Virtual Reality Technologies in Handicapped Persons Education

Branislav Sobota, Štefan Korečko

Abstract**—** This paper presents a set of software tools, developed at the home institution of the authors, which utilizes virtual reality technologies in order to assist in education of handicapped persons. The tools are aimed at deaf-mute persons and can serve as sign language translators. From virtual reality-related technologies they use image recognition, data gloves and contactless sensors.

Keywords**—**virtual reality, image recognition, education, deaf-mute persons.

I. INTRODUCTION

NOWADAYS we witness a massive penetration of information technologies into all spheres of life. This situation requires a development of more interactive and more intelligent user interfaces, which will make human - computer interaction (HCI) [1] adjusted to human users and not to the way computers operate. Such interfaces belong to the area of Human Centered Methods and Technologies (HCM-T) and Virtual Reality (VR) [2] is one of them. There is an active research in the LIRKIS laboratory at the home institutions of the authors, which focuses on the utilization of virtual reality, in the context of HCI and HCM-T, for simplification, acceleration and clarification of communication of handicapped persons with computer systems and other people. In this paper we present a set of tools, which applies VR technologies for deaf-mute persons benefit. The tools primarily deal with sign language processing.

In our work we understand the sign language as a form of communication [3]. This communication is not based on sound patterns, but on a visual transfer of meanings. The meanings can be letters, numbers, words or phrases. They are expressed by gestures, which include hand shapes, positions and movements of the hands or other body parts and facial expressions. Lexically, we can have direct gestures with clear semantics (e.g. waving, “up”, “right”, “I”) or indirect ones where semantics is not clear at first glance (e.g. “who?”). There is no single codified version of the sign language in the world - even within one country we can have more dialects. Every country has its own vocabulary (sign register) and grammar. The tools described here have been developed for use in Slovak Republic but can be adjusted for other countries as well.

II. RELATED WORK AND MOTIVATION

Utilization of VR technologies in HCI context proved to be useful for handicapped persons [4]. In the case of deaf-mute persons they are mostly used to recognize the signs. However, VR is not enough for more sophisticated recognition and a translation in both ways. In such cases we need to include some artificial intelligence stuff [5]. From technological point of view the sign recognition can be implemented using contact sensors (primarily data gloves), contactless sensors or image processing technologies.

Use of data gloves represents the simplest solution. Basic gesture processing of this kind is described in [6]. Its biggest advantage is an open source platform, so it can be easily integrated to other projects. The work [7] focuses on affordability and brings a relatively cheap implementation of contact sensors. As it was mentioned above, there are many dialects of the sign language worldwide. Problems related with implementation for a specific dialect, namely a Malaysian one, are discussed in [8]. One significant disadvantage of contact sensors-based approaches is that the need to wear something (a glove) can be perceived as restrictive by humans [9], especially by the handicapped ones. This led to utilization of less limiting contact sensors based on the muscle tension sensing, such as MYO [10] or somehow simpler FIN [11]. FIN is not suitable for the sign recognition, but can be used to simplify control of electronic devices by a handicapped person.

Solutions that use contactless sensors are much less limiting and many research and development activities in this area use the Microsoft Kinect sensor [12]. A basic solution for this sensor is presented at [13] and it deals with Asian languages. The work [14] understands sign speech recognition on Kinect as recognition of individual signs. An interesting aspect of [14] is that its authors do not see a big difference between gesture recognition for deaf and mute persons and other gesture-based interfaces. Another promising solution for this kind of interface is [15], which has a potential to introduce modifications in the sign language, especially for HCI. The

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solution [16] is quite cheap and robust and focuses on a software support. The work [17] shows a potential of mobile devices in this area. Here a simple graphical application helps mute children to learn. Smartphones are also a promising platform for the both ways sign language translation.

Ideas presented in these works have been used to develop the set of tools introduced in this paper. The set can be seen as an extension of these solutions, which tries to deal with the following challenges:

- To create an implementation platform that will unite different sign language dialects. For now at least for Slovak republic.
- To deliver a software solution implemented on various platforms and using several technologies: desktop solution, mobile solution and utilization of data gloves and MS Kinect.
- To respect difficult economic situation of these persons by developing solutions as cheap as possible.
- To facilitate integration of handicapped persons into society.

