppler audio signals are later analyzed into its frequency components in order to display the velocities of the blood cells for every extremely short period of time called as instant as shown in Figure 2. The short time intervals of the Doppler signal are analyzed. They subsequently will produce an instantaneous spectrum of the frequencies in the sample volume. If an angle correction is then applied, this spectrum will represent the range of velocities in the sample volume. The range of frequencies in each spectrum is displayed in vertical axis and the power of each frequency component is presented as a shade of grey. The consecutive velocity spectra are then displayed as side by side black shaded lines in Figure 2. In this way, a spectral display or spectrogram is built up.

3) Spectrogram (Sonogram)

Spectrogram is generated in real time during the clinical examination and they possibly can store the trace in an analyzer (in a few seconds) for subsequent review. Medical information such as the embolic condition can be seen in the sonograms (Figure 3) that are built in TCD. The spectrogram is based on reflected sound waves in blood flow through a blood vessel by transmitting a certain frequency. They can also indicate the velocity of particles and the information of the changes in velocity in real-time. In addition to these, they are very sensitive to any occurrence of microemboli or foreign particles that through the blood vessel.

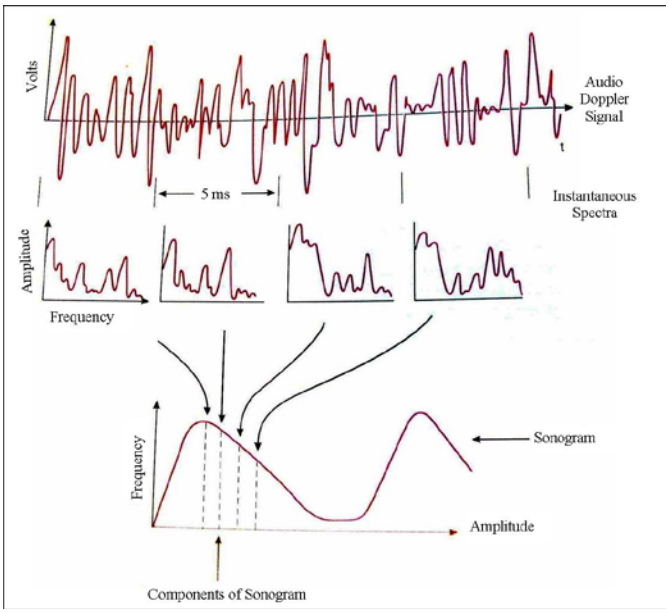

Fig. 2 The distribution of frequencies in each segment is displayed in time intervals as a Doppler sonogram (spectrogram).

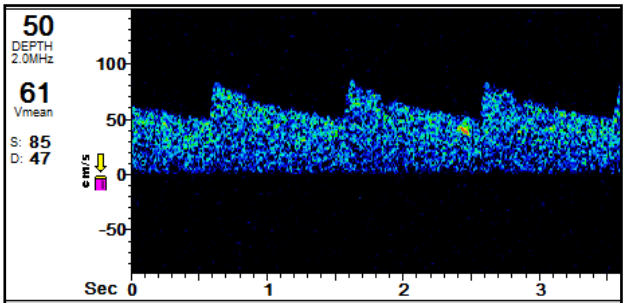

Fig. 3 The emboli detected (red/yellow color) in spectrogram of TCD.

B. Simulator

TCD simulator is used to represent the blood flow simulation of virtual patients. The subjects are selected based on gender, age and vary in scenarios of lesion and anatomy [7] as shown in Figure 4.

The most comprehensive Doppler access to the intracranial vessels is obtained through the temporal acoustic window. The acoustic window is localized where the ultrasonic beam can penetrate without being reflected or excessively attenuated.

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The middle cerebral artery was set at the depths of between 50-55 mm (for adults). This artery is the direct continuation of the internal carotid artery and carries 70-80% of the total blood flow. Increasing the depth will move the sample volume towards the origin of the MCA where the internal carotid artery (ICA) bifurcates. The emboli events can occur in a few milliseconds for a particle to pass through the sample volume. The slower emboli (probably moving closer to the wall) have a longer duration than the faster ones.

When applying the TCD simulator, the ultrasonic power should be reduced to increase the dynamic range of the instrument measured. Thus, a strong emboli signal can easily be detected and discriminated between the real emboli and the artifacts.

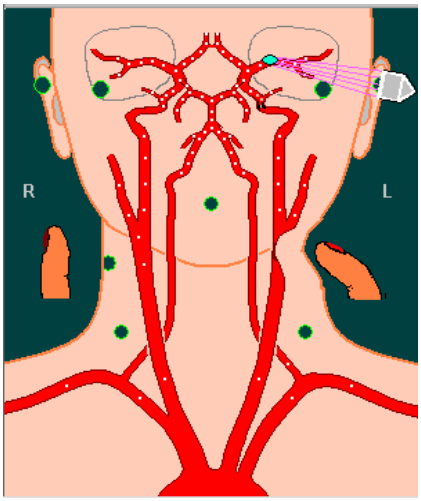

Fig. 4. Cerebrovascular anatomy and phatology.

The first objective of this research was to collect dataset from three different patients that were having stroke using TCD simulator. The patients were distinguished based on gender, ages and the stages of severity. The second objective was to develop an automatic system for emboli detection. There were two different features extraction algorithms were implemented in the suggested model which were MFCC and LPC. The last objective was to evaluate the system performance of automatic detection. The SVM was used as a classifier for both subsystems in the pattern matching process.

The study is summarized as in Figure 5.

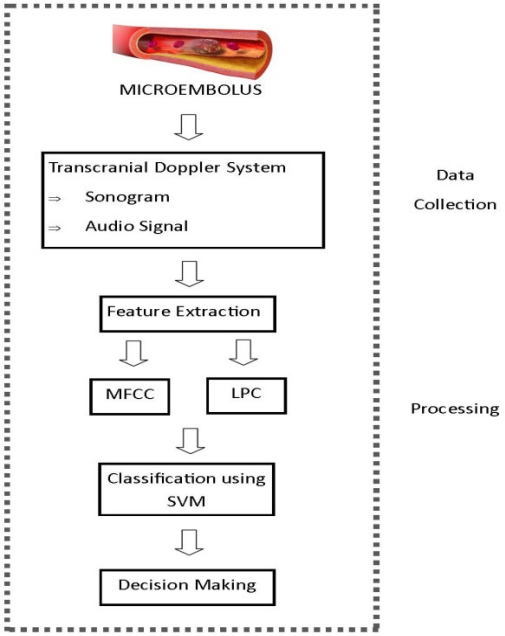

Fig. 5 : The flow chart of data collection and signal processing of emboli detection.

II. Data Collection

A. Audio Signal from Sonogram

The Transcranial Doppler Ultrasound Signal Simulator (version 2.3, Switzerland) was employed for database collection. The signal audio data of all patients were recorded based on sonogram generated by TCD simulator with a transmitted frequency of 2 MHz. The data recorded was in stereo type, 16 bit 8 kHz and WAV format. The spectrogram in Figure 6 illustrates a time varying Discrete Fourier Transform (DFT) of sound recorded for emboli detection with 50% overlap and 1024 window lengths.

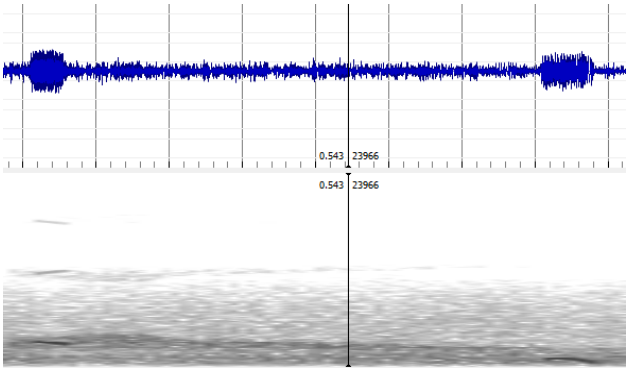

Fig. 6. The emboli simulated from the Doppler signal simulator recorded by audacity. The spectrogram shows a thicker line (black line) which is basically the sound of chirp.

Each of the data underwent a series of pre-processing steps that were pre-emphasis, framing and windowing at the sampling frequency of 7150 Hz [8-11]. The pre-emphasis process is the process of compressing the signal dynamic range by passing it through a filter to emphasize the signal to the higher frequencies in order to raise the signal to noise ration (SNR). In this process, the signal is filtered by using the first order FIR filter in the transfer functions of z-domain:

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$$H(z) = 1 - a.z^{-1} \quad 0 \le a \le 1 \qquad (1)$$

where a is the pre-emphasis parameter.

In the time domain, the relationship between the output $x'(x)$ and the input $x'(n)$ of the pre-emphasized signal are given as:

$$x'(x) = x(n) - ax(n-1) \qquad (2)$$

In this study, the value of a was considered as 0.95. It can increase the SNR to more than 20dB amplification of the high frequency spectrum.

The process of digitization was applied to convert the signal samples from Analog to Digital Conversion (ADC). As stated in digital signal analysis, the spectral evaluation can be performed using short time analysis by windowing the pre-emphasized signal x'(x) into a string of windowed sequence, $x_t(n)$ and t = 1,2,...,T, called frames which are individually processed as arranged below:

$$x'(x) \equiv x'(n - t.M), \quad 0 \le n \le N,\ 1 \le t \le T \qquad (3)$$

$$x_t(n) \equiv w(n).x_t'(n) \qquad (4)$$

where w (n) is the impulse response of window.

In order to reduce the background noise of the digital signal recorded, the post processing method was performed. Data extraction which involved low-pass filtering was applied to modify the power measured from a point scattered to an appropriate position followed by Hamming windowed.

Hamming window, $w_H(n)$ is defined as:

$$w_H(n) = 0.54 - 0.46\cos\left(\frac{2n\pi}{N-1}\right) \qquad n = 0,..., N-1 \qquad (5)$$

A segmentation stage was later introduced to separate the noise and the desired signal of Doppler signal. There were 39 sets of data from the embolic and non-embolic patients were extracted from the TCD simulator. Manual segmentation was done by observing the power signal which produced sounds as in moan, chirp or snap which represented the signal of microembolus (refer Figure 4).

B. Feature Extraction

Some features can be extracted directly from the time domain signal for emboli detection. The common feature used is by measuring the relationship between the power of the background signal and the embolic signal. Other than this, there are other features such as frequency, sample length, duration and velocities are also associated with the emboli detection. However, the time domain features tend to be mixed with the background noise of the signal which has made it more difficult to be classified.

In this study, two features which were the MFCC and LPC were used in the development of the emboli detection. The MFCC feature is based on the known variation of the critical bandwidths of the human ears which is expressed in terms of mel-frequency.

There were several steps in MFCC processing. The first step was to frame the signal into 18 ms per frame (7150 Hz frequency sampling and 128 samples). The frame had to be in sufficient length (not too short) since an ample amount of samples was needed to obtain a reliable spectral estimation. The DFT was computed to all frames of the signal to estimate the power spectrum. By considering $\omega = \frac{2\pi k}{N}$, the DFT of all frames of the signal, $x_t(n)$ was obtained by using equation 6.

$$X_t(k) = \sum_{n-1}^{N} x_t(n)h(n)e^{-j\omega n}, \qquad 1 \le k \le K \qquad (6)$$

where *h(n)* is an *N* sample long analysis window and K is the length of DFT.

The power spectral estimated may contain some unnecessary information for the automatic signal recognition such as there were two closely frequencies found were not differentiated accurately. Therefore, Mel filter bank was employed.

A Mel filter bank processing was the second step in MFCC processing. The filter banks are usually integrated a spectrum properly at a defined frequency and the spectral features are obtained after this process. The outputs of the filter bank are denoted as Y_t (m), 1≤ m≤M where M is the number of band-pass filters. A set of 24 band-pass filter was used in this study.

The third step was the computation of the log energy which computed the logarithm of the square magnitude of the filter banks outputs, $y_t(m)$. This operation was done to match the features to be more closely to the human hearing.

The final step for MFCC processing was the mel frequency cepstrum computation that performed the Discrete Cosine Transform (DCT) on the logarithm of the magnitude of the filter bank output as shown as in equation 7:

$$y_t^m(k) = \sum_{m=1}^{M} \log\left\{Y_t(m)\right\}.\cos\left(k\left(m - \frac{1}{2}\right)\frac{\pi}{M}\right) \quad k = 0,..., L \qquad (7)$$

The final step was needed since the energy from the filter banks were correlated to each other due to the overlapping. Therefore, $y_t^m(k)$ coefficient de-correlated the energy features which led to the implementation of the diagonal covariance matrices can be used to classifier. There were only 12 out of 24 coefficients were stored since the higher coefficients were dropped out as they represented the fast changes in the filter bank energies which can degrade the performance. The resulting features were called as an MFCC.

Finally, there were 12 mel cepstrum coefficients, a log energy coefficient and three delta coefficients per frame were obtained. The process of the MFCC is simplified in Figure 7.

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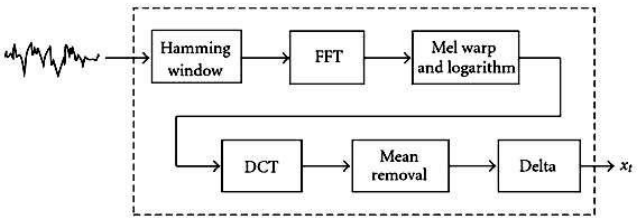

Fig. 7. The MFCC block diagram

In this study, the database of MFCC features were consisted of 4096 sets of MFCC features recorded for an approximately 18 milliseconds per frame.

The LPC feature extraction modeled the process of signal production and is defined as a digital method for encoding an analogue signal in which a particular value is predicted by a linear function of the past values of the signal. The most important aspect of LPC is the linear predictive filter which allows the value of the next sample to be determined by a linear combination of previous samples. In other word, linear prediction filters attempt to predict future values of the input signal based on past signals. The LPC analysis is based on the assumption that the relation between the current sample x(n) and first-order linear combination of the previous p samples is given as:

$$x(n) \approx a_1 x(n-1) + ... + \alpha_p x(n-p) \quad (8)$$

In a Doppler signal processing, it commonly contains 5 or more dominant frequencies. Therefore, an order 14 is often performed for linear predictive model.

The database of the LPC features were comprised of 4096 sets of LPC features obtained from the data of 3 patients which were recorded for approximately 18 miliseconds per sample. There were 14 cepstrum coefficients per frame were extracted by using this method. The overall process of the LPC is shown in Figure 8.

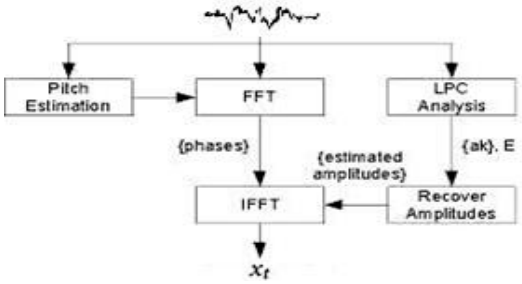

Fig. 8. LPC block diagram

C. Classification using SVM

Classification technique in this work represents the technique of identifying emboli from the background signal based on a training set which its membership category is known. Recently, a relatively new classification method, binary decision tree [12], artificial neural network (ANN) and K-Nearest Neighbors Rule (KNNR) [13-14] had been proposed. The results yielded a sensitivity and specificity of greater than 80% to detect the solid and emboli compositions.

In this study, SVM was used as a classifier due to its good performance for emboli detection. Unlike traditional methods which minimize the empirical training error, the SVM classifier maximizes the margin of the decision boundary. The classification flow can be summarized as in Figure 9.

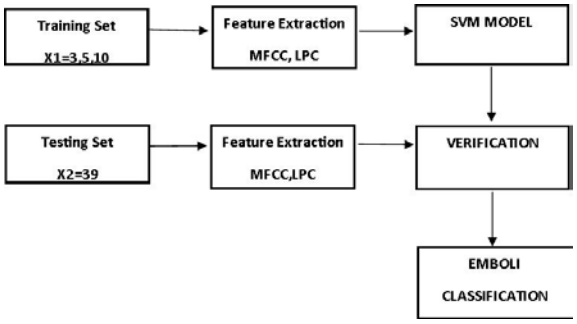

Fig. 9. Flow chart of SVM Classifier

III. Result and Discussion

A. Experimental Setup

In order to evaluate the detection system, two independent data sets were used, each comprising of 39 emboli and 39 normal flows. Three patients were selected which were 25 years old female (patient 1), 25 years old male (patient 2) and 40 years old female (patient 3). A transducer with transmitted frequency of 2 MHz was placed on the right side of the transtemporal for the patients who were having more than 50% of symptomatic internal carotid artery stenosis. The virtual patient was differed by the level of age and severity of stenosis. When an observer was listening to the Doppler sonogram and he/she suspected the emboli event, the permanent storage of the contents of the buffer will be activated. The digital audio consisted of 210 audio data were recorded in a folder which differentiated between emboli and normal signals in three different patients. The signals were then analyzed off-line where the features were extracted by using the MFCC and LPC techniques.

B. Comparisons of using MFCC and LPC

In the first dataset, three samples from the emboli and normal signals (approximately less than 400 *ms*) were measured as training samples. It was followed by an increment of 10 data for the second dataset. The second dataset was developed to validate the detection of the algorithm which was devised from the first dataset. The algorithm was also tested on a third training dataset comprising of 20 embolic signals and normal signals which were recorded pre-operatively from all patients. The results are shown in Table II and Figure 10.

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Table II. The performance of the system based on the LPC and MFCC features.

Training Data		Features	
		MFCC	LPC
3	Patient 1	86.20	86.21
	Patient 2	88.46	92.30
	Patient 3	67.24	67.24
5	Patient 1	81.03	81.03
	Patient 2	82.69	94.23
	Patient 3	74.13	74.13
10	Patient 1	91.37	89.66
	Patient 2	92.30	88.46
	Patient 3	74.13	74.13
Accuracy		**81.95**	**83.04**

The results show that the LPC performed higher classification with 83.04% accuracy compared to MFCC with only 81.95% accuracy. It confirmed the hypothesis stated previously that the chosen linear prediction coefficients of speech signal in LPC are sufficient to be applied in our data. Since the audio signal data were in sinusoidal form and some noises, the LPC was able to work better to estimate the testing emboli which led to an easier prediction of the dominant frequency.

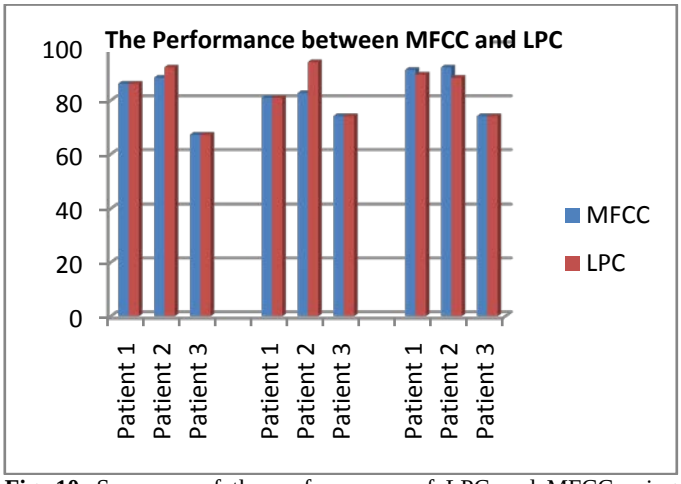

Fig. 10. Summary of the performances of LPC and MFCC using SVM classifier.

In other aspect, the capability of speech features taking part in the ultrasonic audio features was revealed. The ultrasonic signal was converted into wav format of 7150 Hz based on literature review[8][10]. Based on human hearing sound, the speech signal is generally estimated to be around 8 kHz – 20 kHz. Hence, it is satisfactory decision when applying the voice signal method into Doppler signal. Therefore, the application of LPC and MFCC can be implemented for automatic detection of embolic signal.

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Selection of Artificial Data of Minority for Better Data Mining

Hyontai Sug and Douglas D. Dankel II

***Abstract*—**Data mining algorithms like decision trees or rule set learners are made to achieve maximum accuracy, so data instances in minority group are often neglected, because the minority group often does not have enough data instances for accurate classification. But, some domains like medicine minority is often more important. In order to surmount the problem, over-sampling technique generating artificial instances of minority may be used based on a nearest neighbors algorithm. But, even though the instances are made based on a well known nearest neighbors algorithm, it may be possible that the quality of the instances may not be good as expected. In this paper we showed how we may solve the problem by resorting to a different and more reliable data mining algorithm other than decision trees or rule set learners. Experiments using two data sets in medicine domain showed a good result.

***Keywords*—**Decision trees, rule sets, over-sampling, data validation.

I. Introduction

UNDERSTANDABILITY is an important issue in data mining, because we may want to utilize found knowledge models for some important areas [1]. For example, medicine area highly requires the understanding of the found knowledge, because it is related to human life. There are several data mining algorithms for understandability. Among them decision trees and rule set learners can be representatives [2]. Even though decision trees are considered one of good data mining tools, they may not generate good results for a minor class, because they are trained to achieve a maximum accuracy for the whole data set. But, in real world data sets for data mining, a minor class may be more important than the others, for example, in medical data [3]. For more accurate classification of these minor classes in decision trees over-sampling may be applied. But, simple over-sampling may have limited effect only, because the same instances are supplied multiple times for training. On the other hand, we may supply some very similar data instances of the minor classes by generating the instances artificially. SMOTE[4] is one of the representative over-sampling method that generates artificial instances of minor classes. The method generates artificial instances based on K-nearest neighbors algorithm, and success was reported for a decision tree algorithm and rule generator. But, we know that possibly incorrect training instances are easy to lead to classifiers of lower performance. So, supplying possibly correct instances is an important task for better classifiers. In this paper we want to check the quality of the artificially generated data instances by SMOTE empirically so that we may find better classifiers like decision trees or rule sets by supplying good artificial instances. In section 2 we discuss our experiment method, and in section 3 conclusions are provided.

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II. Empirical Procedure

A. Experiment Method

C4.5 [5] and RIPPER [6] can be representative classifiers in decision tree algorithms and rule set learners respectively [7]. SMOTE tries to generate artificial instances of a minor class to build better decision tree of C4.5 and rule set of RIPPER. The artificial instances are made based on K-nearest neighbors algorithm and randomization on continues values of related attributes. But, we may doubt that there is some possibility that the quality of generated instances may not be good as expected because of the randomization. So, we want to check the class of artificially generated instances by SMOTE using more a accurate classifier, if it is available.