III. VIRTUAL REALITY

A Virtual reality (VR) system is an interactive computer system, which creates an illusion of physical presence in a synthesized imaginary world. We can see a VR system as a tool providing a perfect simulation within the environment of tightly coupled human-computer interaction [2]. VR also includes teleoperation, telerobotics and other forms of telepresence and telecontrol.

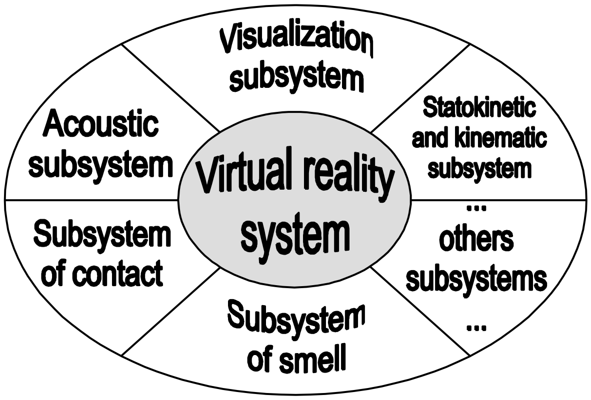


Fig. 1 Subsystems of virtual reality system

There are several levels of VR systems – from entry level, represented by ordinary personal computers, to fully immersive VR systems, which utilize special technologies [18] such as motion tracking systems, haptic devices or stereoscopic and see-through displays. A VR system can be seen as a composition of subsystems that focus on different senses or aspects of reality (Fig.1): visualization subsystem, acoustic subsystem, kinematics and statokinetic subsystem and subsystems of touch, contact and other senses (e.g. sense of smell, taste, pain or sensibility to pheromones). Which subsystems are present and how sophisticated they are depends on the level of given VR system. In addition, VR systems should be adjusted to the needs and limitations of their target groups. For example, the visualization subsystem, a standard for most VR systems, has little benefit for visually impaired persons while the subsystems of touch and contact are very important.

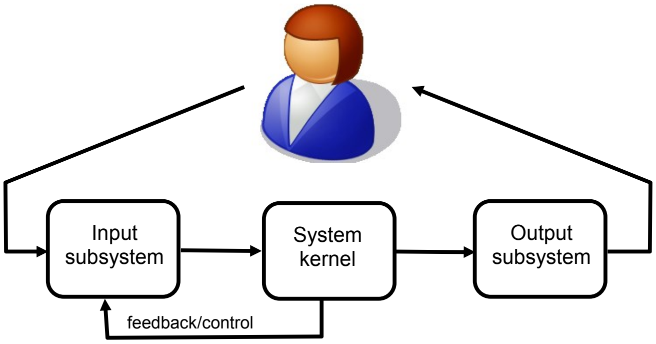


Fig. 2 Interaction in VR system

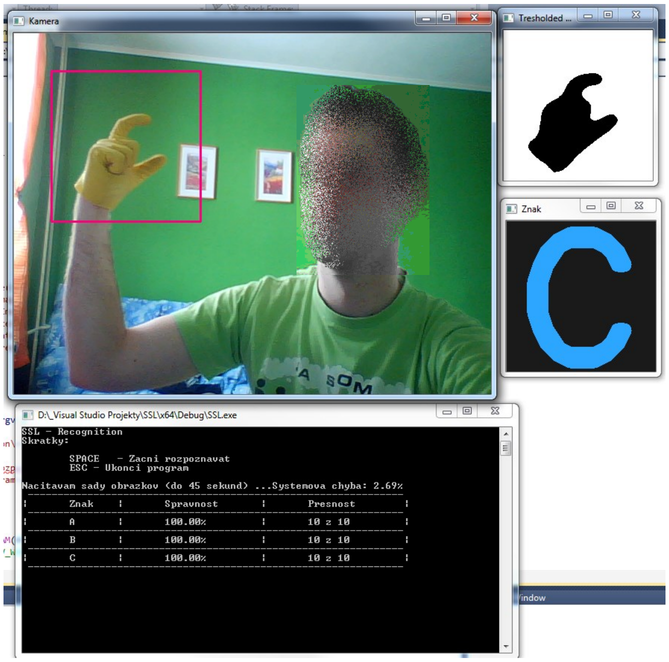
A high level VR system tries to fully immerse a user to a computer generated environment. This environment is maintained by a computer system, which graphical subsystem renders the virtual world. To achieve an effective immersion, the user's mind, and sometimes also the body, has to identify with the rendered environment. This requires a consistency between movements of the user and changes in the environment. Because the user usually only sees the virtual environment, there is no natural connection to it and such a connection have to be created. The basic system of interaction for VR is shown in Fig. 2. The quality of VR experience strongly depends on performance of underlying computer system. With increasing size and complexity of processed data and increasing output requirements more powerful and effective hardware and software is demanded. Another important trend in VR systems development is utilization of more and more interactive and intelligent user interfaces, which are more robust but also simpler from user's point of view [9]. This is also the case of handicapped persons [4], where modern information technologies can significantly help their integration to society.