In the following experiments, we first check the accuracy of three different data mining algorithms, C4.5, RIPPER, and a more accurate classifier X, using the original data sets and the original data set plus artificial instances generated from SMOTE. Experiments were performed using medicine data sets called BUPA liver disorder and echocardiogram in the UCI machine learning repository [8]. The experiment is based on 10-fold cross validation and a data mining tool called Weka [9]. Weka is a comprehensive data mining tool.

B. BUPA Liver Disorder Data Set

The data set contains two classes, and each class has 145 and 200 instances. So, the class having 145 instances is a minor class. Let it be class 1. It has six continuous attributes. Table 1 shows the accuracy of three different data mining algorithms, C4.5, RIPPER, and random forests [10] for the data set. Default parameters are used for C4.5 and RIPPER. The parameters of 100 trees and one are given as the parameter of the number of

trees and the number of attributes to be used in random selection for the random forests respectively. In the table TP rate means true positive rate.

TABEL I
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR BUPA LIVER DISORDER DATA

		C4.5	RIPPER	Random Forests
Accuracy(%)		68.6957	64.6377	75.942
TP rate	Class 1	0.531	0.469	0.593
	Class 2	0.8	0.775	0.88

After generating three data mining models based on the original data set, over-sampling rate of 100%, 200%, 300%, and 400% is applied for the minor class using SMOTE. So, additional instances of 145, 290, 335, and 580 are added to the original data set to make training data sets for each respective over-sampling rate. Table 2 shows the result of the experiment.

TABEL II
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR BUPA LIVER DISORDER DATA IN DIFFERENT OVER-SAMPLING RATES

Over-sampling rate			C4.5	RIPPER	Random Forests
100%	Accuracy(%)		72.8571	74.4898	81.8367
	TP rate	Class 1	0.8	0.8	0.869
		Class 2	0.625	0.665	0.745
200%	Accuracy(%)		74.0157	74.6457	83.622
	TP rate	Class 1	0.841	0.848	0.94
		Class 2	0.52	0.525	0.61
300%	Accuracy(%)		77.5641	77.9487	83.4615
	TP rate	Class 1	0.876	0.878	0.953
		Class 2	0.485	0.495	0.49
400%	Accuracy(%)		83.1351	83.3514	85.6216
	TP rate	Class 1	0.927	0.934	0.975
		Class 2	0.485	0.47	0.425

We can see some positive effect of the over-sampling from table 2. In order to check the quality of the over-sampled data by SMOTE, all the over-sampled instances of SMOTE are checked by the more accurate classifier, random forests. The random forests trained by the original data is used. While 1,163 distinct instances are checked to belong to true positive, the other 274 distinct instances are checked belong to false positive. Using these two groups of over-sampled instances and the original data set, two more experiment were run. Table 3 shows the result of the experiment using over-sampled instances of true positive plus original data set.

TABEL III
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR OVER-SAMPLED INSTANCES OF TRUE POSITIVE PLUS ORIGINAL BUPA LIVER DISORDER DATA

		C4.5	RIPPER	Random Forests
Accuracy(%)		89.0584	88.9257	91.1141
TP rate	Class 1	0.952	0.952	0.986
	Class 2	0.49	0.48	0.42

Table 4 shows the result of the experiment using over-sampled instances of false positive plus original data set.

TABEL IV
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR OVER-SAMPLED INSTANCES OF FALSE POSITIVE PLUS ORIGINAL BUPA LIVER DISORDER DATA

		C4.5	RIPPER	Random Forests
Accuracy(%)		70.5977	73.3441	79.483
TP rate	Class 1	0.924	0.895	0.969
	Class 2	0.25	0.395	0.43

If we compare table 3 and 4, we can find that the true positive instances by random forests are doing better than the false positive instances. Note that adding smaller number of over-sampled instances of class 1 may affect smaller decrease in TP rate of class 2 as we can see in table 2. But, if we look at true positive rate of class 2 in table 4, the three values are worse than those values of over-sampling rate of 100% or 200% in table 2. On the contrary, over-sampled instances of true positive generated similar true positive rate with those of over-sampling rate of 400% in table 2, while the accuracy of the three algorithms are better.

C. Echocardiogram Data Set

Originally echocardiogram data set contains two classes of 74 instances, and the other 58 instances have no classes. So, one more class is added as 'unknown' for convenience. As a result, a new data set with three classes is used for experiment, and each class has 50, 24, and 58 instances for class 1, class 2, and class 3 respectively. So, the class having 24 instances is a minor class. The data set has twelve continuous attributes. Table 5 shows the accuracy of three different data mining algorithms, C4.5, RIPPER, and LMT [11] for the data set.

TABEL V
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR ECHOCARDIOGRAM DATA

		C4.5	RIPPER	LMT
Accuracy(%)		54.5455	63.6364	70.4545
TP rate	Class 1	0.6	0.82	0.8
	Class 2	0.583	0.792	0.625
	Class 3	0.483	0.414	0.655

Over-sampling rate of 100%, 200%, 300%, and 400% is applied for the minor class using SMOTE. So, additional

instances of 24, 48, 72, and 96 of class 2 are added to the original data set for each respective over-sampling rate. Table 6 shows the result of the experiment.

TABEL VI
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR ECHOCARDIOGRAM DATA IN DIFFERENT OVER-SAMPLING RATES

Over-sampling rate			C4.5	RIPPER	LMT
100%	Accuracy(%)		64.7436	71.7949	67.3077
	TP rate	Class 1	0.64	0.76	0.64
		Class 2	0.583	0.792	0.625
		Class 3	0.483	0.414	0.655
200%	Accuracy(%)		72.2222	75.0	73.8889
	TP rate	Class 1	0.66	0.9	0.76
		Class 2	0.889	0.931	0.875
		Class 3	0.569	0.397	0.522
300%	Accuracy(%)		70.5882	79.902	82.3529
	TP rate	Class 1	0.56	0.9	0.76
		Class 2	0.906	0.969	0.969
		Class 3	0.5	0.431	0.638
400%	Accuracy(%)		78.0702	81.1404	83.7719
	TP rate	Class 1	0.62	0.92	0.78
		Class 2	0.95	0.983	0.638
		Class 3	0.569	0.362	0.586

We can see some positive effect of over-sampling from table 6. As before, in order to check the quality of the over-sampled data by SMOTE, all the over-sampled instances of SMOTE are checked by the more accurate classifier, LMT. The LMT trained by the original data is used. While 198 distinct instances are checked to belong to true positive, the other 35 distinct instances are checked to belong to false positive. Using these two groups of over-sampled instances and the original data set, two more experiment were run. Table 7 shows the result of the experiment using the over-sampled instances of true positive plus original data set.

TABEL VII
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR OVER-SAMPLED INSTANCES OF TRUE POSITIVE PLUS ORIGINAL ECHOCARDIOGRAM DATA

		C4.5	RIPPER	LMT
Accuracy(%)		84.8485	86.3636	87.5758
TP rate	Class 1	0.6	0.92	0.78
	Class 2	0.986	0.968	0.973
	Class 3	0.534	0.414	0.586

Table 8 shows the result of the experiment using over-sampled instances of false positive plus original data set.

TABEL VIII
ACCURACY OF THE THREE DIFFERENT DATA MINING ALGORITHMS FOR OVER-SAMPLED INSTANCES OF FALSE POSITIVE PLUS ORIGINAL ECHOCARDIOGRAM DATA

		C4.5	RIPPER	LMT
Accuracy(%)		70.0599	74.2525	72.4551
TP rate	Class 1	0.56	0.94	0.66
	Class 2	0.932	0.915	0.915
	Class 3	0.586	0.397	0.586

If we compare table 7 and 8, we can find that the true positive instances by LMT are doing better than the false positive instances by LMT. Note that adding smaller number of over-sampled instances of class 2 may affect some change in TP rate of class 1 or class 3 that belong to major classes. For better understanding of the change of TP rate of each class for each respective data mining algorithm, we draw graphs as in fig. 1, fig. 2 , and fig. 3 for C4.5, RIPPER, and LMT respectively. In the graphs, X axis is arranged with increasing number of training instances. The total number of instances in class 2 is 48, 59, 72, 96, 120, and 222 for over-sampling rate of 100%, over-sampling of false positives only, over-sampling rate of 200%, over-sampling rate of 300%, over-sampling rate of 400%, and over-sampling of true positives only respectively.

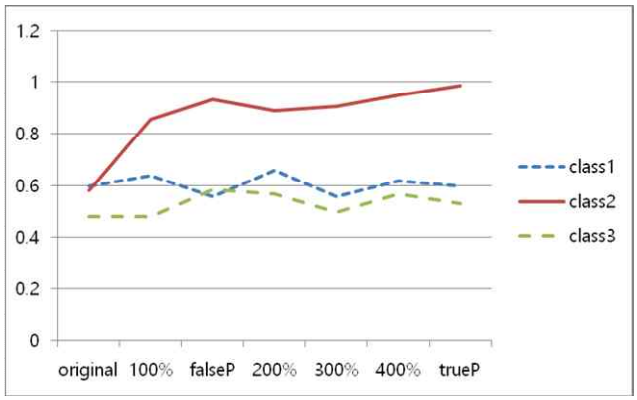

Fig. 1. The change of TP rate of C4.5 for echocardiogram data

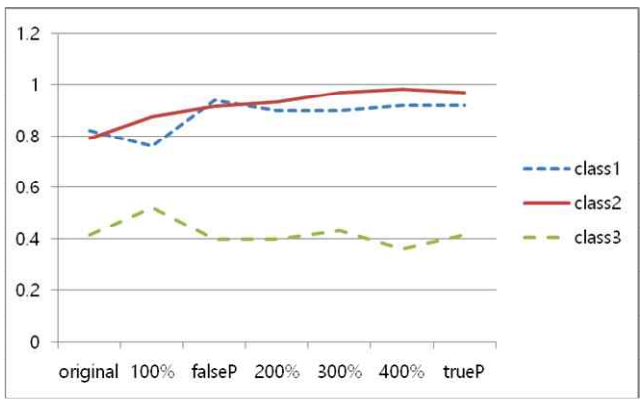

Fig. 2. The change of TP rate of RIPPER for echocardiogram data

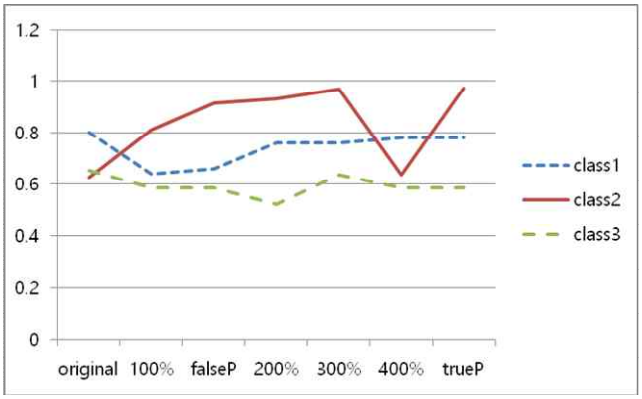

Fig. 3. The change of TP rate of LMT for echocardiogram data

As we can see in the figures, true positive instances of over-sampled instances show better results with respect to true positive rate of each class as well as the accuracy.

III. Conclusion

Data mining algorithms are made to achieve predictive ability as accurately as possible, so data instances in minority group are often neglected, because the minority group often do not have enough data instances for accurate prediction. In order to surmount the problem, some over-sampling technique that generates artificial instances in the minority group may be used, and SMOTE has been considered a good technique for that purpose. But, even though the instances are generated based on a well known nearest neighbors algorithm, it may be possible that the quality of the artificially generated instances is not as good as expected. In this paper we showed how we may surmount the problem by resorting to a different and more reliable data mining algorithm other than C4.5 or RIPPER. Experiments using two data sets in medicine domain showed a good result. Further experiments will be performed to validate the conclusion using data sets in other domains.

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A Study of the Software Development using Agile

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Abstract— **Software development methodologies are constantly evolving due to changing technologies and new demands from users. While agile methods are in use in industry, little research has been undertaken into what is meant by agility and how a supposed agile method can be evaluated with regard to its veracity to belong to this category of software development methodological approaches.**

Here, one study conducted on some well-known agile methods. This information is shown to be useful, for when constructing a methodology from method fragments (method engineering) and when comparing agile methods.

Index Terms— **Behavior Driven Development, Test Driven Development, Software Engineering, Agile Method**.

I. Introduction

To develop software, companies have tried many different techniques. In the past, programming an application was thought of as a solving a problem, and the method for solving the problem was thought to only be as good as the software that was created.

The object-oriented paradigm plays a prominent role in the development of many modern software systems. The different structure and behavior of object oriented software helps in solving or mitigating several problems of procedural software[1].

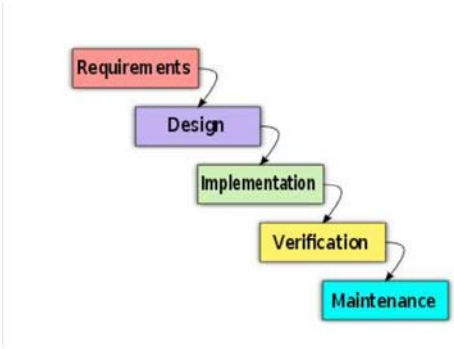

Fig 1: Waterfall Development Model

Agile Development is a term used to define a modular approach to development. These incremental approaches have been used since the late 50's. The Agile philosophy focuses on communication with the client and clean, iterative development. Agile development also descended into development strategies known as Extreme Programming. Extreme Programming and Agile Development use iterations for development iterated thorough a full development cycle, from conception to production. Before the iterative development strategy that Agile Development utilizes, development was normally called a waterfall model (Fig-1).

Agile methodology has become the main stream of software development due to its ability to generate higher customer satisfaction. It is fast and flexible methodology that recommends to incorporating last minute changes and requirements provided by the customer at any stage of software development phase [2] [3].

II. AGILE METHODOLOGIES

Agile development provides opportunities to assess the direction throughout the development lifecycle. This is achieved through regular cadences of work, known as Sprints or iterations, at the end of which teams must present a potentially shippable product increment. By focusing on the repetition of abbreviated work cycles as well as the functional product they yield, agile methodology is described as “iterative” and “incremental.”

Agile development is supported by a bundle of concrete practices suggested by the agile methods, covering areas like requirements, design, modeling, coding, testing, project management, process, quality, etc. Some notable agile practices include:

- Acceptance test-driven development (ATDD)
- Agile Modeling
- Backlogs (Product and Sprint)
- Behavior-driven development (BDD)
- Feature Driven Development (FDD)
- Continuous integration (CI)
- Domain-driven design (DDD)
- Dynamic Systems Development Method (DSDM)
- Iterative and incremental development (IID)
- Pair programming
- Autism spectrum disorder(ASD)
- Refactoring
- Scrum meetings
- Test-driven development (TDD)
- Agile testing
- Use case
- User story

- Story-driven modeling
- Velocity tracking

Agile methods have been extensively used for development of software products and some of them use certain characteristics of software, such as object technologies.

A. Test Driven Development

Test Driven Development (TDD) is the core part of the Agile code development approach derived from eXtreme Programming (XP) and the principles of the Agile manifesto. The TDD is not a testing technique, rather a development and design technique in which tests are written prior to the production code. The tests are added its gradually during its implementation and when the test is passed, the code is refactored accordingly to improve the efficacy of internal structure of the code. The incremental cycle is repeated until all functionality is implemented to final[4]

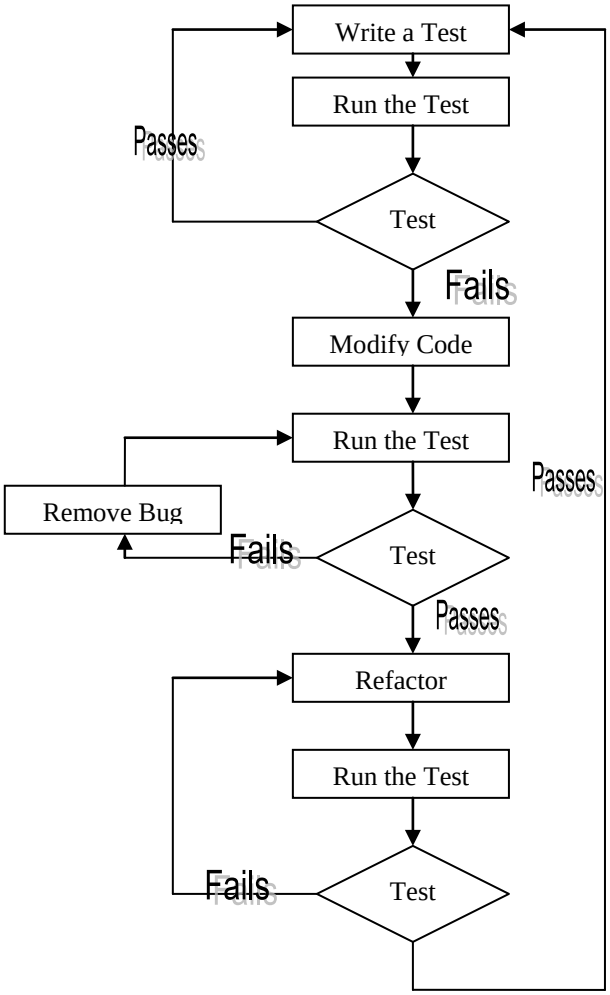

Fig. 2: Test Driven Development

This is it. This is the simplest way of explaining TDD in my opinion. Now, the main focus of TDD will be on testing the low-level functionality and units (for single classes and methods) that can lead to more flexible code and easier refactoring. In a simple language we can say, **we write these tests to check if the code we wrote works fine**

B. Agile Specification Driven Development

This is a technique that combines both- TDD and Design by Contract (DbC). DbC –this allows a language to declare invariants for the class and pre and post condition for a method. It was given by Bertrand and Meyer. Microsoft has introduced their version of DbC into .NET framework, called code contracts. Meyer has also introduced an approach called Quality-first Model to software development. Another developer described Quality approach as:-

- Write code as soon as possible because then supporting tools immediately do syntax, type and consistency checking.
- Current set of functionality should be working before moving to next. Abnormal cases must be dealt with. Interwine analysis, design and implementation
- Always have a working system. Get cosmetic and style right.

The DbC approach is at core of Quality-first model. **Similarities in DbC and TDD:** In both the approaches one unit of functionality must be finished before moving to next. **Differences:** in TDD, it asks the developer to focus on the most common case, whereas DbC expects the developer to focus on abnormal cases first. Acceptance Test Driven Development. Now, let us consider another approach which is Acceptance Test Driven Development (ATDD) that adds 'A' before TDD which stands for Acceptance. Now, why was this even needed? Wasn't the TDD good enough and better? I would say no and the reason was that TDD was more of telling to make sure the code works fine but it did not say that if the code that is written was even required at first place. In ATDD the acceptance criteria are defined in early in application development process and then those criteria can be used to guide the subsequent development work. ATDD helps developers to transform requirements into test cases and allows verifying the functionality of a system. A requirement is satisfied if all its associated tests or acceptance criteria are satisfied. In ATDD acceptance tests can be automated. TDD and ATDD are adopted widely by the industry because they improve software quality and productivity [5, 6].

ATDD is a collaborative exercise that involves product owners, business analysts, testers, and developers. **ATDD helps to ensure that all project members understand precisely what needs to be done and implemented.**

However, many developers find themselves confused while using TDD and ATDD in their projects, "programmers wanted to know where to start, what to test and what not to test, how much to test in one go, what to call their tests, and how to understand why a test fails" [6]. Some of the problems of TDD and ATDD are that they are focused on verifying the state of the system rather than the desired behaviour of the system, and that test code is highly coupled with the actual systems' implementation [8, 9]. In addition, in these approaches unstructured and unbounded natural language is used to describe test cases which are hard to understand [6].

C. Behavior Driven Development

To develop software, companies have tried many different techniques. In the past, programming an application was thought of as a solving a problem, and the method for solving the problem was thought to only be as good as the software that was created. As higher level languages evolved, software development became more popular and software became increasingly mainstream. Therefore the method that a developers used to create software came into question. Behavior Driven Development (BDD) was born out of that evolution. BDD has a strong focus on collaboration during software development, much more than it's predecessor Test Driven Development (TDD).

BDD's focus does not end with developer collaboration, but instead attempts to bridge the gap between the developer and client, where features of an application are defined by how a user would interact with them rather than a feature being defined in technical terms. BDD bridges the gap between the developers and the stakeholders in software by providing a clear concise methodology to develop software.

The basic work flow for software developed using BDD techniques requires the developer to communicate with the shareholders, and it requires developers to create a well defined picture of the application. Then, through the development process, shareholders communicate with the developer to shape each individual feature to the specific goals of the shareholders. This approach creates a dialogue between the developer and shareholder to create an end application that meets the specifications much more closely than applications developed in any other way.

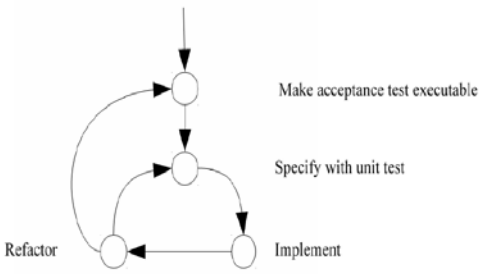

Fig 3: BDD Implementation Cycle

III. . COMPARATIVE STUDY

So let us discuss about some difference between these terms and find out how are they different from each other.

- As discussed earlier, the immediate obvious difference between TDD and ATDD is the 'A'. While that may sound sarcastic, the point is that TDD (as usually practiced) has an implied U on the front, standing for Unit, while the A stands for Acceptance. TDD focuses on the low level, ATDD on high level.