IV. THE TOOLSET

In this section we present the set of tools we developed to assist in learning and recognition of the sign language. Considering the existing approaches and solutions, a practical implementation of gesture recognition is possible by means of:

1. image recognition,
2. data gloves,
3. contactless sensors such as MS Kinect,
4. muscle tension sensing and
5. EEG scanning.

Advantages of the first method are no need of contact sensors and use of standard devices such as smartphone or computer with a camera. Its disadvantages are a limited accuracy and a strong dependency on light conditions. The second method provides faster and more precise recognition but the need to wear additional equipment can annoy the user. The third method is fast, accurate and comfortable; however the sensors are usually not very portable and cheap. The last two approaches haven't been excessively studied and implemented at the home institution of the authors but they present promising areas for future development. For now we only experimented with single channel EEG.



D:_Visual Studio Projekty\SSL\x64\Debug\SSL.exe

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SSL - Recognition
Skratky:

        SPACE   - Zacni rozpoznavat
        ESC - Ukonci program

Nacitavam sady obrazkov (do 45 sekund) ...Systemova chyba: 2.69%
 ----------------------------------------------------------------
¦       Znak    ¦       Spravnost       ¦       Presnost        ¦
 ----------------------------------------------------------------
¦       A       ¦       100.00%         ¦       10 z 10         ¦
 ----------------------------------------------------------------
¦       B       ¦       100.00%         ¦       10 z 10         ¦
 ----------------------------------------------------------------
¦       C       ¦       100.00%         ¦       10 z 10         ¦
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Fig. 3 Desktop image recognition-based gesture translator

A. Image Recognition Based Gesture Translators

The first two tools in our set use image recognition technology to identify and translate individual gestures of the sign language. First of them is a desktop application, which gesture scanning and recognition subsystem is implemented by means of the Open Source Computer Vision (OpenCV, http://opencv.org/) library. After scanning and processing a gesture it is necessary to identify it, that is to assign a meaning to it. This is done by comparison of the scanned gesture with a database of known gestures. The system performs well in recognition of static gestures (i.e. gestures that don't involve movements), but is not very useful for dynamic ones (i.e. those involving movements). Fig. 3 shows the tool in the process of scanning and recognizing a gesture for the letter "C".

The second tool uses a mobile platform, namely an Android – based mobile device. Smartphones and tablets seem to be very handy for a sign language translator because people usually carry them everywhere. Use of this prototype tool can be seen on Fig. 4. Practical experiences with the tool confirmed handiness of the platform, but also revealed recognition speed limits. These were primarily connected to limited memory and performance of the platform and a need of good network connection required for access to a shared database of gestures.

Fig. 4 Gesture recognition using mobile platform

Both tools work with bare hand but speed and accuracy of the recognition process can be increased up to about 20% when the user wears a single colored glove. This is also the case of Fig. 3 and 4.

Fig. 5 Gesture recognition with the VHand glove

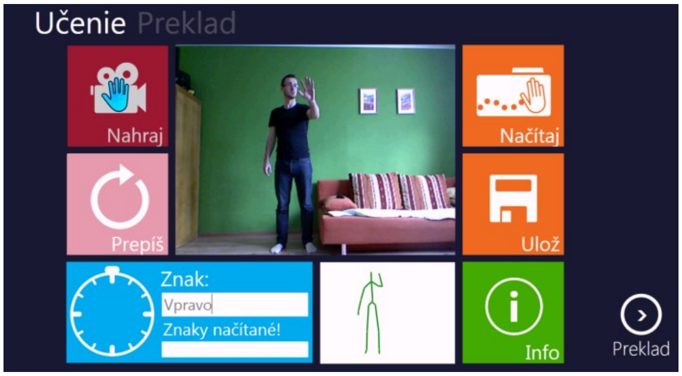
B. Data Gloves Based Tool

The third tool allows recognizing letter gestures by means of contact sensors, namely data gloves. It supports the commercially available DGTech DG5 VHand 2.0 (Fig. 5) and our own LIRKIS glove prototype (Fig. 6). Thanks to a build-in accelerometer (both gloves) and G-sensor (LIRKIS glove) it is also possible to recognize dynamic gestures. If two gloves are available the tool is also able to recognize two-hand gestures. The recognition is faster and more precise as in the previous two tools. This makes the tool suitable for teaching of the sing language, including automatic testing of pupils.