TABLE I. SUMMARY OF SOFTWARE DEVELOPMENT OF LIFE CYCLE OF POPULAR AGILE METHODS

Sr. no	Method	Phases	Description
1	XP	Exploration	Write story for current iteration
		Iteration Panning	Prioritize Stories, effort and resource estimates
		Iteration to release	Analysis, design, coding, testing
		Production	Rigors testing,
		Maintenance	Customer supports, release for customer use
		Death Phase	No more requirements
2	Scrum	Pre-game	Preparation of product backlog list ,effort assessment, high level architectural design
		Development	Sprints, analysis, design, delivery,
		Post game	System testing, integration testing, documentation releases
3	FDD	Develop over all model	Scope, features, model, use cases are decided in various iterations
		Build the feature list	Feature list is prepared
		Plan by feature	Not clearly specified
		Design by feature	Not clearly specified
		Build by feature	
4	DSDM	Feasibility Study	Feasibility of the system is assessed
		Business Study	Essential business and technology characters are analyzed
		Functional model iteration	Analysis, functionality prioritization, nonfunctional requirements and risk assessment.
		Design and build iteration	Build and testing of system
		Implementation	Actual production of the system
5	ASD	Speculate	Project initiation, adaptive cycle planning
		Collaborate	Concurrent component eng.
		Learn	Review, F/A, Release

- So if ATDD leans towards the developer-focused side of things like [U]TDD does, the BDD is where the step of making it more customer-focused comes in. BDD is usually done in very English-like language, and often with further tools to make it easy for non-techies to understand. This allows much easier collaboration with non-techie stakeholders, than TDD.
- By contrast, TDD tools and techniques are usually much more techie in nature, requiring that you become familiar with the detailed object model (or in fact create the object model in the process, if doing true test-first canonical TDD). The typical non-programming executive stakeholder would be utterly lost trying to follow along with TDD, let alone participate, and frankly shouldn't be involved with that level of detail.
- BDD focuses on the behavioral aspect of the system rather than the implementation aspect of the system that TDD focuses on. BDD gives a clearer understanding as to what the system should do from the perspective of the developer and the customer. TDD only gives the developer an understanding of what the system should do.

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IV. CONCLUSION

TDD and BDD practice follows the same basic idea as Acceptance Test-Driven Development, where acceptance tests are elaborated for each user story and automated as the software is built.

BDD is **more than TDD** because it focuses on collaborating with business people. Dan North, who originated the BDD moniker, noticed that business people switched off in conversations about "tests" as these seem to be too technical. He hoped that framing conversations about "behaviours" would be a way to engage the whole team.

BDD is about figuring out what to build that helps flesh out behaviour. BDD isn't an Agile framework or project management approach. Teams using Scrum or Kanban with BDD will need to figure out what to put in their backlogs and boards for planning purposes. You might want to measure the number of BDD scenarios delivered instead of velocity but often these scenarios are too fine-grain for release planning purposes.

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Half-Bridge Converter Based VAr Compensation of Single-Phase R-L Load

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Abstract* -The paper explain the operation of a half-bridge converter working as a STATCOM that is used to compensate the reactive volt-ampere (VAr) required by a single-phase R-L load. Single-phase p-q theory based control technique suggest and implemented to compensate the lagging VAr required by the load by STATCOM operation of the converter. The number of solid-state power switches (IGBTs) needs to construct a STATCOM is reduced one- half of the H-bridge converter and cost also. In order to validate the proposed technique a single-phase power system along with STATCOM and its controller is rigged in MATLAB / SIMULINK forum using built in libraries of power system toolbox of the software. Simulated results show the voltage and current is time in phase (unity power factor) at source side. Performance of this system studied with a step change in the load.

Key words – Half-bridge converter, STATCOM, VAr compensation, single-phase p-q theory, simulation

I.INTRODUCTION

At present, the use of solid-state switching devices are increases in various applications such as adjustable speed drives, energy efficient lighting and switched mode power supply (SMPS) that behave as nonlinear loads and challenge the quality of power supply. Power factor improvement is one of the issues in power quality assurances. Obviously, addition of capacitor across the load will improve the power factor. Thyristor switched capacitor (TSC) and fixed capacitor thyristor controlled reactor (FC-TCR) are most popular scheme for power factor improvement of the system [1]. Each scheme has its own advantages and disadvantages. Development of advanced power electronics devices are take care on the input power factor by the advanced controllers.

Series and parallel connected static VAr compensators comprised with self-commutating switches are used to eliminate the power quality issues caused by the non-linear loads either dynamic or in static nature. STATCOM is one of the advanced VAr compensator used to regulate the terminal voltage, to compensate the VAr required by the loads and working as an active filter. The control technique used for STATCOM operation based on instantaneous reactive power theory well established in a three-phase system [2]-[4]. Disadvantage of system comprises with STATCOM is more expensive. The research is going on how to optimize the overall cost of the system.

The aim of this work, develop a STATCOM with reduced number of switches that are used to compensate the lagging VAr required by the load continuously. A half-bridge converter is shown in Fig.1 is considered for STATCOM operation. [5]

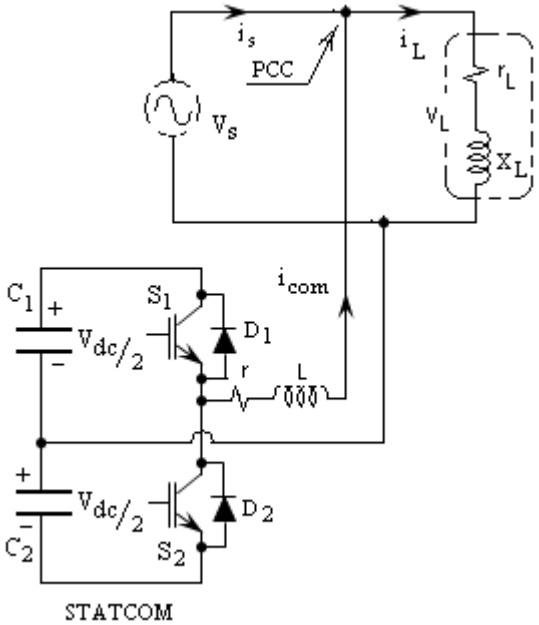

Fig. 1 proposed half-bridge converter based statcom with single-phase power system

Shen -Yuanou et al [6] explained a single-phase half-bridge converter design and analysis of for power factor correction of employed in AC/DC converter both continuous and discontinuous current. W. Y. Choi et al [7] presented a half-bridge converter topology for high power factor operation with single stage. Power quality improvement in electric drive using a half-bridge converter and personal computer power supply is discussed in detail [8] and [9] respectively. bi direction power flow of the half-bridge converter explained in detail [10].

The main objective of this work, selection of convertor topology and a brief review about half-bridge converter design is explained in subheading-I, subsequent paragraph i.e sub-heading-II, discuss about the configuration of the proposed system and its operation and its limit. Analytical based controller derived for VAr compensation of R-Load and it changes. Implementation of proposed control algorithm along with R-L load powered from a single-phase supply is

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described in section -IV. Simulated results are presented in section – V, Conclusion given in section -VI.

II. System Configuration

Figure 1 shows the proposed system comprises with single-phase power system with R-L load. Two solid-state IGBTs with d.c capacitor working as a STATCOM connected in parallel with load at point of common coupling (PCC) through the inductance L , where r is the internal resistance of the coil.

As STATCOM has inherent characteristics for real power exchange with a support of proper energy storage system, operation of such controller is possible in all quadrants of Q - P plane [11]. The power flow relation in a single-phase system is:

$$S_A = \frac{V_{pcc}V_{inv}}{X_L}\sin\alpha - j\left(\frac{V_{pcc}V_{inv}}{X_L}\cos\alpha - \frac{{V_{pcc}}^2}{X_L}\right) = P - jQ \quad (1)$$

Where S_A is the apparent power flow, P is the active power flow, Q is the reactive power flow, V_{pcc} is the system phase voltage(rms) at PCC, V_{inv} is the STATCOM fundamental output voltage (rms), X (=2πfL) is the leakage reactance, f is the system frequency and α (alpha) the phase angle between V_{pcc} and V_{inv}. Variation in α control the active power where as magnitude of voltage for reactive power. For lagging α, power (P) flows from V_{inv} to V_{pcc}, for leading α, power (P) flows from V_{pcc} to V_{inv} and for α = 0, then P is zero and Q is derived from (1) as:

$$Q = \frac{V_{pcc}}{X_L}\left(V_{inv} - V_{pcc}\right) \quad (2)$$

The magnitude of the ac output voltage (V_{inv}) of STATCOM is controlled by dc capacitor voltage (V_{dc}) and it is controlled by varying the phase difference between Vc and Vs and also modulation index of the PWM control.

III. Control Alogorithm

Figure 2 shows the block diagram of the proposed single-phase synchronous d-q frame theory based control lock for a single-phase STATCOM.

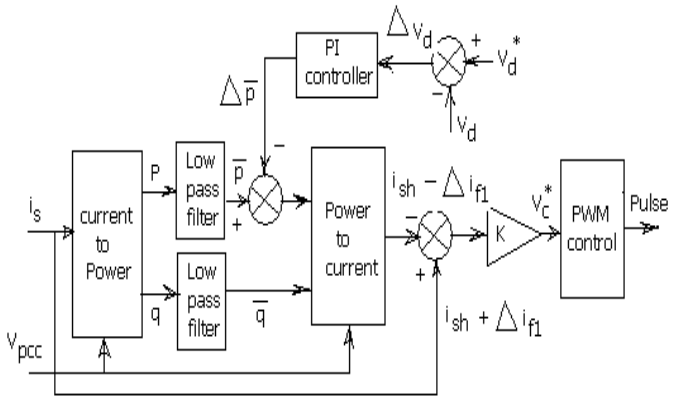

Fig. 2 over all control block diagram

The generalised instantaneous p-q theory [12] is well established. However instantaneous theory on single-phase circuit presented in details [13]. Based on this theory, different controllers are developed in different applications [14] – [15]. The subsequent headings explain the individual block in detailed.

A. D. C. Voltage Control

To maintain the dc bus capacitor voltage of the STATCOM at a reference value, it is sensed and compared with reference value and then obtained voltage error of the STATCOM V_{dc} at k^{th} sampling instant is given by

$$V_{dc}(k) = V_{dc\_ref}(k) - V_{dc}(k) \quad (3)$$

Where, $V_{dc\_ref}(k)$ and $V_{dc}(k)$ are the reference and measured dc voltage of the STATCOM. In this present investigation, the dc voltage reference is set to 204V.

The output of the PI controller for maintaining a constant dc bus voltage of the STATCOM at k^{th} sampling instant is given by

$$\left.\begin{aligned} I_{loss}(k) = I_{loss}(k-1) + K_{pd}\{V_{dc}(k) + V_{dc}(k-1)\} \\ +K_{id}\,V_{dc}(k) \end{aligned}\right\} \quad (4)$$

Where I_{loss} is the active power component of the current, which is supplied to meet the losses in the STATCOM by the source. K_{pd} and K_{id} are the proportional and integral gain constant of the dc bus voltage PI controller respectively. The source should supply the power loss component of the currentI_{loss}.

B. Estimation of Lagging / Harmonic Current

Considered a single-phase system having voltage and the current drawn by the system as:

$$v = \sqrt{2}V\sin\omega t \quad (5)$$

$$i = \sum_{n=1,3,5....}^{\infty}\sqrt{2}I_n\sin(n\omega t - \emptyset_n) \quad (6)$$

In α-β coordinates, consider v and i as voltage and current of a phase 'a'

$$\left.\begin{aligned} \begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \begin{bmatrix} v(\omega_t) \\ v(\omega_t - 90^o) \end{bmatrix} = \begin{bmatrix} \sqrt{2}V\sin\omega t \\ -\sqrt{2}V\cos\omega t \end{bmatrix} \\ \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} i(\omega_t) \\ i(\omega_t - 90^o) \end{bmatrix} = \begin{bmatrix} \sum_{n=1,3,5,...}^{\infty}\sqrt{2}I_n\sin(n\omega t - \emptyset_n) \\ \sum_{n=1,3,5,...}^{\infty}\sqrt{2}I_n\sin(n\omega t - 90^o) - \emptyset_n \end{bmatrix} \end{aligned}\right\} \quad (7)$$

The instantaneous active and reactive power can then be obtained as [1]:

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix}\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} \vec{p} \\ \vec{q} \end{bmatrix} + \begin{bmatrix} \overrightarrow{p} \\ \overrightarrow{q} \end{bmatrix} \quad (8)$$

Where, $\underset{p}{\rightarrow}$ and $\underset{q}{\rightarrow}$ are the dc components in p and q , corresponds to the production of fundamental voltage and current is given by

$$\begin{bmatrix} \vec{p} \\ \vec{q} \end{bmatrix} = \begin{bmatrix} 2V_1 \cos \emptyset_1 \\ 2V_1 \sin \emptyset_1 \end{bmatrix} \quad (9)$$

$\underset{p}{\Rightarrow}$ and $\underset{q}{\Rightarrow}$ are oscillating components in $p$and q, given by

$$\begin{bmatrix} \vec{p} \\ \vec{q} \end{bmatrix} = \left.\begin{bmatrix} \sum_{n=4k+1} \sqrt{2} I_n \cos[(n \pm 1)\omega t - \emptyset_n] \\ \sum_{n=4k+1} \sqrt{2} I_n \sin[(n \pm 1)\omega t - \emptyset_n] \end{bmatrix}\right\} \quad (10)$$
$$where, n = 1,2,3 \ldots$$

Taking reverse transform of the equation (8) on $\underset{p}{\rightarrow}$ and $\underset{q}{\rightarrow}$ gives the fundamental component of the currents i_α and i_β is given by

$$\left.\begin{bmatrix} i_{\alpha 1} \\ i_{\beta 1} \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix}^{-1} \begin{bmatrix} \vec{p} \\ \vec{q} \end{bmatrix} = \frac{1}{v_m^2} \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} \vec{p} \\ \vec{q} \end{bmatrix} \right\}$$
$$= \begin{bmatrix} \sqrt{2} I_1 \sin(n\omega t - \emptyset_1) \\ \sqrt{2} I_1 \sin(n\omega t - \emptyset_1 - 90^o) \end{bmatrix} \quad (11)$$
$$where\ v_m = \sqrt{v_\alpha^2 + v_\beta^2}$$

Here, $i_{\alpha 1}$ is the exactly the fundamental component of in real system current $'i'$.Therefore, the harmonic current obtained as:

$$i_h = i - i_{a1} \quad (12)$$

C. PWM Pulse Generation

The single-phase reference source current is comparing with the measured current and the error is feeding to a current controlled PWM pulse generator for switching the IGBT switches.

IV. MATLAB/SIMULINK BASED SIMULATION

By using the equations (5)–(12), the control blocks are developed in MATLAB / SIMULINK built in library power system toolbox is shown in Fig. 3, to control the reactive volt-ampere required by the load.

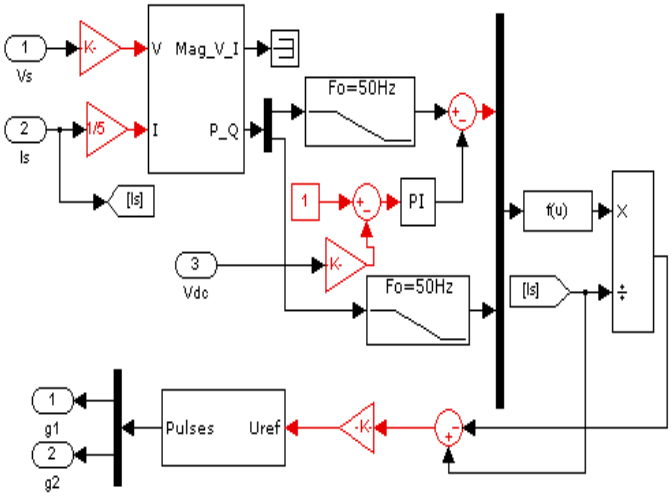

Fig. 3 proposed controller of MATALB / SIMULINK diagram

In conjunction with the developed control circuit and half-bridge converter are connected at PCC of a single-phase power system is shown in Fig.4. A 230V single-phase source (with source inductance) supplying power to a complex load i.e S = 800+j600 is shown in Fig.4 configured in MATLAB / SIMULINK software. Simulation completed for 0.5 seconds and ode23t is considered to solve the equation govern by the system as shown in Fig.4,

In order to investigate the performance of the controller at a step changes in load an additional load power of S = 800+j600 is connected into the system at 0.2 seconds of simulation time using the switch is shown in Fig.4. Two number of 500μf capacitors are used to maintain the d.c bus voltage of 204 V. A proportional integral controller employed to stabilize the dc voltage level. Therefore, the output voltage of the half-bridge voltage source converter (HBVSC) is controlled which in turn control the current drawn by the converter as a leading or lagging current. An inductor of 30mH is connected in series with the half-bridge voltage source converter. A transformer replaces the inductor in a large-scale system.

The required lagging current of the load obtained from the measured voltage at PCC and load current. A single-phase P-Q theory based controller will give the control voltage (Vc). It is compared with ramp signal of 2000Hz will generates the gating pulses for the IGBTs. Driver circuit and isolation is necessary in practical system.

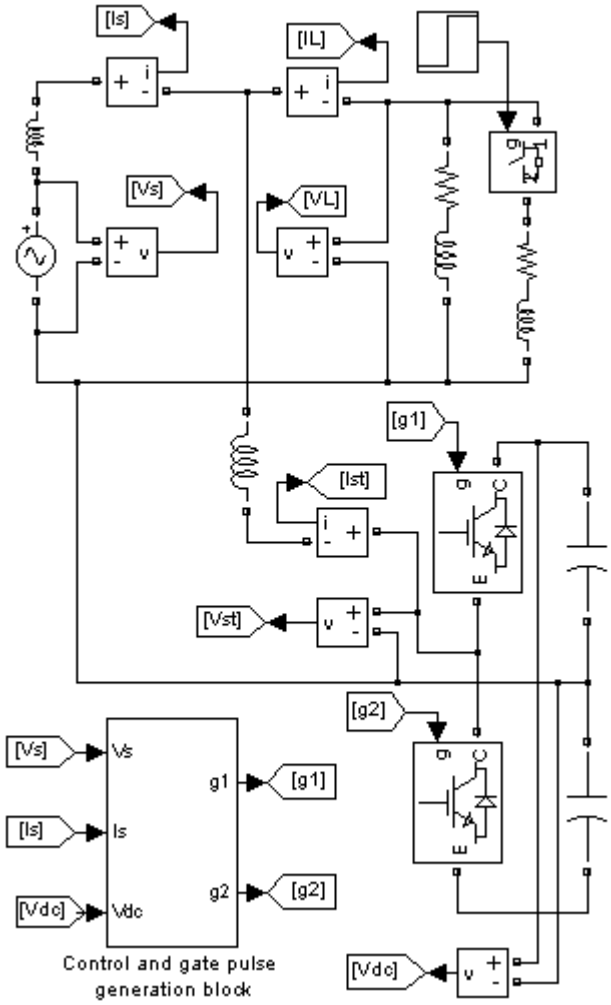

Fig. 4 proposed controller of MATALB / SIMULINK diagram

V. Simulated Results

The simulated results of the study system are stored in the scope is shown in Fig.5. Those voltage magnitudes are reduces with gain of 1/30 for comparing with current waveform. Without STATCOM the voltage and current waveforms of source and load is shown in Figs 5(a) & Fig. 5(b) respectively. It shows both active and reactive power is supplied by the source alone. By employing STATCOM, the necessary reactive current drawn by the load is supplied by the STATCOM by controlling the dc voltage level. Therefore the source current is time in phase with voltage is shown in Fig.5(c),where as load voltage and load current is shown in Fig.5(e).

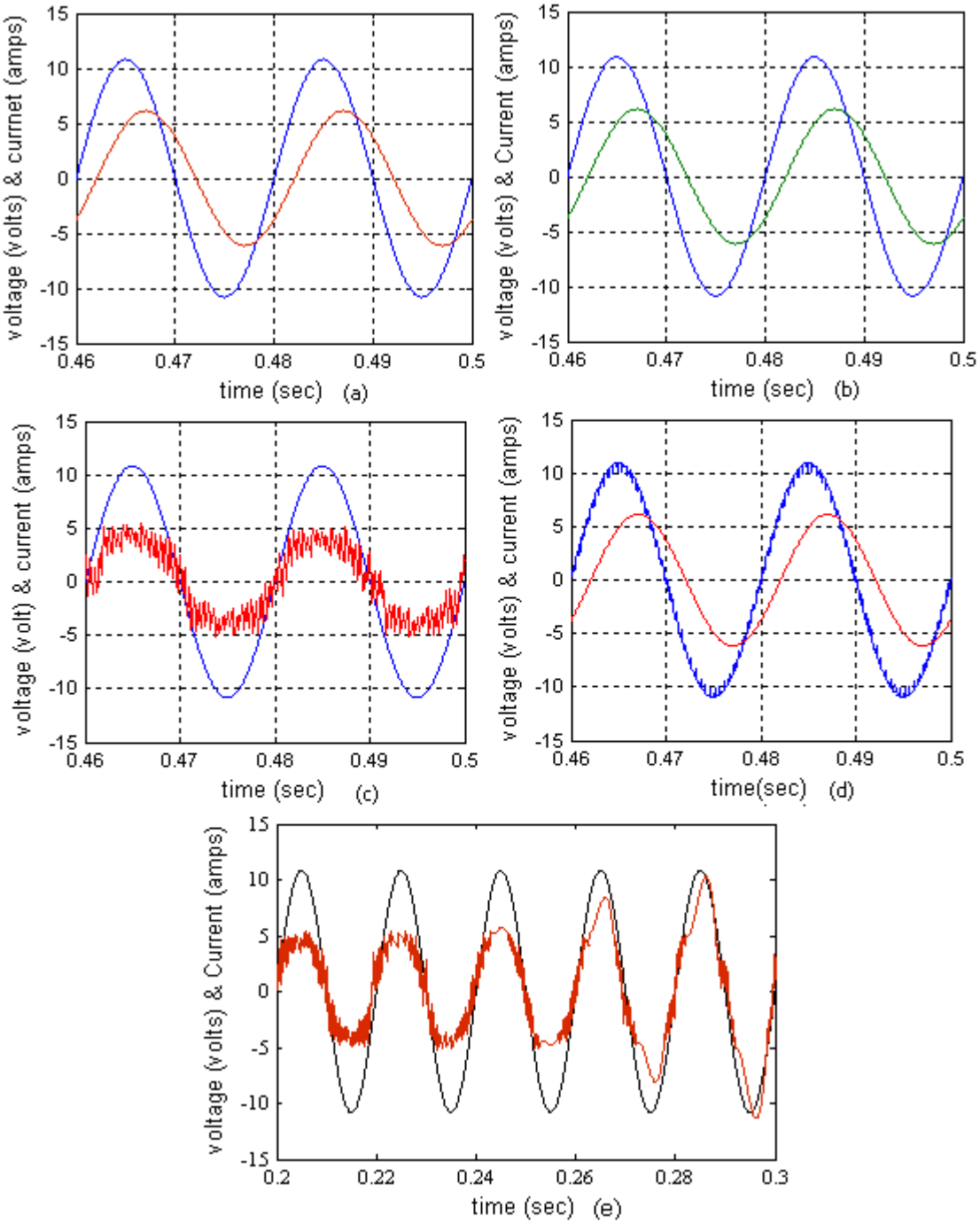

Fig. 5 Simulated results (a) Extracted source voltage and current waveforms without STATCOM (b) Extracted load voltage and current waveforms without STATCOM (c) Extracted source voltage and current waveforms with STATCOM (d) Extracted load voltage and current waveforms with STATCOM (e) Extracted source voltage and current waveforms with STATCOM and additional load

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It is a lagging power factor and needs reactive current, which is compensated by the STATCOM current as shown in Fig. (6). its magnitude changed as when as load current change.

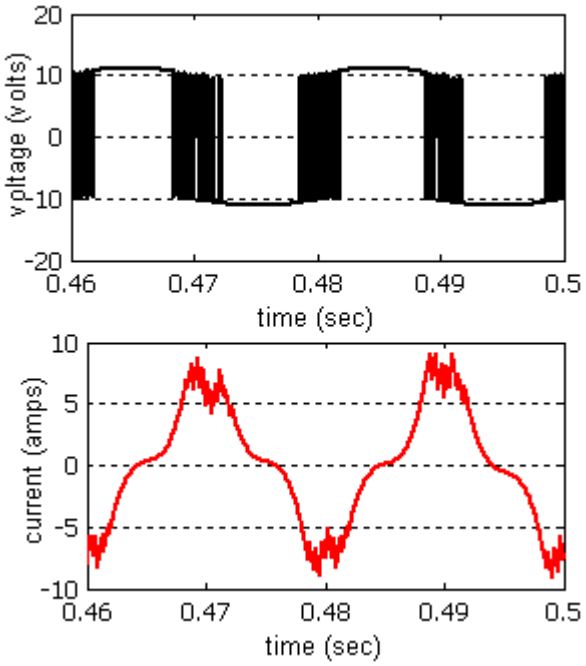

Fig. 6 simulated converter output voltage and current

Figure 6 illustrates the simulated voltage capture at PCC and current flowing through the inductor (L) waveforms. it show current is in peak magnitude while voltage goes to zero at 0.47 and 0,49 seconds concludes that capacitive in nature. The source current has harmonic components is shown in Fig.7.

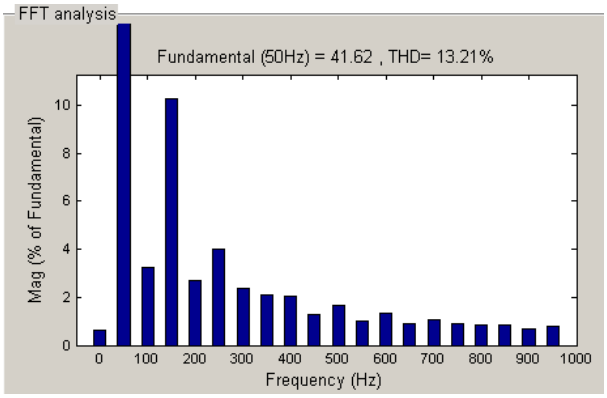

Fig. 7 simulated converter output voltage and current

Attempt made in investigate the source current harmonics, Fig.7. It shows third harmonic is predominant over others. It is well known that 3rd harmonics are could be eliminated by three-phase delta connected system and higher harmonics are easily filtered by the passive filter networks.

VI. CONCLUSION

Half-bridge VSC controller derived using single-phase P-Q theory and implemented. The observation of the simulation work is

- it generates harmonics
- it can be extended to large scale system
- simple in control
- it can be working as VAr compensator
- it reduces the power switch
- it has low switch loss
- overall system efficiency improved

Properly designed passive filter could able to eliminate the higher order harmonics generated by the half-bridge STATCOM. Capability of the STATCOM working as a voltage regulator and active filter is for further investigation.

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Pervasive Universal Gateway for Medical Devices

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ABSTRACT

Health organizations such as hospitals and clinics are increasingly resorting to the technologies to ensure patient safety, increase productivity and improve efficiency in the delivery of health care. The collection of patient data in real-time is important to provide appropriate services and support the decisions of health professionals.

This work present a pervasive universal data acquisition architecture for medical devices which will provide patient data in real-time to INTCare system. This system is operating in the Intensive Care unit of Centre Hospitalar of Porto. This architecture is based in a set of gateways able to collect a set of patient parameters (vital signs, ventilation, laboratory results and other) in a pervasive way. As example to present this concept it was used the ventilation system. The gateway is able to collect a set of parameters from different ventilation monitors. The data are collected from ventilation monitors in real-time and are sent to a server multithreading whose main role is to receive data streams and insert in the database. The main contribution of this work is the pervasive universal architecture which independent of the monitors models and the type of patient data, the system is able to collect, interpret and store the data in a database in a universal and a pre-defined format.

Keywords

Gateway, Vital Signs, Ventilation, Medical Devices, Pervasive, Real-time

1. INTRODUCTION

A report from the Institute of Medicine [1] presents a set of new concerns arising from the increase of information technologies in health care and the needs of it support the patients. The report highlights some benefits including significant improvement in the quality of health care and in reducing medical errors. The document provides some evidence of unplanned consequences of Health Information Technology (HIT) on patient safety. The inappropriate use of HIT can lead to a significant increase of complexity in health care. In other words, can lead to unexpected adverse consequences, for example dosing errors, failure to identify in the life-threatening illnesses and treatment delays due human/computer interactions [1].

The HIT are able to reduce costs in the delivery of health services, reducing the spent time by clinicians in notes the information on paper, allowing them to focus on health care assistance to patient. This goal can be achieved by implementing systems able to automate some clinical workflow. The implementation of this system also can reduce costs. Besides these costs HIT can be reduced organizational and human costs, such as medications requests, number of nurses need and others [1]. In summary, integration of information systems in the healthcare environment has provided the opportunity for improvements in work, being the tasks performed faster, more consistently and with less cost [2].

This work aims to create a pervasive system capable of collecting in real-time the data monitored by a set of medical devices / sensors connected to the patient (ventilation, vital signs, therapeutics). With this modification the physicians and nurses have electronic access to the patient data anywhere and anytime. The clinical historical of patient can be obtained by consulting the stored values in the database. To explore the idea and prove the concept of the approach proposed, this paper will use as example, the ventilation system. The system was developed and tested in a real environment using real data collected from the patients admitted in the Intensive Care Unit of Centre Hospitalar of Porto.

The proposed system arises due to the fact that of the ventilators are operating without making any record of the monitored values. In other words it was impossible for health professionals accessing / consulting patient's records shown in ventilation monitor. In order to overcome this problem it was developed a pervasive universal gateway which was added to the INTCare data acquisition sub-system. It is able to collect all the patient data electronically and in real-time, making them available to consult by the Electronic Nursing Record.

This paper is organized as follows. In the second chapter it will be presented an introduction to the Intelligent Decision Support System (IDSS) exploring the data acquisition systems for ventilators and discussed the interoperability among health systems. In the third chapter is discussed the architecture to support INTCare system and presented the main changes obtained with this work. The data acquisition / gateway requirements and their features are presented in the fourth chapter. In the last chapter are depicted some conclusions and further work.

2. BACKGROUND

Health information is still largely stored individually and in paper format. In general this information is not entirely shared / consulted by who should have access: physicians and nurses. The sharing of patient electronic health records is increasingly necessary for professionals, in order to support the decision making process and provide the best healthcare in the right time, in a comprehensive and coordinated way. In order to support the interoperability of the health information systems it is needed to follow a recognized pattern. This pattern supports the communication of complex information among different health information systems and allows the flow of health information among the systems, being the information semantically computable [3].

The pervasive computing and communications are changing the way how medical staff and nurses are interacting with their patients. With the implementation of hardware/software to perform a continuous monitoring of patients and the use of ubiquitous devices it is possible to ensure timely interventions by health professionals, having the right information in the right time and in the right place [4].

Remote health monitoring has several advantages and allows for reducing medical costs, increases the quality of healthcare and provides real-time data (e.g. ventilation, vital signals and clinical results). These types of architectures are used in technological development of wired and wireless networks for collecting and monitoring of patient data [4].

2.1 INTCare SYSTEM

INTCare is an Intelligent Decision Support System (IDSS) designed to support physicians and nurses in their decision making process. This system aims to avoid the gap that sometimes exists between the data used in the ICU (offline and paper) and the data there is available to the clinicians support their decisions. Through the use of streaming data, intelligent agents and the data transformation processes in real-time, INTCare is able to support the decision making process by providing new knowledge in real-time (e.g. outcome – die probability; organ failure - organ failure probability in the next hours; readmission - readmission probability; discharge - discharge probability in the next hour) [5].

INTCare is composed by a several semi-autonomous agents. These agents automate the collection, processing and transformation of data and induce the data mining models in real-time. Their tasks do not require human intervention.

The characteristics of INTCare system were defined taking into account the environment, the information needs and Data Mining requirements. These characteristics are fundamental for the development of a universal system [6].

2.2 Interoperability

The interoperability of health services constitutes a challenge on several levels. The objective involves converging emerging language development, different types of communication, different incentives and professional identities. The biggest challenge is to ensure the interoperability of consistent communication of information. The Interoperable systems are of utmost importance as they are able to improve the quality of clinical information by collecting patient data provided by heterogeneous systems [7]. For the communication between heterogeneous systems be properly performed it is necessary to follow a set of rules, syntaxes and patterns.

The Health Level 7 (HL7) is a language composed by a set of patterns where the interoperability perspective is evident. HL7 communication standard was developed specifically for the healthcare environment allowing communication between institutions and almost of all healthcare areas. With HL7 all important communication tasks of a hospital can be effectively treated, improving the communication processes that handle with information [8].

Given this context some platforms that follow the principle of interoperability in health care have been developed. The Agency for Integration, Archive and Diffusion of Medical Information (AIDA) is a technology-based multi-agent platform interoperable among several HIS. AIDA was developed by a group of artificial intelligence researchers at University of Minho and is now the main tool for guarantying the interoperability in various Portuguese health organizations [9]. This is the case of the Centro Hospitalar do Porto (CHP) [9].

2.3 PERVASIVE HEALTHCARE

Pervasive in Healthcare (PH) can be defined as a "system for providing healthcare to anyone, anytime and anywhere by removing restraints of time and place, while enhancing the quality of health care" [10]. This approach is based on the information that are stored and available online [11]. However, although the PH has the potential to reduce costs, improve quality of health services and facilitates patient care, faces some technical and administrative obstacles, such as resistance to significant changes in the area of technology and information systems [12].

The main difficulty in implementing PH is in the fact of the information is not always available when it is needed. Often, this happens because there is a lot of information on paper. This limitation prevents physicians to make better decisions. As a solution, the necessary information should be available electronically and can be complemented by predictive models that can help clinicians make better decisions in real time [13].

3. ARCHITECTURE

INTCare is divided into four subsystems: Data Acquisition, Knowledge Management, Inference and Interface [5]. The data used for the models of DM are collected in the ICU and match the clinical conditions of the patients (data monitored, nursing records, and laboratory results), variables derived as Sequential Organ Failure Assessment (SOFA), critical events, relationships and modified Scores with prior notice. The data is collected from heterogeneous and distributed sources to ensure the viability of the system in real time is based on intelligent agents. This work is focused on the data acquisition subsystem, where the ventilators data acquisition functionality was introduced. This architecture has been presented in previous publications, but without the introduction of this new feature. Formally, INTCare is defined as a tuple:

$$\Xi \equiv < C_{INTCare}, \Delta_{INTCare}, a_{gat}, a_{vsa}, a_{eni}, a_{lr}, a_{pp}, a_{cde}, a_{dm}, a_{pf}, a_{mi}, a_{dr}, a_{pd}, a_{sc}, a_{int}, a_{ic}, \boldsymbol{a_{va}} >$$

- $C_{INTCare}$ is the context and corresponds to alogical theory represented as a triple *Lg*, *Ax*, *D*, where *Lg* stands for an extension to the language of programming logic, *Ax* is a set of axioms over *Lg*, and *D* is a set of inference rules;
- $\Delta_{INTCare}$ is the set of bridge rules defining the interaction

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among the systems' components (the agents);

- a_{gat} to a_{va} are the system's agents.

This architecture has been extended with the agent a_{va}. This agent is prepared to execute autonomous operations between the server and the database in the ventilation context. The data collected from the ventilator monitor can be now used in the other three subsystems. This work as previously stated focuses on the development of data acquisition subsystem in order to achieve the proposed objectives. The agents go beyond saving, collecting and integrating of relevant information they encompass the discovery of previously unknown, implicit and valuable knowledge [14]. This subsystem is able to collect and store data from monitoring vital signs, laboratory results and drug-related data. However, the advances verified in other related research work required the need to follow and extend the principle of collecting real-time patient data. For this reason arose this work. In the upper left corner of Figure 1 are presented the changes made to the former architecture INTCare.

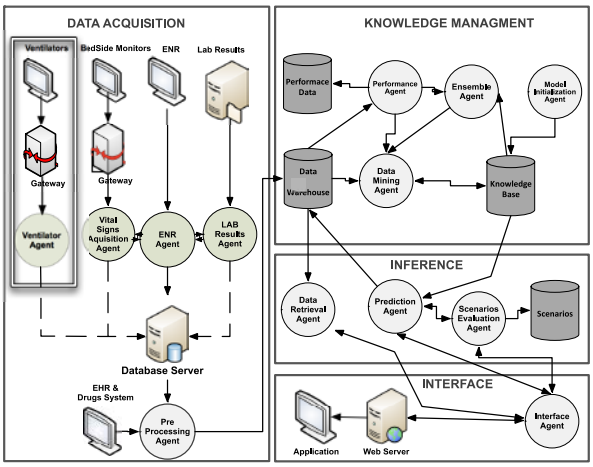

Figure 1 – INTCare System (extended)

The ventilation gateway is composed by several Clients (one by each ventilation monitor) and a multithreading Server. Each client receives a message from the ventilator and then streams the data over a Local Area Network to the Server. The ventilation agent is prepared to make a pre-validation of data and convert them into a universal pattern. This system is intended to use collected data in various hospital departments, such as Intensive Care Units of Adults, Neonatology and Paediatrics.

Figure 2 shows the architecture of data acquisition [5]. Data collected by the agents is stored into local databases and then processed and sent to the database server. Concluded this process, the data is made available to be used by INTCare. The data is provided from six different data sources / systems:

a) Laboratory (LR);
b) Pharmacy System (PHS);
c) Electronic Nursing Records (ENR);
d) Electronic Health Records (EHR);
e) Vital Signs Monitor (VS);
f) Ventilation Monitor (MVE).

The data acquisition system (f) corresponds to the changes made in the context of this work. This corresponds to the acquisition of data from the ventilation monitors. Once the messaging of ventilators used in the ICU are different (only the Servo-I returns in HL7 message, a new pattern universal for all ventilation monitors has been developed. In this context it was defined a pattern for ventilation messages, designated by Ventilation Language (VL). The Clients create the VL message after receiving the ventilator message. The VL message uses the dictionary type (variable type used by Python) and has the following format:

$$MSG = \{IP, Bed, State\_Vent, State\_Com, List\_Values, List\_Fields\}$$

Where,

IP: Corresponds to the address of the machine that has the Client;

Bed: The number of patient bed associated to the ventilation monitor;

State_Vent: This variable is binary: "0" - the ventilator is turned off and "1" - when the ventilator is switched on;

State_Com: This variable is binary and identifies whether the client is receiving the message with the values monitored by the ventilator: "0" - the ventilator does not send the data and "1" - the ventilator answered to the client request;

List_Values: Corresponds to a list of values already treated by the Client, which only has the values required to be recorded into the database. These values are associated to the list_fields defined.

List_Fields: Are the variables that were defined as required and which the client should be monitoring. This list is registered / defined in the database and before the gateway starts.

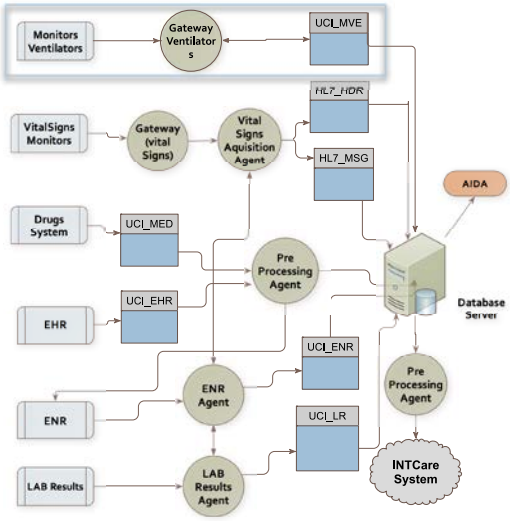

Figure 2 - ICU Data Acquisition Architecture

4. Mechanical Ventilation data acquisition system

4.1 Ventilators setting

ICU contains a set of ventilators. In this case two different types are in use: Puritan Bennett Model 840 and the Siemens Servo-I. The communication with ventilators is done through the serial communication port RS-232. A first set of experiments were

carried out in order to find the best configuration and which parameters are required to make correct communication between the client and the ventilation monitoring system. The parameters available to be configured in the ventilation system are:

- Baud Rate: Matches the transmission rate of bits per second, this parameter can take the following rates in 1200, 2400, 4800, 9600, 19200 and 38400 bit/s for the Puritan Bennett 840 ventilator, the Servo-I only has the rate of 9600 bit/s.
- Parity: It's the method of detecting errors in transmission, its value vary between NONE, EVEN and ODD for the Puritan Bennett 840 ventilator, the Servo-I only varies between EVEN and ODD.
- Byte Size: This is the number of data bits this parameter can take two values for the two fans, seven, or eight bits.

4.2 System Requirements

In this section functional and technical requirements for developing the gateway are presented.

Functional requirements:

1. Client communication with ventilator must be done through the RS-232 port;
2. The server must be able to receive messages from different clients (data acquired through client communication with the monitors ventilation);
3. Store the data into a database;
4. Create standard messages for communication between systems;
5. Efficiently treatment of exceptions;
6. Log and alert system (mail sending when an error occurred).

- Technical requirements:
  1. Low disk space;
  2. Restricted memory usage.

4.3 Ventilation Standards

Messaging is the standard process for collecting and insertion of data interoperable.

The variables in use (list_fields) by the Puritan Bennett 840 are shown in Table 1. The ventilator code associated and descriptions correspond to the universal codes defined by the VL messages. The ventilator agent is responsible to make and ensure this map for all ventilators models.

Table 1 – Ventilation Codes and Description

Ventilator Code	Description
9	Ventilation Mode
10	Frequency
36	Minute Volume
11	Current Volume – INS
35	Current Volume – EXP
13	FiO2
15	PEEP
12	Flow
40	Pressure Pause
38	Pressure Peak
39	Medium Pressure VA
101	Ratio I:E
63	CSTAT
64	RSTAT
65	CDYN
66	RDYN

4.4 Developing Tools

To develop a system capable of operating with the ventilation system and the database it was necessary to develop a gateway. According to this evidence it was necessary to conduct a survey focusing on programming languages able to create a communication among the gateway, ventilators and the database systems. A survey on candidate programming languages, such Java, C, Ruby, and Python was made. Python was chosen for the following characteristics [15]:

- Software quality: the code in Python is designed to be readable, portable, reusable and easy to change;
- Productivity Developer: Enables increased productivity due to its syntax, is typically about one-third to one-fifth the code developed in Python compared to C + + or Java;
- Program portability: the implementation of the developed software can be run without having to make changes between Windows and Linux typically;
- Support libraries: an extensive collection of pre-built and portable features, known as standard libraries;
- Component integration: Python scripts can easily communicate with other parts of an application, using a variety of integration mechanisms;
- Enjoyment: Python's ease of use and built-in toolset, it can make the act of developer more pleasure than chore.

The choice of Python was not determined solely on the basis of the characteristics presented, but rather, by the facility on interacting with the serial port and easy management of database system (Oracle technology). This feature arises from the existence of two main libraries, Serial, Socket and cx_Oracle library.

Serial library was used for communication between the developed platform and the ventilator. The Socket library functions were used to perform the data streaming between client and the server. The cx_Oracle library was used to perform the communication between the server, that receives the data streamed from multiple clients, and to store the data collected by the client in the database

4.5 Gateway

In order to provide a deeper understanding of the Gateway, a use case diagram, according to the modelling language UML (Unified Modelling Language), is presented in Figure 3.

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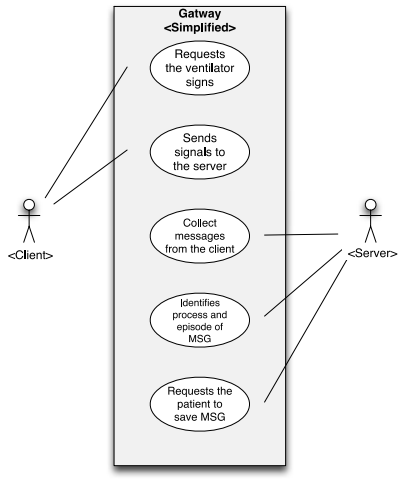

Figure 3 – Use Case Gateway

Figure 3 represents the interactions between the user and the system. However and since there are not human interactions presented in this functional unit, the interlocutors (client and server) presented are an integral part of the system. The client and server are two integral parts, each of which performs a set of tasks necessary to provide all the functionalities of the gateway.

To demonstrate the interactions between objects and scenarios performed by the methods or operations through two operations, a sequence diagrams were depicted.

Figure 4 and Figure 5 represent multiple logical operations performed sequentially with respect to time. In other words, the messages are exchanged according to temporal ordering between then entities. Figure 4 elucidates how the data is acquired through Client and from the ventilator.

The Client (Ventilator (X) - where X is an individual ventilator) performs a set of messages exchanged between two objects: Port RS-232 and Ventilator. Initially the Client has to identify if there is any Serial port as identified on the computer that supports the execution of the Client, if yes, it sends a message (MSG) identified by the ventilator port. Then, the Ventilator sends a message with the respective values of the fields requested by the Client. Finally, the Client receives the message sent by the Ventilator and chooses the set of fields that will be introduced, creates a message according VL syntax and sent it to the Server.