Fig. 6 LIRKIS glove prototype

C. *Contactless Gesture Recognition System*

The last tool we would like to present uses the Microsoft Kinect sensor [12] and its software development kit. We also considered the Leap Motion controller [19] but opted for Kinect because of its better availability and more widespread use in our area.



Znak:
Vpravo
Znaky načítané!

a)

b)

Fig. 7 Contactless gesture recognition tool in teaching mode: screenshot (a) and workplace (b).

The tool is a desktop application and can be run in two modes: gesture translation and gesture teaching. The second mode is used to teach the system new gestures. The Kinnect sensor not only recognizes the gestures but it can also be used for the control of the tool itself (similarly to Microsoft Xbox games). However, we are aware that even this form of control can be hard to handle for people with multiple handicaps and we plan to implement alternate means of interaction in the future.

When a user choses the teaching mode a screen with several possibilities appears (Fig. 7). Here the user can choose whether he wants to load a file with already defined gestures or to create a new file. Teaching a new gesture starts by typing its meaning in the blue box in the lower left corner of the screen. Then the user is given 3 seconds period to show the gesture. This recording period can be changed but it is sufficient for most gestures. The system records with 30 frames per second speed and each frame contains coordinates for body parts positions. These coordinates are then saved to a file and used in the translation mode for gesture recognition.

The gesture translation mode is shown in Fig. 8. Here the user shows gestures and the tool tries to recognize them on the basis of data recorded in corresponding file. As in the case of the teaching mode the most of the screen is occupied by the scanned image of the user (upper left part). The lower left part (red box) shows the meaning of a gesture just recognized, the white box next to it renders the skeleton of the user as perceived by the Kinect sensor and the right, dark grey, part hosts a list of recently recognized gestures.

Fig. 8 Contactless gesture recognition tool in translation mode

Because this version of the tool is primarily intended for pupils in the home country of the authors, its user interface (Fig. 7 and 8) is in Slovak. To better understand the interface we provide English translation in Table 1. The first column shows the Slovak word or words, used in the user interface, the second column is its English translation and the third column is more precise meaning of the word in the context of the tool.

Table 1 Meaning of Slovak words in Fig. 7 and 8

Slovak	English	Meaning
Učenie	Teaching	Names of basic modes of the tool.
Preklad	Translation	
Nahraj	Record	Starts teaching (recording) of a new gesture.
Prepíš	Rewrite	Rewrites last recording.
Znak	Gesture	Label for a text field with gesture meaning.
Vpravo	Right	Meaning of just recorded gesture.
Znaky načítané	Gesture recorded	Message that indicates successful recording of a new gesture.
Načítaj	Load	Loading and saving of the gestures file.
Ulož	Save	
Info	Info	Shows basic info about the tool.
Výsledok	Result	Result of last gesture recognition.
Rozumieť	To understand	Meanings of recently recognized gestures.
Deň	Day	
Ahoj	Hello	

V. CONCLUSION

In the work presented we focused on utilization of selected virtual reality technologies and algorithms as progressive means for better, faster and easier understanding and increasing of attractiveness of handicapped persons education in the areas with hardly manageable concepts. Our particular goals have been to create an experimental setting for practical evaluation of these technologies with subsequent application of achieved results into pedagogical practice by means of supporting software and hardware solutions. The results achieved are primarily aimed at people with multiple handicaps, in particular at deaf-mute persons. Originality of the results lies in its application to the environment of Slovak republic. The tools also try to use as cheap solutions as possible in order to bring these technologies to majority of handicapped persons where the economic situation is not very good. Some of the tools developed have been field-tested at Pavol Sabadoš special boarding school in Prešov, Slovakia. In the future we plan to develop more sophisticated learning environment on the basis of these tools. To achieve this we plan to utilize artificial intelligence technologies, such as expert systems and agent systems.

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