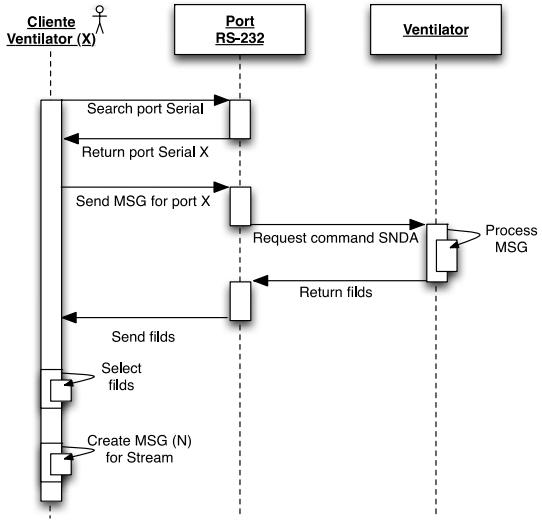

Figure 4 – Diagram Sequence of Client

The sequence diagram shown in Figure 5 represents the operations after performing the streaming of data from the Client to the server. This diagram is a sequence of the diagram presented in figure 4.

The Server receives the message and identifies the Client IP and the Bed associated to the message. Then a request is sent to the database to identify what is the patient (episode) that is being monitored. After the data collected is correctly identified (match between the data and the patient), the Server updates the message (adding the patient episode) and inserts the data collected from the Patient Y in the database.

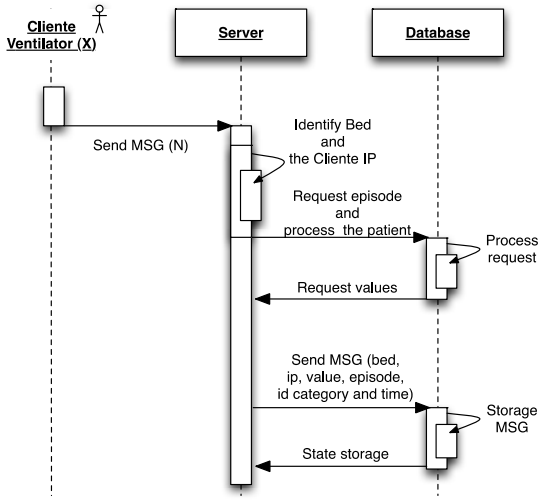

Figure 5 – Diagram Sequence of Server

Sequence diagrams of Figures 4 and 5 represent the operations performed by the Gateway developed. The Client and the Server are responsible to ensure an integral communication between heterogeneous systems parts.

5. Conclusion

This paper introduced a new acquisition system designed for collecting data from the ventilation monitors in real-time that was developed and incorporated into the INTCare system. This gateway allows for a greater capacity and collects universal data

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sets, enabling their use for predicting failure of patient respiratory system.

Several functional and technical requirements were considered and completely accomplished. The gateway needs less storage space on disk (about 1Mb) and memory usage is never greater than 8Mb. All the usage and workflow was presented in terms of UML diagrams.

The experiments carried out proved the reliability and effectiveness of the approach. To prevent failures, a log message is send to the database and an email is sent always some new uncommon error appear (e.g. client are not sending messages or the server is not receiving messages for a time upper than 15 minutes).

In the future this gateway will be improved and deployed in other hospital settings. The proposed approach will be followed in future data sources.

Acknowledgement

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Investigating the Relationship between Social Media Usage and Students' Grades in Saudi Arabia: A Mixed Method Approach

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***Abstract*--The use of social media to exchange information for the purposes of learning and social activity among the university students is common practice in Saudi Arabia. However the excessive use of social media can raise questions about whether academic performance is affected. Our previous study involving a quantitative approach into the area highlighted a lack of relationship between social media use and academic performance regarding Saudi students.**

The research study presented in this paper explores lectures' thoughts in regards to the issue of whether social media usage affects academic performance amongst Saudi students. The findings are compared to the results from the quantitative study to observe the triangulation.

Keywords: Students and Social Media; Academic Performance and Media; Saudi Arabia Twitter.

I. INTRODUCTION

Social media plays a variety of roles in education as highlighted by [1], which include providing a medium to share ideas and opinions as well as allowing students to build their own communities to collaborate with each other. Studies such as Junco et al [3]; Tariq et al [7] and Camilia et al [2] have explored the effects of social media use and academic performance regarding students.

Junco et al [3] research study explored the impact of Twitter usage on USA college student engagement and learning . Results indicated that Twitter can engage students by being used as an educational tool and to facilitate a more active role, in which teaching staff can participate. Tariq et al. [7] study explored the impact of social media, on the education of Pakistani students. Camilia et al [2] looked into the role of social media in Nigerian students' studies via the distribution of a survey. The study found that the use of social media by students had no affect on their studies. In contrast to [2, 3, 7], this paper concentrates on university students in Saudi Arabia.

The aim of this paper is to explore the relationship between the use of social media by Saudi Arabia university students and their academic performance. Our research study involves a mixed method research paradigm. The first part of the research which is detailed in Shahzad [4], involved a quantitative approach of distributing an online questionnaire to Saudi students. This was to ascertain information on their social media usage and academic performance.

One of the main findings was that there was no relationship between social media usage and academic performance of Saudi students. Our hypothesis that *the increase in use of social networks decreases the academic performance of the students* was proved wrong in this case. The aim of this research study is to use a qualitative approach to investigate the findings of the quantitative study from a lectures' point of view. For the qualitative approach, semi structured interviews were carried out with several lectures from the same university used for the quantitative study. The structure of the paper is as follows. Section 2 presents the qualitative aspect of our study which involves semi structured interviews. Section 3 presents a brief overview of the results from the quantitative part of the study. Section 4 discusses the results and Section 5 concludes the paper.

II. QUALITATIVE ANALYSIS

Interviews provide a means of informal interaction for the purpose of information extraction. Many types of interviews, including Structured, Un-structured, Semi Structured, Group, Exit, Stress, Individual, Formal, Informal and Panel interviews [8]. Semi structured interview technique is a hybrid of structured and unstructured interview methods. Like the structured interview, a time to conduct the interview is agreed between the interviewer and the interviewee and like the unstructured interview method, the questions to be asked from interviewee are not informed

in advance and the flow of the questions is governed by the direction of the discussion during the interview.

The theme of the semi-structured interview is such that it focuses on the discussion of the issues instead of already decided / agreed questions. As the flow of information can't be anticipated, the exact number of questions to be asked also can't be determined in anticipation. The intention is to gain an insight and the interviewer can ask any number of questions within the stipulated time.

Interviews were conducted with five teachers in the college. The interviews covered the following directions.

- The age group of the students. (Ex. 20-30 years etc.)
- Observation about the usage of the social media over time for students of this college (e.g. in last 2 years)
- Observations about the impact of social media on the academic grades and whether there was a relationship between them.
- Suitable number of hours per week for students to use social media.

The contents of the interview are analysed by documenting the transcript of the interview. When performed on several individuals, the recurring words are collected as categories and the issues addressed are categorised in the addressed categorised. Zhang [9] has mentioned eight steps in doing the content analysis, that include 'prepare data', 'define unit of analysis', 'develop categories and coding scheme', 'test categories and coding scheme', 'code all the text', 'define coding consistency', 'draw conclusion' and 'report the results'. The coding scheme mentioned by Zhang was used after the transcript of the recorded interviews were carefully prepared by following the direction mentioned by Swarthout [6] . Table 1 describes the results.

The findings of the qualitative study propose that the average age of the students is among 20-27 years. The respondents believe that the connectivity on social networks has increased over time. The respondents however, believe that there is no direct relationship between the social media usage and the academic grades unless the usage does not become excessive. The respondents also believed that an average use of social media exceeding by 13 hours a week (2 hours a day) may however, affect the academic grades of the students.

III. QUANTITATIVE ANALYSIS

The quantitative aspect of the study, which was the questionnaire, was carried out prior to the qualitative aspect. The aim of the questionnaire was to test the hypothesis that an increase in use of social networks decreases the academic performance of the students.

The following research questions for the quantitative analysis were formed in this regard.

R1- What has been the percent change in the students' social network usage over the past two academic years i.e. 2012-2013 and 2013-2014?
R2- How the GPA's of the students have changed over time (the results of previous semesters)?
R3- What is the suitable amount of time to be spent on social media to escape from the downfall in the academic grades?

Survey Monkey was used to administer the questionnaire and it was live from February 2014 to April 2014. The link was distributed to students via email and a central notice board. One hundred and eight students responded. The age group of the respondents was between 19 and 30 years with an average of 22 years. Presented below is a brief overview of the results according to the research questions.

R1 *What has been the percent change in social networks usage in the past two years (2012-2014)?*

The total number of hours that the 108 respondents in 2012 was 2741 hours averaging 25.37 hours per week. In contrast, in 2013 the total number of hours was 2835 hours averaging 26.74 hours per week. The percentage change in the past two years is a 3.4% increase in usage from 2012 academic year to the 2013 academic year.

R2 *How the GPA's of the students have changed over time (the results of previous semesters)?*

The students provided data about their academic performance for the 2010-2013 academic years with. eight semesters in total. Two semesters make up one academic year e.g. semester 1 and 2 would be the 2010 academic year. The average GPA of the students for each semester is presented in Figure 1.

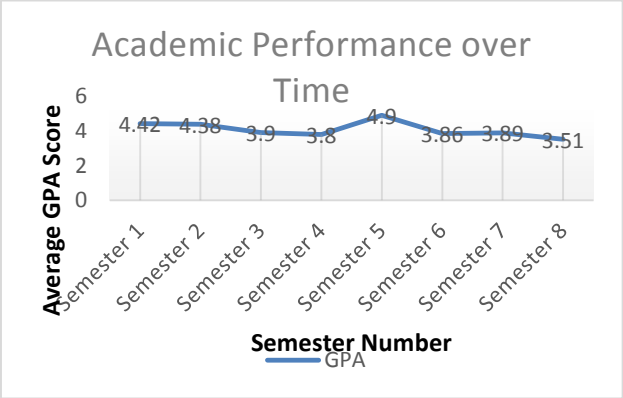

Fig. 1: Students' academic performance over time

The average GPA score fluctuates but peaks in semester 5 which is in the 2012 academic year.

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R3 Does the increase in use of social networks decrease the academic performance of students?

The relationship between average GPA scores over the semesters and hours per week used for social media were investigated. Thirteen cases, were removed due to incomplete data. This left 95 cases for analysis.

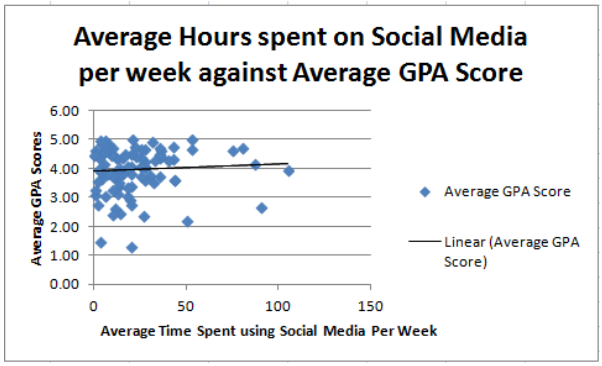

Fig. 2: Social Media Usage against Average GPA Score

Figure 2, highlights a very weak correlation between the two variables, with R^2= 0.049 and therefore no relationship between the two variables. Some of the results are clustered together. The lack of relationship agrees with Camilia [2] findings that the frequent use of social media has not effect on their studies. The scatter plot shows some extreme values. This highlights the excessive use of social media by some participants.

IV. FORMATION OF RESULTS

The findings of the qualitative study are presented in Table 1, while the findings of the quantitative study are presented in Section 3. The findings on the age group are similar in both the qualitative and quantitative results. The quantitative results confirm the initial findings of the qualitative results.

In terms of trend identification in social media usage, the qualitative analysis demonstrated that the social media usage has increased over time among the students while 60% of the respondents in the quantitative findings agreed with this statement. The 40% of the respondents who did not agree to this can't be neglected, therefore the findings of the qualitative and quantitative partially converge.

The results of the qualitative and quantitative are similar on the identification of the impact of social media on academic grades and on the identification of the relationship among the social media usage and the academic grades. The findings for the qualitative results demonstrate that the suitable usage for social media per week may not exceed 13 hours a week. The quantitative results indicated that students thought on average 10 hours a week was suitable usage for social media. The survey participants were also asked in the survey to identify other reasons that affect their studies apart from the excessive social networks usage. More than 25% of the respondents had issues with time management. 11% of students argued that the football matches have affected their studies negatively, while some respondents gave social and environmental issues.

V. CONCLUSION

It can be concluded that the hypothesis "*The increase in use of social networks decreases the academic performance of the students*" is not satisfied by the findings of the quantitative part of our study. The qualitative study highlights the feeling that there is a lack of relationship between social media usage and GPA score. In terms of trends, the qualitative analysis demonstrated that the social media usage has increased over time among the students while 60% of the respondents in the quantitative findings agreed with this statement.

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Table 1: Results of interviews

Respondent No.	**Age Group**	**SM Usage trend (2010-14)**	**SM impact on AG**	**Relationship among SM and AG**	**Suitable hr per week**
1	20-30	Increased	No	There is no direct relationship	12
2	19-28	Consistent	Moderate	The relationship only holds usage is more than 30 hours a week.	18
3	20-26	increased	No	No	9
4	20-27	Increased	Moderate	No direct relationship	12
5	20-24	increased	No	No direct relationship	15
Findings / Trends	20-27	Increased	Negligible	No direct relationship	13

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A Human-Machine Interaction System for the Recognition and Synthesis of Arabic Digits

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Abstract: *In this work we present a Human-Machine Interface in which we investigate both of the automatic recognition process and the automatic synthesis process applied on the Arabic digits in one system that we named ARSSAD (Automatic Recognition and Synthesis System of Arabic Digits). The system is therefore divided into two sub-systems; a recognizer and a synthesizer. The main task of the recognizer is the automatic recognition of the pronounced digit, so it transforms the input sound wave into a text representing the appropriate digit, the second sub-system perform the opposite process of the first sub-system; indeed, it transforms the text (digit) produced by the recognizer to a speech generated by the synthesizer. The methodology used for the system design is based on three essential stages: the creation of the acoustic database (corpus development), the recognition of the read signal and the generation of the synthetic speech. We explain the basics modules that compose it, starting from the signal acquisition and finishing by the decision taken. For the recognition sub-system we make the choice to use the Dynamic Time Warping (DTW) method for the comparison task. ARSSAD contains a front-end and a back-end module, the front-end module converts the input sound into feature vectors that are based on Mel Frequency Cepstral Coefficients (MFCCs), to be used in the DTW method. The back-end module uses the concatenative method to perform the synthesis of the recognized digit, for this end we create a sound database that contained diphones of the Arabic alphabets. The obtained results show that the system presents a success rate of 94.85% on the three corpuses which we recorded in a noised environment.*

Keywords: analysis techniques, speech recognition, speech synthesis, synthesis by diphones, synthesis by phonemes, PRAAT, MFCC, DTW, Standard Arabic.

1. Introduction

The automatic speech processing (ASP) is an area of research for which a significant effort has been undertaken over the past three decades. The challenges are considerable and have fundamental nature. They are also multidisciplinary: signal processing, pattern recognition, artificial intelligence, computer science, phonetics, linguistics, ergonomics and neurosciences; which behave at varying degrees in the solutions found.

These long-standing works nevertheless give birth at the present time to intermediate products which find their place in practical applications in the context of the Man-machine communication, as shown in [1], [2] and [3].

However, Automatic Speech Recognition/Synthesis (ASRS) systems dedicated to the Arabic language are at the moment still very modest. In this article, we will introduce our ASRS system of the first ten digits of the Standards Arabic language (SA) in mono mode speaker. We are interested exclusively to the step of analysis of the speech signal which allows us to extract the acoustic vectors characterizing it. This step is very important and primordial in the process of automatic recognition, since it produces in output a set of parameters considered pertinent and efficient for the high-quality operation of the speech signal, on this same set we will apply the algorithms of recognition and comparison.

In speech recognition, the step of feature extraction, commonly known as the step of analysis, can be achieved in several ways. Indeed, the acoustic vectors are usually extracted using methods such as temporal encoding predictive linear (Linear Predictive Coding LPC) or Cepstral methods as the MFCC encoding (Mel Frequency Cepstral Coding), as well as the encoding PLP (Perceptual Linear Predictive coding) which is an example of the application of knowledge of the auditory system in human speech recognition. The extraction of characteristics is a key element for the development of an ASR system.

The second part of our system represents a Text To Speech (TTS) system, in which the main, commonly known, techniques used in it design are: Articulator synthesis, Formant synthesis, and Concatenative synthesis [4].Articulatory synthesis attempts to model the human speech production system directly.

Formant synthesis, which models the pole frequencies of speech signal or transfer function of vocal tract based on source-filter-model. Concatenative synthesis, which uses different length pre-recorded samples derived from natural speech.

In our case, we have used the concatenation method for the synthesis implementation which represents, in our opinion, the method that produces a synthetic voice the most natural and intelligible compared to the others. This result came from the fact of using a set of recording units pronounced by a real speaker, priory collected and embedded within our sound database.

So, for the recognizer, we have to deal with two essential problems, the first one is the choice of the technique of analysis used, and the second one is the choice of parameters and their number to extract the relevant parameters of the voice signal. The purpose is to determine which gives the best recognition rate. Whereas, for the synthesizer, we have to face two other problems; the choice of the transcription method (rule-based method or lexicon-based method) in one hand, and the co-articulation problem to improve the quality of the generated speech, in the other hand.

2. System design

When designing a system, two broad ways could be taken into account, the first one is to design the whole system using the known theories, and use it as it is designed, in the real conditions. An alternative way would be to subdivide the system into modules that can be independently created and tested, to eventually be used in other systems to perform several functionalities.

To facilitate the implementation and improvement of our system, we have used the modular approach; this concept makes the program understandable on one part and decreases the cost of development of each module in another part. We have also used the concept of the object-oriented programming which is particularly suitable with the modular technique. We must therefore make out different modules which structure the system as shown in the following diagram (Fig.1):

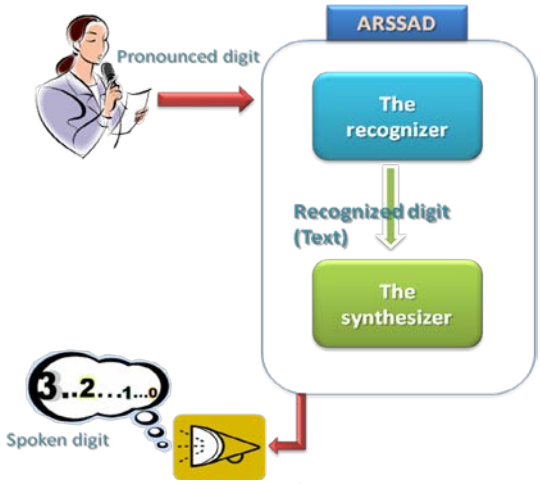

Fig. 1. General architecture of our system ARSSAD

The objective here is to describe the role of each module, explaining in the same time the interest of links which provide the cooperation between them.

3. The recognizer

This module represent the front-end of the whole system, it is also composed of a set of sub-modules that can be shown in the following diagram (Fig.2)

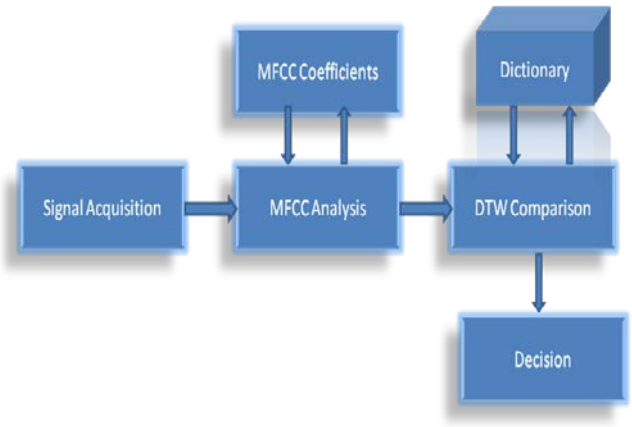

Fig. 2. General schema of the recognizer

We give now the principal functionalities of each sub-module one after another.

3.1. Signal Acquisition

This module carries out the acquisition of the acoustic signal recorded by a microphone and converts it into a digital form that can be used directly by a machine. There are many types of microphones but all of them provide the same function: transform the pressure fluctuations caused by the acoustic wave of speech into an electrical signal.

This signal will be converted from the analogical form to the digital one, i.e. it will be discrete both in time (sampling) and value (quantification) [5]. As a result we obtain a digital signal in the form of a sequence of samples which measure the amplitude of the microphone's signal in regular spaced moments, and the amplitude of each sample is represented in its digital form. The choice of the sampling frequency is usually determined by the application and referred to the platform used [5].

3.1.1. Sampling Frequency

Some thoughts on the frequency of sampling are required in first. According to the theorem of Shannon [6]: « a bandlimited function can be perfectly reconstructed from a countable sequence of samples if the bandlimit, B, is no greater than half the sampling rate (samples per second)".

Sounds that are made by the human voice normally contain relatively insignificant frequency components at or above 10 kHz [6]. Sampling such an audio signal at 20k sam/sec, or more, provides an excellent approximation to ensure that the Shannon criterion is met. But often the sample-rate is pre-determined by other considerations, such as an industry standard format (e.g. 8k sam/sec).

In this situation, the human voice should be filtered, to remove frequency components above 4 kHz, before being sampled. So we consider in our work that the acoustic signal is located mainly in the bandwidth (50 Hz -8 kHz), the frequency of sampling should therefore be at least equal to 16 kHz, according to the theorem of Shannon. For the case of our application, we have used a sampling frequency of the order of 22050Hz, the

default value taken by the software used in this operation PRAAT [7].

3.2. The corpus preparation

Most of the works carried out in the field of Man-Machine communication often require the registration, and the manipulation of corpus of continuous speech, and this to carry out the studies on the contextual effects, on the phonetic indices, and on the variability intra and inter speakers. There were three recorded corpuses each one containing ten sounds of ten prime numbers of Standards Arabic (Wahid (one), Ithnane (two), Thalatha (three), Arbaa (four), Khamsa (five), Sita (six), Sabaa (seven), Thamania (eight), Tisaa (nine), Aachara (ten)) in a noisy environment and we have changed the speed of elocution from a corpus to another without changing the speaker. The step of analysis may therefore begin.

3.3. The Cepstral Analysis (MFCC)

The aim of the analysis of the voice signal is to extracts the acoustic vectors which will be used in the stage of recognition follows. In this step the voice signal is transformed into a sequence of acoustic vectors on the way to decrease redundancy and the amount of data to be processed. Then a spectral analysis by the discrete Fourier transform is performed on a signal frame (typically of size 20 or 30 ms) [6]. In this frame, the voice signal is considered to be sufficiently stable and we extract a vector of parameters considered to be enough for the good operation of the voice signal, in our work we choose to use of MFCCs coefficients resulting from a Cepstral analysis of the read signal.

The method of extraction of the MFCCs coefficients is a famous method used for the acoustic vectors extraction, in the field of automatic speech recognition. We have also decided to use it in our context of application and we chose a set of 12 coefficients. We expose the different steps leading to Cepstral analysis using the tool of speech analysis, PRAAT, we show the different parameters required for the analysis that we have chosen, and in the end the exploitation of the MFCCs coefficients resulting.

Step1: reading the file to analyze and the choice of MFCC method

- Start PRAAT
- Open the sound file:
- Read > Read from file (open a sound file)
- Edit (for the view)
- File > Extract Selection (for "cutting" the sound)
- Write > Write to .wav file (to save a sound file)
- Select the file to analyses
- Choose the Cepstral method:
- Formants&LPC > To MFCC

Step 2: determination of the parameters required for the analysis

- Number of coefficients: 12
- Duration of windows: 30 ms
- Duration between the windows: 10 ms

Step 3: analysis Results

- It remains now to save the results in a text file format with the extension .MFCC (Write > Write to txt file), to be used in the following stage.

3.4. The use of DTW method

Our speech recognition sub-system is based on the algorithm of DTW (Dynamic Time Warping), this method is based on an evaluation of the distance between an observation and a list of references (dictionary). As well the reference for which this distance is minimal allows us to decide what word is it. The evaluation of the distance between two signals is not performed with the signals themselves. This would lead to lot of calculations. It is therefore in a prime time to find a better representation of the signals. Here MFCC analysis shines.

So we have programmed the DTW method using, for the comparison, the MFCC coefficients. The training part concerns the recording of the sounds corpuses in order to design our dictionary which will be used as reference in the comparison of the signals tested. Problems of recognition may appear depending on the conditions in which the signal to test is recorded. If the word is pronounced more or less close to the microphone, recognition rates can vary greatly. However if the user says the word always at the same distance and with the same intensity, the rate of recognition is very acceptable. We judge, though, that the representation using the MFCC coefficients provides better results, and it supports better the limitations related to the problem of the capture of the signal. The common skeleton of the DTW algorithm has three steps illustrated as follow:

- Acquisition of the sound file to test
- Extraction of the MFCC coefficients
- Comparison with the dictionary of references

3.5. The decision

This last module of our recognizer plays two essential roles; it represents the interface in which the user interacts with the system. After the user has entered his voice signal, he starts the search and awaits the results. The system displays the recognized digit written in both Arabic and French language.

The second role is that this same decision (the displayed digit) represents the input (text) of the second module of our system, which is the synthesizer.

4. The synthesizer

It is based essentially on two principal parts; a front-end and a back-end. The front-end is composed of two modules, the first is for the sound database creation and the second is for the conversion text-to-phoneme or grapheme-to-phoneme. The back-end part represents the speech generation module or in other words the synthesizer itself. So the different modules that compose the system are as follow:

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- The sound database creation (segmentation): we have recorded a set of pieces of speech and store it in our database, this set is composed of phonemes and diphones which are the basic units utilized within the back-end module in order to generate voice using the concatenation method.
- The grapheme/phoneme conversion: before achieving this process, a text normalization or preprocessing operation has to be done. After that the module assigns to each word in entry it phonetic transcription, and then divides and marks the text into prosodic units like syllables. This process of assigning phonetic transcription to words is called text-to-phoneme or grapheme-to-phoneme conversion. The output of the front-end module is a symbolic linguistic representation resulting from the phonetic transcription and prosody information together, which represents the input of the back-end module.
- The synthesizer: the back-end module uses information provided by the front-end to converts the symbolic linguistic representation to speech using a specific method. In literature, there are two kind of synthesis method; rule-based method and concatenative corpus-based method.

Like we have mentioned before, we have used the concatenative method of phonemes and graphemes previously stored in our sound database. The general architecture of this module could be shown in Fig.3 as follow:

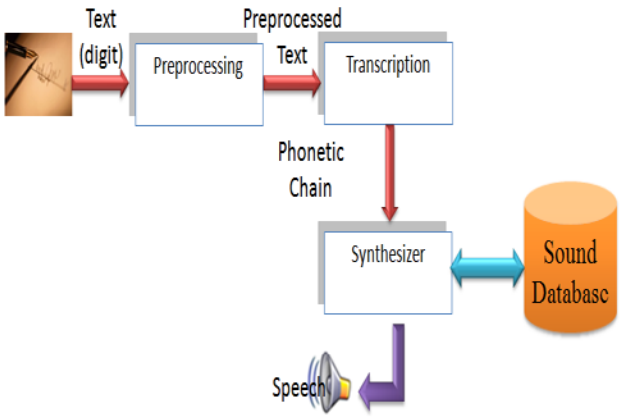

Fig. 3. General architecture of the synthesizer

4.1. The corpus description

We have created two corpuses; the first contains phonemes: It is composed of a set of basic sounds (which consists of the phonemes corresponding to the 28 consonants and 6 vowels, and other additional characters (corresponding to the three sounds of tanwiin ([an], [a], [in]), and the silence).

To improve the quality of the words synthesized by the method of concatenation of phonemes, and to reduce the effects of co-articulation, the solution is to record the transition that exists between phonemes instead of recording the phonemes themselves; we talk about diphones which are an adjacent pair of phones.

Indeed, the transition (diphones) is the bearer of a significant quantity of acoustic information in relation to the phoneme itself. Each transition or diphone also varies from the stable part of a phoneme up to the stable part of phoneme that follows.

4.2. The phonetic and orthographical transcription "POT":

Transcription provides a phonetic text from the alphabetic text. To accomplish this, it must apply to many pronunciation rules. French language has a few thousands of basic rules; English language has tens of thousands of rules. Therefore, during the passage from the written form to the spoken form two approaches can be used which are: the lexicon-based approach and the rule-based approach [8] [9];

- The use of rules
  In this approach each grapheme is converted to phoneme depending on the context and this is thanks to the use of a set of rewriting rules [10]. The main advantage of this approach is the ability to model the linguistic knowledge of human beings by a set of rules that can be incorporated into expert systems. Each of these rules has the following form:
  [Phoneme] = {LC (Left Context)} + {C (Character)} + {RC context)}
  Our transcription module grapheme-phoneme is based on a set of rules;
  The rule of tanwin, al madd, etc… Prioritized, and organized in the form of a tree list. Each rule is written in the graphics context in which it is applied.
  Here is a concrete example of transcription rule "The rule of Tanwin":
  If (grapheme [char] == 'Tanwin')
  {If (API [position] [0] [= = ' ') ً
  Phoneme = phoneme + "an";
  Else
  {If (API [position] [0]
  [= = ' ') ٍ
  Phoneme = phoneme + "in";
  Else
  Phoneme=phoneme+ "a";}
  }

- The use of the lexicon
  In this case we must assign to each word in entry the pronunciation which corresponds to it without taking into account its context. The speed, flexibility and simplicity are the main advantages of this approach.

4.3. The acoustic generation sub-module

This is the heartbeat of the synthesizer module, in fact the user after that he had pronounced the digit he

will see the recognized digit displayed on the screen, and will hear the system spelling back the recognized digit. This is the task of the acoustic generation sub-module.

To accomplish this task, we have implemented a reading function which is exposed below:

```
Position= seek (grapheme [ig], API);
If ((grapheme [ig] == 'أ') && (grapheme [ig+1) == 'ل'))
    {
     MP2- >FileName= "C: \\son_hanane\\alif.wav";
     MP2- >Open ( );
     MP2- >Wait=true;
     MP2- >Play ( );
      IG=ig+2;
      Position=seek (grapheme [ig], PLC);
      If (API [position] [1] == ')
      {
        MP2- >FileName= "C: \\son_hanane\\l.wav";
        MP2- >Open ( );
        MP2- >Wait=true;
        MP2- >Play ( );
        MP2- >FileName=API [position] [2]);
        MP2- >Open ( );
        MP2- >Wait=true;
        MP2- >Play ( );
       IG++;
      }
Else
      {
        If (API [position] [1] == 'S'
       {
        MP2- >FileName=API [position] [2]);
        MP2- >Open ( );
        MP2- >Wait=true;
        MP2- >Play ( );
        IG++;
      }
     }
   }
```

5. Tests and results

The main interface of our system, with an example of the recognition of the digit ten (AACHARA) is shown in the following figure (Fig.4):

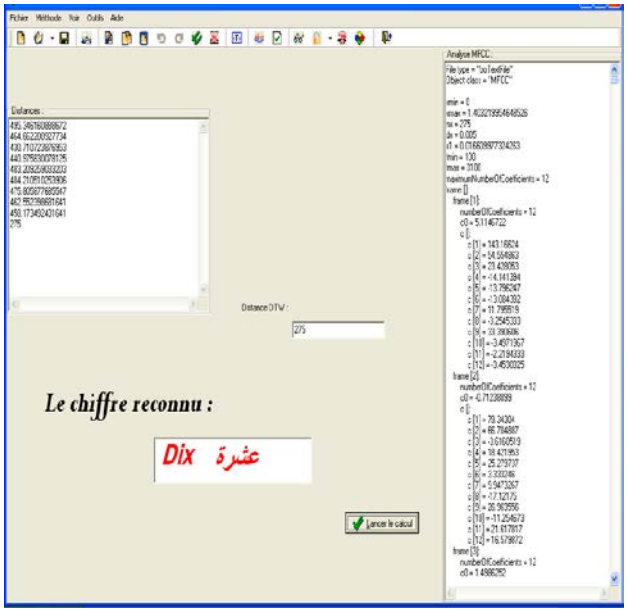

Fig. 4. Main interface of our system

We have applied the recognition on a corpus containing Arabic digits from one to ten pronounced by a male sex speaker in the Standard Arabic language.

To evaluate the performance of our system, we have illustrate two formula for each module; a recognition rate (RR) for the recognizer, and a success rate (SR) for the synthesizer.

We have fixed the number of tests performed to recognize a digit to twelve times. The recognition rate (RR) for each digit is calculated by the following formula:

$$RR = \frac{Nb\_recognized\_digit}{Nb\_tested\_digit(12)} * 100\% \quad (12)$$

In the other hand, to calculate the success rate (SR) associated with each digit tested; we got the following formula:

$$SR = \frac{Nb\_well\_prononced\_digit}{Nb\_tested\_digits} * 100\%$$

The results obtained for each digit are summarized in the following table:

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Table 1 : Recognition/ Success rate for the ten digits

The word in Arabic	Transcript	The word in English	RR	SR
واحد	WAHID	ONE	85.7 %	100%
اثنان	ITHNAN	TWO	100%	100%
ثلاثة	THALATHA	THREE	100%	85%
أربعة	ARBAA	Oven	100%	100%
خمسة	KHAMSA	FIVE	100%	100%
ستة	SITTA	SIX	85.7 %	100%
سبعة	SABAA	SEVEN	100%	86%
ثمانية	THAMANIYA	EIGHT	100%	80%
تسعة	TISAA	NINE	100%	86%
عشرة	AACHARA	TEN	88.6 %	100%

When investigating across the natural language processing field, we haven't found a lot of works dealing with the automatic recognition and speech synthesis in a same work, especially for the Arabic language. Therefore, in the comparison with previous works, we take into account just the success accuracy of the automatic recognition.

The comparison results obtained are summarized in the following table:

Table 2 : Comparison with previous work

ASR using CMUSphinx [11]	**85.55 %**
DTW-Based ArSR [12]	**86%**
DHMM-Based ArSR [12]	**92%**
Heuristic Method [13]	**86.45 %**
Heuristic Method with RNN [13]	**95.82 %**
Monophone-Based ArSR [14]	**90.75 %**
Triphone-Based ArSR [14]	**92.24 %**
Syllable-Based ArSR [14]	**93.43 %**
Word-Based ArSR [14]	**91.64 %**
VQ and HMM Rrna [15]	**91%**
MCCF-based Rrna [15]	**61 %AP -92%**
Wavelet-based Rrna [15]	**76 %AP -92%**
LBC-based FPGA Rrna [16]	**91 % -96%**
MCCF-based FPGA Rrna [16]	**95 % -98%**
ARSSAD	**96%**

The recognition sub-system achieved 96% correct digit recognition in the case of mono-speaker mode. On the other hand, the speech synthesis sub-system achieved 93.7% correct well synthesized digit. So the system present in general 94, 85 % of success rate.

6. Conclusions

We set several objectives for this research: that of discover the definitional character of the human voice, to describe the various stages and components used in the production of the voice and to dissect an ASRS system in its main floors. To that end, we have detailed our system of recognition and synthesis of Arabic digit as well as the results obtained. The system presents, using isolated words and in the absence of noise, a success rate quite honorable and acceptable. The acoustic variability of the voice signal, and in particular that due to the effects of coarticulation, is better apprehended by the modeling of its production.

In fact, the voice signal is not an ordinary acoustic signal and the Anatomical constraints may explain the effects of coarticulation, for example, in the framework of the articulatory phonology.

At the end of this rapid assessment on the voice recognition and synthesis, it has been noted that this area is particularly broad and that there is no miracle product capable of responding to all applications. The noise, for example, remains a brake to the generalization of recognition systems. The voice recognition is still a compromise between the size of the vocabulary, its possibilities multi-speaker, its rapidity, training time, etc... The power of the current calculating tools and the integration capabilities of systems have caused a resurgence of interest in the recent years among the industrials. In fact, they see in the voice recognition or synthesis, "the more commercial ", allowing making the difference with the competition.

A quick tour of horizon on the very numerous publications allows us to set the ideas on the nature of the work in progress. Apart from the products dedicated to the voice recognition, the systems with analytical approach (HMM and ANN) give today the best results [11], and currently have the wind in their sails.

As regards the future prospects, the optimism is more measured than in the past. Without risk, we can say that the general problem of the automatic processing of the voice signal will probably not rule before the middle of the next century. We can as even quote a few perspectives to our work in the following points:

- Enlargement of the vocabulary for all digits;
- Recognition of continuous speech;
- Recognition in speaker independent mode;
- Use of the HMM, neural networks and hybrid methods.

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Standardization of Electronic Health Record EHR Interoperability Unified Of Colombian Health Care.

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***Abstract*— Currently, Governments and institutions are developing ambitious reforms including the restructuring of the social sector in Latin America. Such reforms include the health sector and from this, coverage, increasing the cost of efficiency and improvement of quality of service that includes management. In this article the main objective consists in the formulation of a proposal in distinction to standardized clinical documents, from a platform designed for the Colombian Caribbean Islands health system; this project includes three aspects within its own range, Feasibility Study, service design, and an implementation plan. Since the encounter of the information system of medical records with its own needs including, the communication protocol Health Level Seven (HL7), and the own inventory services for interaction with the XDS, document repository and headers, designed for the exchange of clinical documents. The proposed solution solves the information ubiquity of every patient inside the system. Required for their attention, through a full service of integral intermediation that includes the design of interoperability organized according to the state data base, as is regulated by the Fosyga. Such purpose of architecture design linked to CDA (Clinical Document no Architecture) must be oriented by the Colombian Caribbean islands system, must be able to respond to Communication Services and Storage (SOA) off the given information, from the Electronic Clinical Information (HCE) monitoring and control of the electronic information of the users, from the presentation, business logic and data repository geographic with the health entities.**

Keywords: Management of clinical documents, E-health, HL7, interoperability.

INTRODUCTION

According to the special health care provides, recognized by the Colombian Ministry of Social Protection. There are 7.851 providers, conformed and distributed by Juristic nature. Which 6.539 IPS are of private character, 1.247 are nonprofit and the remaining 5.292 are private nonprofit [20]. Likewise of public nature there are 1.208 health provider institutions and 32 are mixed. From this we can understand that the governmental action especially in Colombia the reform guide aspects about efficiency cost of the resources that are being used, decentralization of health care providers, quality of health care and hospitals, clinics, and health centers management. It is from this approach that the contribution and the technology relation and knowledge in the specific areas where the appropriation of knowledge comes to be part of the society and the clear path to promote efficiency process into a context. These aspects can support the context of health service, and the diverse forms that supports the concept of geolocation that for this area has been taken from the platforms design of geolocation in charge of locating health centers. And specifically a plan to execute a geolocation for the electronic health history supported by the electronic health record system HSE. By this way the theme that is being presented not only in a national context, but also we can see it in more develop countries. Starting an argument about communication standards between platforms for the information to be homogeneous and updated for a real consult in different locations.That is where HL7 under the employment and development standards (ANSI, American National Standards Institute) provides a compressive framework and related standards with the exchange, integration and reception of electronic health information that supports the clinics practice, the management and the delivery of health services assessment. With this contextualization, it is pretend to apply this to the standards letting to understand the operation, and applicability in the electronic history clinics HCE, in the Colombian Caribbean Islands system, developing an approximation in the general system of improvement and standard operating in Colombia**.**

I. THEORICAL APPROACH

A. Description of the problem

The implementation design system for the management of clinical documentation standards for the Colombian Caribbean islands health system consist in studying in detail the necessities of information that health institutions have, and the way to record this information, starting from the HL7 standard to establish a form where systems of information of institutions that are part of the system of national health can integrate, communicate and manage de implementation of services based in information technologies and in condition in electronic business models, a services structure that involves the health care system that are included in private and public entities, thanks to the interface of interoperability that will be provided through the system platform. In addition, and according to the necessities of monitoring and control from the governmental entities, it is given as a mandatory the fact of collecting all the data of the health care system users and their respective clinical records, from the most recent approbation of the Colombian law 2011, that makes mandatory the use of electronic clinical records since 2013[3], form a centralized server that is within the reach of the social protection ministry and people or authorized entities.

B. Justification

Being Colombia referred in many investigations like part of the health care system crisis in Latin American standards [1] established inside of them the lack of monitoring and control by the state as the main judgment for the lack of quality in relation to health, letting this health care provider entities generate their own rules in a permissive way.

It is good to mention that to obtain the improvement and strengthening of the social security in Colombian health, that will allow to offer a better quality services, inclusive and equitable, that was approved by the Colombian law in 2011, that makes mandatory the use of electronic clinical records, since 2012, with full probative value, that is part of the new reform where the main objective of every effort will be for residents of the country [20]. The application of this law requires the respective mandatory decrees that must be elaborated by the executive power.

The mayor difficulty is the execution of the state control in the absence of a data base that will provide the people affiliated and beneficiaries of the health care sytem, and what kind of services have been executed by the institution: remarkably, that the terms of validation of complaints that are presented to Fosyga will be limited, that will make possible an adequate service, and at the same time they can enjoy a good health care service without depending on a regionalized model that does not admit the national portability of the right to health.

These types of identification and finding elements in the standardization in the systematization of clinical records, in many countries has been permitted the improvement of provision of health services at a national level , through the integration health information systems, that includes the generation of Electronic Clinical Records. (HCE) permitting the development of an international coverage for users.

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The management from a standardized platform of Unified Health Record Interoperability for Health will allow institutions that count with information heterogeneous systems, to communicate between them. Facilitating reference problems and against reference, at the same time will improve the time of identification of users and the services respective presentations. On the other side, Given the centralization and systematization of data, communication errors will reduce, redundancy information will be avoided, and government it is going to be able to execute real control and verification over the performed procedures, giving better efficiency to the collection and recollection of entities before the Fosyga.

In the same form the service structure is based in the possibility to integrate to electronic transactions systems, increasing the possibility and viability of the project as more patients adhere and become part of th public and private health care institutions system.

The Ministry of Social Protection from 1448 resolution issued in 2006 in the Law 1122 of 2007, it begun efforts for health institutions, universities, and investigation groups that have executed the extension of the provision of services through telemedicine. According for health, the efforts have been isolated, what has prevented the achievement of getting a real repercussion in the Colombian health system, despite the existence of laws such as the 1419, 2010 [1] and the 1438, 2011 that stipulate mandatory efficiency and large coverage in the service presentation, as the establishment and use of one clinical history.

These types of proposals, projects from the necessity of setting the opportunities to have electronic medical records for patient care. As will benefit the private or public emergency system (residential care unit) in which patient mobility requires monitoring and availability.

Will improve the consult time in a successful way, making feasible access to information from the employment of new technologies from the information of all institutions in the health area, without caring about the size of the provider services.

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This is the reason why the project seeks to centralized in the management of information of the social protection, in order for the standards application to have a direct effect in all the country, still projected as an initiative in the system of the Colombian Caribbean islands, make it extend throughout the country, analyzing other Latin American systems, within the new forms to provide the attention service in health care.

II. CONCEPTUAL FRAMEWORK

In order to describe the interoperability needs of health systems is important to make an introduction of the basic element of the investigation, the evolution of the medical records of patients and its passage into the technology world and the transmission of electronic data and electronic medical records EMR.

This is tool is one of the most important for daily basis for health workers as physicians, internists, specialists, nurses, medical assistants and administrative staff. It could be defined as a document that contains the medical record in a clear, precise, detailed and ordinate way of all the personal and family data of a specific user and could be used in the medical appointment

The government has decreed through the law 1419 of December 13, 2010 [1], that any activity that occurs under Telehealth, must accomplish with the principles of efficiency, universality, solidarity, integrity, unity and quality, among others. On the other hand, all the insurers and service providers, the law stipulates that their portfolios should be expanded and must provide the telemedicine as an additional service. In order to achieve a continuous development of this area, the law promotes all kinds of investigations and education for all the technologies focus to the health subject.

Besides of the promoting telemedicine law, the Congress establish as mandatory the only use of medical records as mandatory use of electronic medical for all the health institutions by the law 1438 of 2011 [3] on December 31st, 2013 (see transitional paragraph of Article 112), and established that it should exist a connection between all of the health institutions, in order to facilitate and enable the portability of services anywhere of the country.

In accordance with state requirements established by the law, all the necessary topics will be discussed to establish a clear context on topics or issues related to project management in a standardized platform for the Unified Health Record Interoperability state of health system..
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A. Proceso de cobro y recobro

In Colombia, there is an entity called FOSYGA (Fund of Solidarity and Guarantee) where the government guarantees to their citizens the service to emergency events, caused for traffic accidents, terrorism, natural disasters and other events that are stipulated in the law 100 of 1993 [4]. The operation of this entity its based on two (2) processes, whose description can be found in the Article 7 of the Decree 1281 of 2002 [5], known as collection and recovery. The charging occurs when an IPS (Lending Institution of Health) presents a bill to the corresponding EPS (Health Promotion Agencies) to which the user attended is affiliated or to the FOSYGA when the user belongs to the subsidized regime. Additionally, when a service is vital to a patient, and is not covered by the POS or subsidized system, the user may submit a guardianship claiming it's right, if this guardianship is turned in the patient's favor, then the EPS will cover just some amount of the bill and any other financial obligations will be FOSYGA's responsibility.
The recoveries from the EPS' bills (contributory or subsidized basis) to the FOSYGA, claiming the refund of payments made to the IPS after the health services provided and drugs that are not included in the POS [7] . In the presentation of a collection or recovery, it is indispensable the delivery of document that gives the evidence that health service provided has been given. These supports consist the delivery of individual invoices and records of the consultation given, the procedures, emergency services, hospitalization, drugs [6], all these must be submitted within six (6) months from the provision services..

B. Reference against reference system

The process of reference consists on the transfer of a user to a service provider entity to another, with the implication that the professional sender must attach a properly formatted reference the identifying of the user, including a summary of the medical record and the description of treatments and tests that have been made, it also has specify the reason and the type of service that the patient requires. According to the health plan service benefits [8], the system of reference and counter-reference was created to ensure adequate provision of services to patients when an IPS does not have the physical resources to give the attention needed.

C. Estándar CEN EN13606

This standard, is originally recognized as the European standard by the European Committee for Standardization, and the international standard by the International Organization for Standardization, also known as CEN / ISO EN13606, it corresponds to the standard set for defining the architecture or structure of the information of EHR (Electronic Health Record) - in order make the communication the between systems that need to exchange patient information; in other words, the systems in which this standard is implemented will achieve semantic interoperability among themselves, preserving the meaning of each of the elements [9].

The experience in the implementation of the last defined standards, had given enough maturity for the development of the standard EN3606, the fact that the clinical information results system are difficult to maintain and they turn obsolete really fast, because the clinical information is characterized by its complexity, the heterogeneous base types and the medical knowledge presents a continue actualization [10] according to the dual model definition, with its architecture is composed of two elements, the reference model that structures the information of the EHR through the entities, which storages the medical data, and an Archetype model in which defined and related entities are found, those who correspond to the medical domains [9].

According to the Reference Model, the standard EN13606 has directed that any annotation they wish to place is an HER it must be part of any of the classes that have been already defined as: folder (folder), composition (composition), section (section), entrance (entry), cluster (cluster), element (element) [11] [12] the figure 1 corresponds to the scheme of the clinical information organization.

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As we said earlier, the knowledge model is composed of archetypes. These archetypes that are not more than representations of the concepts that are manage in the medical domains, composes the ontology system; for which they developed: besides of giving the structure to the information of HER it also establishes relations that exists between the different entities of the Reference Model [10] . the archetypes are composed of three (3) elements [11]:

- The header (header): contains an identifier of the archetype and author information.
- The definition (definition): is the description of the concept or entity making use of the other entities in the Reference Model.
- The ontology (ontology) describes the entities used in the definitions.

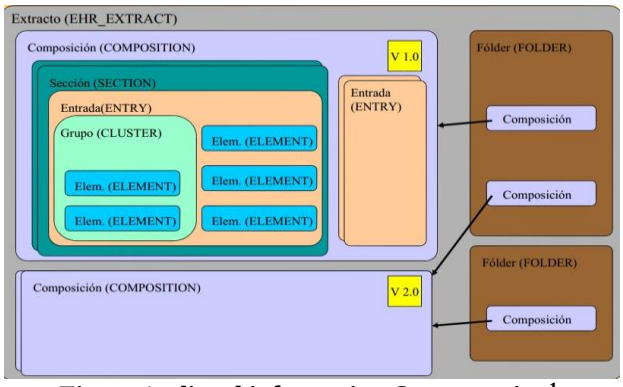

Figure 1. clincal information Oraganzation[1].

D. Estándar HL7 (Health Level 7)

The HL7 standard was defined by the Foundation with the same name, which has dedicated from the foundation to create standards for the health area.

In the beginning, the HL7 foundation was dedicated to create specifications for messages to send information between health institutions, through time, and observing that institutions wanted to establish communication, they had to invest high amounts of money to add modules or redesign their systems (Because they did not have a standard to define events and related items to patients), HL7 undertook the assignment to generate standards, not only for communication but also for the structuring of medical information, that's how HL7 V2 was born. Later, thanks to the absence of a clear model for implementation, the foundation created the standard HL7 V3, which prevent the designer to wander among the wide range of possibilities that V2 allowed, thanks to this, it was accomplished in the year 2004 generate a clear standard, easy to implement and manage[13]. In the figure number 2 it is shown the interoperability with the architecture view to the evolution of the HL7 standard.

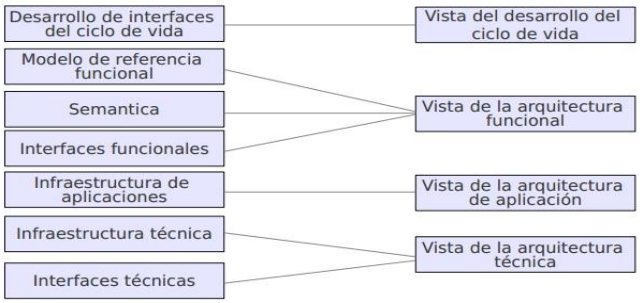

Figure 2. Relations between the levels of interoperability with the architecture view.

It is important to have in count that the HL7 model does not define the structure of the clinical electronic documents, XML from CDA are found in the RIM, so each of the versions that are from the CDA are related directly to the corresponding RIM, which takes every class that are need it to each specification of the parameters of the documents to define and with them to create what we know as the redefine model or RMIM[14].

In the reference model of the HL7 there are three superior classes to the clinical domain: event (act), number of participants in the event (role) and involved subject in the event (entity) [15] [16].

The HL7 and EN13606 standards have different origins, whereas HL7 emerged as a standard of communicating clinical data and EN13606 has always been based on a development communicative structure, but currently, boat chase the same objectives: to achieve the semantic interoperability and functional between the different systems of health institutions. Currently, in Europe EN13606 has been implemented in several countries, while in the US the standard used is HL7. Since this is a globalized world, it has become necessary to establish communication between heterogeneous systems for the standard. So it is necessary to clarify the similarities and differences between them. To start, the structural models are different but each one as their corresponding, as shown in the Figure 3.

[1] Tomada de foro de normalización en salud. Seminario II: AENOR y CEN TC251, Adolfo Muñoz Carrero. Disponible en la URL: http://www.conganat.org/SEIS/normalizacion05/AdolfoMunoz/SeminarioAENOR-TC251.pdf

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Figure 2. clinical data and administration of HL7 and EN13606[2].

The Reference Model of EN 13606 covers the same domain of HL7, but the Reference Model of EN 13606 Provides a structure based on the structure That has-been traditionally used in all the clinical documents. That's the reason many Institutions that have wanted to apply a standard work , have chosen to work with the terms of EN13606 and map them to the domain of HL7-RIM [15].

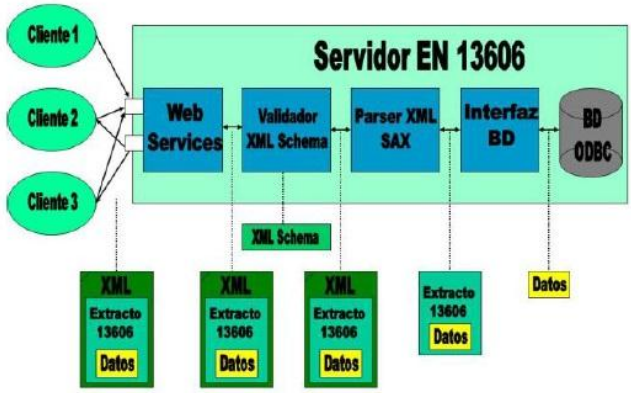

Figura 4. Esquema de servidor HCE EN 13606[3].

D. Clinical records characteristics

Medical records must accomplish a set of basic components as an: accurate, Affordable, Organized, Confidential, Safe, Legit and Complete. Also it must accomplish the following parameters in order to be taken as a medical document [17].

• Integrity: A medical record must have the information about the scientific, technical and administrative aspects of health care in the stages of building health promotion, targeted prevention, diagnosis, treatment and rehabilitation of diseases, approaching it as a whole in its psychological and biological, social and interrelated with their personal, family and community dimensions.

• Sequentially: The records of health service provision must be recorded in the chronological sequence in which occurred the attention. From the archival medical record's point of view, the medical record is an expedient that in a chronological way should have the relative documents relating the health services provided to the user.

Rationality: Is the application of scientific criteria in the process of registration of the different health actions given to the user, in a way that can be logic, clear and complete evidenced the procedure performed of the patient health diagnosis.

Availability: The possibility of using the medical record at any time needed , with the limitations imposed by law.

Opportunity: It is the registration process of the medical records in the same time as the serviced has been offered.

E. Electronic Record Health ERH

As it has been indicated, currently the attention of health information systems was made as a need of the management of the user data, workers and all the entities; this responsibility is shared with all the professionals who are involved in this disciplines or institutions. Consequently, it is important that all the professionals share the EHRs of all the patients, in a easy, safely way and keeping the original information in the [20] In order to achieve this goal, the HC has to be considered as the only clinical document to save all the patients information and share the clinical records as the european standar EN13606-1.

F. Interoperability between health institutions

The interconnection between the departments and the health institutions is a current necessity. Each time is grater the way that in Latin America the picture archiving systems (PACS) are being used, the information in radiology (RIS) in laboratories (LIS), in electronic clinical records (HCE), connected to administrative systems (HIS) and in patients' administration (ADT). This interconnection at various levels requires the use of informatics standards; for example, el DICOM, el HL7, etc. the institutions should require, when they acquire an informatic solution, compatibility with the different standards, and for this, they most know what is made of.

The standards are protocols that are used in software industries (In a regulated form), to facilitate interoperability and integration. They come in various layers of communication: - data transportation, that permit messages to transport with any semantic: XML, XML-HTTP, etc; - messaging: HL7; images: DICOM; - vocabulary, that allows to define vocabulary controlled specifically by each domain: laboratory, pathologic

[2] Imagen tomada de **¡Error! No se encuentra el origen de la referencia.**
[3] Imagen tomada de **¡Error! No se encuentra el origen de la referencia.**

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anatomy, images diagnostic, nursing, procedures, etc.; - marked documents, to differentiate the different tipes of documents that can be interchanged and their content; communication; example; the cabling, TCP/IP routers, etc. [18]

G. HL7 Standards of interoperability

HL7 V2x: The last version is the v2.7 2008, but the most used in messaging in inter-hospital are the versions 2.3, 2.4, and 2.5, with a high level in the market penetration for providers of software and users (hospitals, providers, etc). It is weak for regional implementations, with a greater ambiguity; it requires a negotiation site to site and a data implied model. As the examples of utilization there are LIS, A HIS, LIS, a BILLING, HIS RIS, ADT broadcast, between their domains there are patients admissions, laboratory, radiology, orders, interconsultation and shifts.

Hl7 v3- messaging a regional level. The last version is the normative 2010, available exclusively with syntaxes XML

HL7 CDA R2- *clinical documents.* Is the standard for interchanging clinical documents instead of messaging, their last version was the normative 2005, CDA R2; el CDA R3 are in discussion (no ballot). [19]

H. Modeling

The system has to start from and oriented architecture for services that are linked directly with the CDA (Clinical Document Architecture) for this is necessary a service inventory empowered for the query of medical records of the patients, exposing only their own capacities of consolidation and consult processes of the information inside the context of the specific information.

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By the same method, it is proposed an own service inventory for the interaction with the XDS document repository and headlines designed for the interchanged of clinical documents in accordance with the HL7 standard, lastly, it is determined an inventory of specific services for the identification context and inform and access to the patient demographic information PIX.

The modeling SOA for HL7 that has to be applied most be determine by the next 4 stages:

- • Consumer Layer
- • Business Process Layer
- • Services Layer
- • System Layer

The consumer layer must provide a set of services that allows the visualization of the local HIS (Hospital information system) consult. The administrative web client consultation, consultation most be from regulated entities.

The Business Process Layer is composed of a set of inventories of services like consultation of patients, HCE consultation, consultation of information indicators, also surgical services, reference against reference, hospitalization, emergency, and admissions.

Services Layer contains user applications, passwords, admission, notifications, authorizations, and informed consent.

Layer System contains repositories of XDS, CDA, PIX

Each repository named in the layer system has their system of sub layers for the architecture generation, to these layers is adhered to another layer called component services, that is in charge of the authentication process, data access, security, tracking and users permit.

Cooperative work service

Cooperative work service [1] provides and infrastructure about making synchronous (real time) as asynchronous (storage and retransmission) applications, based in virtual spaces of cooperative work, that enables comprehensive integrate care for patients, sharing access to the coming information of all the care levels, the interaction conscious of the patient with the rest of the agents of the sanitary system and the cooperation between the members of care team. In figure 1 it can be seen the four defined systems. The messaging service releases to the applications the necessity of managing the shipping and reception of messages between users.

By the same path, makes it possible to leave a record in the HCE of those messages with clinical content that has been transmitted from different pathways of the hospital information systems (for example commercial electronic e-mail costumer or short messages SMS). The alarm services by one side and the management of events by the other side. Supplies the necessary functionality for these applications so these can define and monitories the occurrence characteristics of certain events during the patient care plan, like receiving automatic notifications and alarms that keeps you informed of the events of your interest that produces the system.

RESULTS

The results that the management execution of a standardized platform of the Unified electronic clinic history, may allow, from the health's interoperability:

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Inviolability: not being adulterated. Granted access through a digital signature, plus the insertion of automatic time and date. Information backup. Sequence of information: granted by devices of automated numeric fields and the insertion of automatic time and date.
Accessibility: usable at any time or place via internet, wireless and WAP.
Availability: ready at hand whenever it is required, enabled people may have access to the information regarding the medical record, the audit, statistics, and Prevention plans.
Risk of information loss; granted security by the means of a correct information guard policy.
Integrity of the clinical information; unified information that avoids the loss of data.
Durability; unalterable through time so it may be consulted.
Readability; reader-friendly.
Legality and probative value; granted through the digital signature. And others such as: *personnel identification, precise temporality, audit warranty, redundancy, consignment errors, data standardization, management crew costs, printing costs, paper costs, evolutions time lapse search, supplementary studies time lapse search, orientations towards therapeutic attention, reminders and alerts, data availability for statistics, patients' information searching and data classification according to several items, clinic history robbery*.

The development of this interoperable HL7 proposal is a specification for an electronic data interchange standard in the field of health attention, which allows every entity that uses it to increase the incursion towards new information technologies and communications, improving the response times for the user between several institutions. Helping to perform an appropriate management of the electronic clinical documents, solving one of the Country's current shortcomings Regarding health concerns.

This proposal, developed as an academic project, will permit the decrease of displacement to the state entities to consult the information about procedures, though enabling the governmental bodies and health institutions that use systems of record access and trace control over patients, as well as lab record, specialists reports among others, to enjoy a more efficient service, getting access to facilities that ensure a high quality of the required services.

Considering the applications in the health ground, governmental bodies, as future users of these type of information systems, will be able to increase their savings in the generation of processes as well as in the budget to purchase an ITC system for this type electronic documents' management, decision-making support, nursery applications, auxiliary services applications, ECH, out-of-hospital information needs, since the development of this system will preclude in officious time expenses for procedure fulfillments through technology without any setback, being operable from any mobile device with access to the platform.

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CONCLUSIONS

The research behind the platform design will reveal the problems that often do not know such as the health technology. The selection of SOA for transmission and reception of HL7 messaging is technologically and strategically valid for the health systems as an internationally level and it accomplished the needs of the system management of Colombian Caribbean islands.

The understanding of the standard HL7 between independence application to client server currently allow rapid development and coupled to the electronic medical record, highlighting the advantages of the storage, conservation and searching systems. The use of EMR, allows the developing of system proofs of knowledge changes (situation that is very common in the medical field and makes the different systems be obsolete in no time). The standard provides the necessary structures in order for the information to be transmitted to all contexts.

The interoperability based on the HL7 standard is beginning to be used in Colombia. Guaranteeing the management and neutralizing of the effects of distance ensuring the registration and consultation.

The main development of this proposal is the platform for the easy management of the medical records in all departments in the Colombian contexts.

The conjunction between the cheapest infrastructure hardware, the integration of the free software, the cost of telephone services and the accessible application through the development of this platform will let the Government take over control in all the health entities, also they will count with the confidence and fast communication tools once the HL7 protocol in implemented, this will allow them to verify the different data from the FOSYGA entities.

The health subject has many issues that haven't been covered, yet the design and implementation of this proposal could be the start of a new investigation that may contribute to the

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understanding of this important topic for our country in health, education and environment subjects.

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Human Identification based on Ear Recognition

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ABSTRACT

Biometrics is the identification of humans based on their characteristics or traits. This paper presents the study of investigating the ear as an effective biometric trait in order to identify humans. The study involves using 2D images of ears and processing them to determine who the individual is. Various feature extraction techniques were explored. The study also presents many methods of classification. Principal Component Analysis (PCA), Local Binary Patterns (LBP), and spatial histograms were used for feature extraction, with spatial histograms yielding the highest success rates. For classification, Support Vector Machine (SVM) and K-nearest neighbour classifiers were used. The highest success rate achieved by the classification was 88%.

Keywords

Ear recognition, Human identification, PCA, LBP.

1. INTRODUCTION

DUE to the fact that conventional means of human recognition, such as passwords, ID cards, etc. can be stolen, faked, or forgotten, there has been much research in the field of using biometric characteristics for this purpose. Biometric characteristics are universal, unique, permanent, and measurable. Many methods for identifying humans have been researched, including those based on face, iris, fingerprint and gait recognition, however, these are considered to be slightly invasive because they require the co-operation of the individual. Ear recognition is non-invasive, and is not affected by factors such as mood or health, unlike facial recognition. The appearance of the ear is also unaffected by age, making it suitable for long-term identification.

Therefore, this paper presents an overview of the state-of-the-art of various feature extraction techniques and classification methods for improved ear recognition.

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2. LITERATURE REVIEW

The French criminologist Alphonse Bertillon was the first to become aware of the potential use for human identification through ears, more than a century ago [3]. Much research has been done to show that the appearance of the outer ear is unique and relatively unaffected by age. While it has not been proven that each person's ear is unique, studies shown in [10] gave supporting evidence.

Iannarelli inspected more than 10 000 ears and discovered that they are all distinguishable, and created a method where only 12 measurements are used to differentiate individuals. In 1995, Carreira-Perpiñán investigated using artificial neural networks with linear nodes for feature extraction.

In a study by D. J. Hurley et al. [8], a force field feature extraction approach based on simulated potential energy fields was used. The force field transformation sees the image as a collection of mutually attracting particles that act as the sources of a Gaussian force field. This approach was performed on 63 individuals and the results showed that it was an improvement on PCA-based methods; however, it is only applicable when there is a small background in the ear image.

In 2005, M. Choras presented a study on ear biometrics using geometric feature extraction [6]. This involved image normalization, edge detection, calculation of the centroid, coordinate normalization and two steps of geometrical feature extraction. The geometric features extracted used the points of intersection between circles of different sizes with the calculated centroid as their centre and the contours extracted from the ear image. However, this method was carried out on extremely high quality images with ideal conditions. Because the environment was ideal for recognition, the results were error-free. We cannot expect the same results in the case where the images are of lower quality or there are changes in illumination.

B. Moreno et al. [7] carried out two experiments with neural network classifiers. For the first experiment, features were extracted by performing edge detection and getting seven known feature points of the outer ear to form the feature vector. For the second experiment, the intersection points between h horizontal cuts, v vertical cuts and $2(h+v)$ diagonal cuts over an $h \times v$ size image forms a morphology vector. The first method resulted in an extremely low 43% recognition rate, while the second approach resulted in an 83% recognition rate. This indicates that ear morphology is much more effective than the feature point approach, although ear morphology is still not ideal as there is much room for improvement.

Prakash and Gupta recently described a new approach on ear recognition using edges [5]. They used skin segmentation and classified the edges into 2 groups: convex and concave. Thereafter, the edges in the skin region are broken up into edge segments, which form an edge connectivity graph. The convex hull of all edges is computed from this connectivity graph. The enclosed region is the ear region. This study used full profile images and a 96.63% detection rate was attained.

H. Alastair et al. [4] proposed the ray transform approach, which detects the ear in different positions and ignores straight edges in the image (which are caused by glasses or hair). This method uses a light ray analogy to scan the image for cylindrical and curved structures, such as the outer helix. The simulated ray is reflected in bright tube-shaped regions, highlighting these regions in the transformed image. Since glasses have straight edges, they are not highlighted by the ray transform. This method had a 98.4% recognition rate.

3. METHODOLOGY

The method uses a training dataset and testing dataset of ear images. The basic procedure is outlined in Figure 1 below:

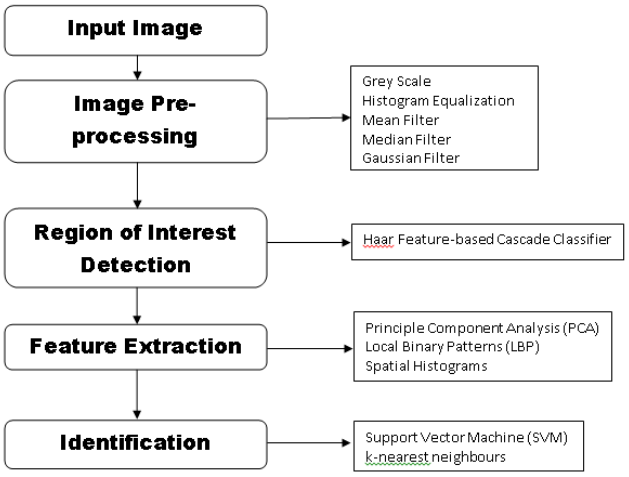

Figure 1: Overview of the System

An ear image is selected from the database be to be pre-processed.

3.1 Preprocessing

Preprocessing involves converting the image to grey scale, performing histogram equalization, and Gaussian filtering. Pre-processing is essential in order to remove noise and smooth the image.

3.1.1 Converting to grey scale

Converting to grey scale involves mapping colour RGB triplets to a single value representing the grey scale intensity. Each color pixel is described by a triple (R, G, B) of intensities for red, green, and blue. A weighted average of these values is calculated as the grey scale intensity as follows:

$$I = 0.21\,R + 0.72\,G + 0.07\,B$$

A weighted average is used for human perception, because humans are more sensitive to green than other colours, therefore green carries the largest weight.

3.1.2 Histogram Equalization

Histogram equalization involves transforming the histogram of the image in order to increase the contrast. The intensities will be distributed evenly on the histogram. Suppose the intensity values range from ***0*** to ***L-1***, then let ***p*** denote the normalized histogram of the grey scale image as follows:

$$P_n = \frac{no.\,of\ pixels\ with\ intensity\ n}{total\ no.\ of\ pixels} \qquad n = 0, 1, \ldots, L-1$$

P_n creates a mapping function for the pixel intensities, ***T***, as follows:

$$T(K) = (L-1)\left(\sum_{n=0}^{K} P_n\right) \quad K = 0, 1, , \ldots, L-1$$

The intensity value ***K*** will be mapped onto ***T(K)*** in the output image.

3.1.3 Gaussian filtering

Gaussian filtering is used to reduce noise in the images by decreasing the intensity variation among pixels. It uses a 2D sliding window matrix (kernel) that sequentially traverses the image and uses the pixel values contained in the sliding window to replace the centre pixel value. The equation of the Gaussian function is:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Gaussian filtering uses this 2-D distribution as a point-spread function, and this is achieved by convolution. This function is used to set values of the sliding window and performs the sum of products.

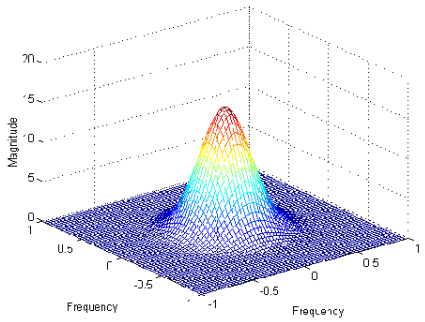

Figure 2: Gaussian function

3.2 Region of interest detection

Region of interest detection involves identifying the boundary of the ear in the image and extracting it. To implement this, I used a Haar Feature-based Cascade Classifier.

3.2.1 Haar Feature-based Cascade Classifiers

Haar Feature-based Cascade Classifiers are trained with a few hundred samples of an object, in this case, ear images, called positive images, and arbitrary images of the same size, called negative images. Afterwards, the classifier is applied to an image and outputs a 1 or 0, depending on whether the image contains the object of interest (in this case, the ear). This approach is not 100% effective, and in many cases, the original image has to be used.

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3.3 Feature Extraction

Feature extraction deals with isolating distinct features of the ear in the image. I implemented PCA, LBP and spatial histograms to accomplish this.

3.3.1 Principal Component Analysis (PCA)

PCA is a method of dimensionality reduction, used to reduce the number of features to only those with a large variation between them. Firstly, each pixel in an image is taken row by row and converted to a row vector of the intensity values. All the row vectors of the training set (or testing set) are combined to form a matrix. Thereafter, the covariance matrix is calculated as follows:

$$cov(x_i, x_j) = E[(x_i - \mu_i)(x_j - \mu_j)]$$

for $i, j = 1, 2, 3 \ldots n$, where E is the mathematical expectation.

Principal components analysis (PCA) is an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. This is done on the covariance matrix *(C)* by satisfying the relation $Ce_i = \lambda_i e_i$ where e and λ are the corresponding eigenvectors and eigenvalues respectively. Thereafter a matrix *A* is constructed from the eigenvectors sorted by decreasing eigenvalues, and each training image is projected onto the PCA subspace. A test image will be projected onto the PCA subspace, and then compared with the training images to classify it.

3.3.2 Local Binary Patterns (LBP)

LBP does not look at the image as a whole, but instead isolates local features of an object. Each pixel is compared with only its neighbourhood. A pixel is taken as the center and used as a threshold value. If the intensity of the neighbour pixel is greater than or equal the centre pixel, then denote it with 1. Otherwise denote it with a 0. The result is a binary number for each pixel, eg.11001111, called an LBP code.

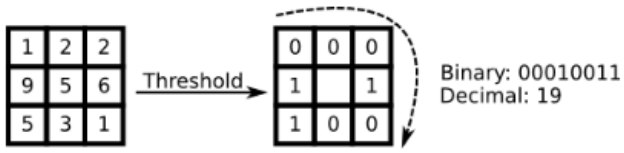
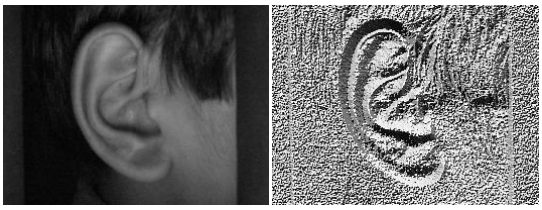


Figure 3: Example calculation of LBP

Local Binary Patterns reveal the texture of an image, and the features extracted have a low dimensionality.



(a) (b)

Figure 4: (a) Original image (b) Local Binary image

3.3.3 Spatial Histograms

Spatial histograms are used to preserve local information in an image. Instead of computing one histogram for the whole image, the image is divided into n x n smaller regions, and a histogram is calculated for that each region separately. Thereafter, all the regional histograms are concatenated to form the spatial histogram. The region size used was 8 x 8.

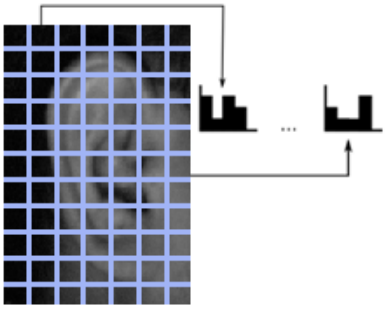


Figure 5: Image divided into regions to compute histograms

3.4 Identification

Identification is the final act of classifying an ear image as belonging to a certain individual. It involves using the set of features that were extracted and comparing them to the database to determine which image matches the closest to it. In order to achieve this, I implemented the SVM classifier, and the K-nearest neighbour algorithm.

3.4.1 Support Vector Machine (SVM)

SVM is a supervised machine learning classification technique. It is based on the concept of decision planes that define decision boundaries. A decision plane is one that separates a set of objects belonging to different classes. SVM determines the optimal separating hyperplane in order to categorize data.

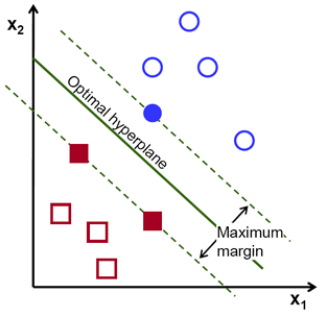


Figure 6: Optimal hyperplane for classifying data

The example above depicts binary classification. However, ear recognition is a multi-class classification problem, which the algorithm takes care of by repeatedly performing binary classification. The SVM algorithm learns from the training set of images, determines the optimal hyperplanes of each separation, and uses this to classify a given test image.

3.4.2 K-Nearest Neighbours

K-nearest neighbours is a classification algorithm that uses a measure of similarity to classify objects. A distance is calculated between a test sample and all the training samples to determine which *k* training samples have the smallest distance from the test sample. The test sample will be placed into the class of the majority of its nearest neighbours. If $k = 1$, the test sample will simply be assigned to the class of its nearest neighbour. The distance formula used is the Euclidean distance:

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$$d = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

where x_i are the components of the training sample vector and y_i are the components of the test sample vector, and n is the number of components in each vector.

4. RESULTS AND DISCUSSION

The experiments were tested using the testing set of 125 ear images. The dataset of ear images used was the IIT Delhi Ear Database version 1.0. This database contains ear images of 125 different individuals, acquired during October 2006 – June 2007 using a simple imaging setup. Each individual has 3 – 6 ear images, 1 of which was used in the testing set, and the rest used in the training set. All individuals are in the age group 14 – 58 years. The images use an integer to identify each individual, ranging from 1 to 125. The resolution of these images is 272 x 204 pixels and all these images are available in jpeg format.

(a) (b)

Figure 7: (a) Image 004_01.jpg from dataset. (b) Image 004_02.jpg from dataset.

The images were preprocessed, which includes conversion to grey scale, histogram equalization and Gaussian filtering. Thereafter the region of interest was detected and feature extraction was performed. Each of the 3 feature extraction methods were tested, along with both the classification methods that were implemented. The results are summarized in **Table 1** below, displaying the success rates of each combination.

Classification / Feature Extraction	Support Vector Machines	K-Nearest Neighbours
Principal Component Analysis	60 %	58.4 %
Local Binary Patterns	71.2 %	69.6 %
Spatial Histograms	85.6 %	87.2 %

Table 1: Success rates of each feature extraction method using both classification algorithms

The success rates of using the PCA feature extraction technique are significantly lower than the other two. This is because PCA determines components with maximum variance over all the classes. These may not necessarily be useful for classifying the images. Therefore, in images with a lot of illumination variation, the wrong components were identified and used to define the PCA subspace. Another factor is the small number of images for each individual in the training set, which causes the covariance estimates for the subspace to be slightly incorrect. In order to achieve a 90% success rate using PCA, at least 8 images per person are needed, however, there are only 3-5 images in this case.

The LBP technique yielded success rates of 69.6% and 71.2%, which are acceptable. Because LBP does not see an image as a high-dimensional vector but only considers local features, factors such as illumination variation and small training set size have very little effect. However, what does affect LBP are factors like rotation, scale and translation, which may have caused the average success rates.

The spatial histograms feature extraction method resulted in the highest success rates, 85.6% and 87.2%. Just like LBP, this method does not look at images as a high-dimensional vector but instead considers a group of regions or grids into which the image is divided. Therefore, it is not affected by the large variation in illumination or the small training set size, and very slightly affected by scale, rotation and translation. Therefore, spatial histograms are the most effective method of feature extraction.

Both the SVM and K-nearest neighbours classification algorithms resulted in very similar success rates, given the method of feature extraction.

5. CONCLUSION AND FUTURE WORK

This paper investigated the effectiveness of using the ear as a biometric trait to identify humans, and compared the accuracy of using different methods for feature extraction and classification. The most notable feature extraction method was spatial histograms, which yielded the highest success rate because it uses local descriptors as opposed to the entire image. However, these results depend on the dataset used, as factors such as illumination variation in the images and training set size could drastically affect the outcome. Presumably, when using a different dataset, the preprocessing carried out might need to be altered, as well as the feature extraction techniques used.

The features that are extracted is what affects the success rate of the system most, therefore, in future work, other feature extraction methods should be investigated. Methods such as Scale Invariant Feature Transform (SIFT), Histogram of Oriented Gradients (HOG) and Speeded Up Robust Features (SURF) should be applied to the problem of ear recognition to determine if the success rates can be improved. In addition, other classification methods should be applied, eg. Random/Decision trees, Multi-Layer Perceptron and k-Means Clustering.

6. ACKNOWLEDGMENTS

The people who put together the IIT Delhi Ear Database are hereby acknowledged and thanked for allowing the use of this database for research and investigation.

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Medical Image Compression by Region of Interest based on SPIHT and Global Thresholding using Huffman coding

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Absract - Medical imaging produces human body pictures in digital form. Since these imaging techniques produce prohibitive amounts of data, compression is necessary for storage and communication purposes. Many current compression schemes provide a very high compression rate but with considerable loss of quality. On the other hand, in some areas in medicine, it may be sufficient to maintain high image quality only in region of interest (ROI). This paper discusses a contribution to the lossless compression in the region of interest of Scintigraphic images based on SPIHT algorithm and global transform thresholding using Huffman coding.

Keywords*:* SPIHT Coding, Global Thresholding Transform, Huffman Coding, Region of Interest, scintigraphic images.

I. INTRODUCTION

The massive use of the digital terms in medical imaging produces volumes of data more increasingly important. Compression of digital images becomes a necessity to ensure their archiving on the one hand and facilitate their transmission on the other. For a good number of medical images, clinical information is concentrated in one or more regions of the image. An approach that brings a high compression rate with good quality in the ROI is thus necessary.

The general idea is to preserve quality in diagnostically critical regions, while allowing lossily encoding the other regions. It is in this framework that is this present work. After the evolution of digital imaging techniques, many researchers have attempted to apply compression methods to medical data. The lossless compression studies have all resulted in low compression rate. Transform coding schemes such as DCT transform and wavelet transform were applied [1, 2,3] to get better rates. In order to achieve higher compression rates without detracting from quality, region of interest based methods were investigated [4,5].

In this paper, we propose a compression algorithm by region of interest of the scintigraphic image based on SPIHT algorithm and global transform thresholding using Huffman coding. The paper is organized as follows. Section II describes the proposed process of compression. Section III explains experimental results and discussion. Finally, a conclusion is given in section IV.

II. THE PROCESS OF COMPRESSION

The block diagram in Fig.1 describes the process of our coding scheme. To find a good compromise between compression ratio and the clinical information of the medical image, we thought of implementing an algorithm by areas of interest (regions of interest: ROI).

Indeed, the ROI will be coded without loss with SPIHT algorithm [6, 7,8] using the classic SPIHT algorithm adapted to the lossless compression while the difference image will be encoded with losses representation using global thresholding and Huffman coding.

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A. Selection of the regions of interest ROI

The principle of scintigraphy is to get the image of a body after injection of a weakly radioactive solution in a body and save the emitted radiation over time.

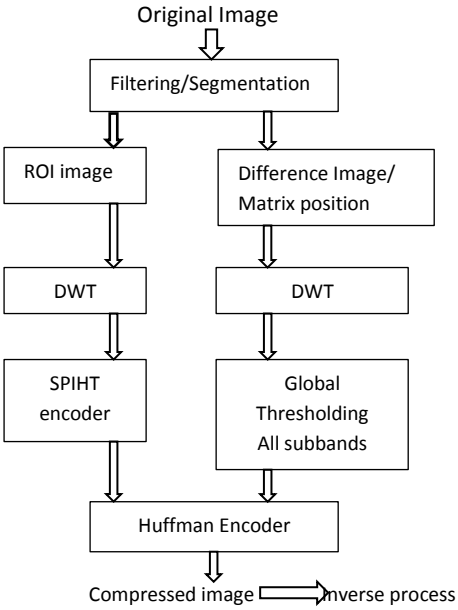
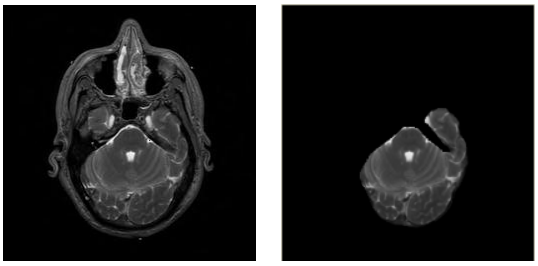
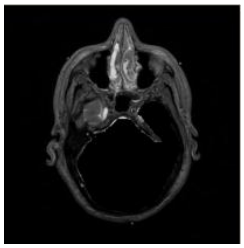


Fig. 1: Compression process

The quantity of registered radiation to learn more about the activity of the body explored. Clinical information locates so in fixation of the radiopharmaceutical product areas, which thus define our areas of interest. The selection of the ROI is by application of 3 stages: filtering, enhancement and segmentation [9]. The image is thus partitioned into two parts, as shown in figure 2.



a) Original Image b) ROI



c) Difference Image

Fig. 2: Scintigraphic image Partition (a,b,c)

B. Encoding of DWT coefficients

All coefficients in all sub-bands of the ROI image are encoded directly by SPIHT encoder followed by Huffman coder without thresholding (coefficient detail in sub-bands are considered important for ROI). We also need to encode and transmit a position matrix of the ROI image in a lossless manner. This issue guarantees to us to reduce the effect of border in the reconstructed image between ROI image and remaining image. After introducing many zeros in all sub-bands of the remaining area due to the global thresholding, we encode our coefficients by Huffman coder to convert redundant data into bit stream. The use of Huffman encoder makes compressed data ready for transmission.

III. SIMULATION RESULTS

For measuring the originality of the compressed image, Peak Signal to Noise Ratio (PSNR) is used,

$$PSNR\ (dB) = 10\ log_{10}(255)^2 / MSE \qquad (1)$$

Where MSE is the mean squared error between the original image I_{ij} and the reconstructed compressed image I'_{ij} of the size MN, wich is calculated by,

$$MSE = \frac{1}{MN}\sum_{j=1}^{M}\sum_{i=1}^{N}\left[\{I'_{ij}\} - \{I_{ij}\}\right]^2 \qquad (2)$$

We conducted several simulations on a group of medical images in order to test the effect of the proposed coding method.

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The measurements were performed for different level of decomposition using bior4.4 wavelet for DWT with 13/19 tap filter in first stage and 14/14 tap filter beyond level one. For different size medical images, and different form of region of interest, we applied the following algorithm,

1- Selection of region of interest,
2- Compress the image of the remaining (Fig.2.c) with global thresholding and Huffman coding,
3- Compress the position matrix of ROI and the ROI image (Fig.2.b) with SPIHT coder and Huffman coding.
The results are presented in Table I and II. Fig. 3 and Fig.4 shows the reconstructed images at various bit rates and at different positions of ROI.

TABLE I: Performance coding for image 'mri.bmp'

Level-1 decomposition		Level-2 decomposition		Level-4 decomposition	
bpp	**PSNR(dB)**	**bpp**	**PSNR(dB)**	**bpp**	**PSNR(dB)**
2	35,41	1.5	32,12	0.6	29,012
3.4	36,432	1.76	34,031	0.7	29,87
4.2	36,61	1.9	34,87	0.8	31,32

TABLE II: Performance coding for image 'thorax.bmp'

Level-1 decomposition		Level-2 decomposition		Level-4 decomposition	
bpp	**PSNR(dB)**	**bpp**	**PSNR(dB)**	**bpp**	**PSNR(dB)**
2	32,97	1.2	31,5	0.55	29,8
2.9	33,012	1.4	31,7	0.7	30,865
4.1	34,32	1.8	32,14	0.8	31,45

Observing results, we conclude that PSNR is inversely proportional to compression ratio (CR). At first level of decomposition 'bpp' is more than higher levels due that low sub-bands requires more numbers of bits. The total number of bit required to compress the scintigraphic image decreases as we set up the level of decomposition. Slight reduction in image quality is observed.

TABLE III: Comparison with existing method (CBTC-PF [10])

Proposed method MRI image			CBTC-PT		
bpp	**PSNR(dB)**	**CR**	**bpp**	**PSNR(dB)**	**CR**
0,8	31,3	29,6	1.17	31,93	20,51
1,5	32,12	15,4	1.50	30,15	16
1,2	32,02	23,2	1.20	31,79	20
1,9	34,87	14,7	1,12	31,31	21,42

We achieve good CR at level 4 of wavelet decomposition. Highest CR achieved with proposed method is 42% for image 'thorax.bmp' (PSNR= 29,8dB, bpp=0.55). Table III reveals that the proposed method is competitive with existing methods.

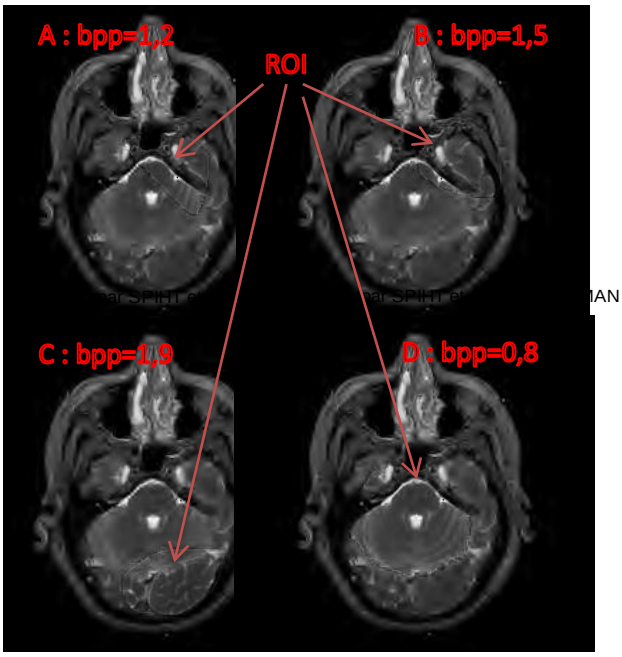

Fig. 3: Reconstructed image for different ROI position at various 'bpp' (table III)

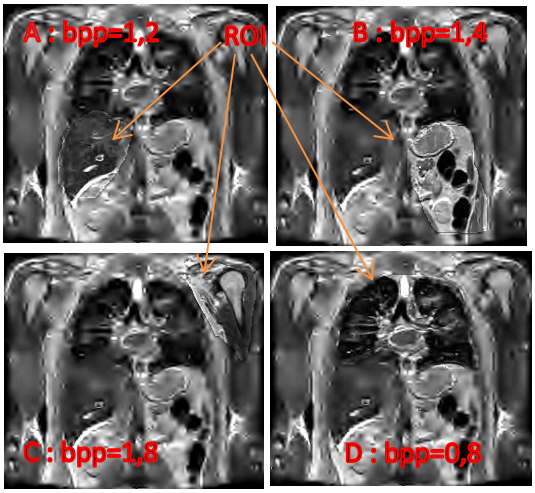

Fig. 4: Reconstructed image for different ROI position at various 'bpp' (Table II)

IV. CONCLUSION

In this work, we propose a method for compression based on region of interest of medical images using two algorithms based on SPIHT and Huffman coders. The original image is first divided into two images: one containing the regions of interest and another containing the rest, the first is coded without loss using SPIHT coding and the second is encoded with loss using global thresholding and Huffman coding. A matrix of position of the ROI is also coded with loss and transmitted to the decoder to reduce border effect. Our proposed method has comparable results with low complexity. This issue of coding medical images is very interesting and allows us to compress only the important area in image (ROI) by lossless compression. The use of SPIHT coder for lossless compression shows interesting results and we have achieved good CR with proposed method (42%). The rest of the image has been coded by global threshold algorithm and Huffman coding which makes compression data ready for transmission.

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