Abstract—Recently, knowledge engineers have begun to investigate the usage of artificial intelligence (AI) theories and approaches to develop a new generation of intelligent e-learning/training/educational systems. The main characteristics of such AI-based e-learning systems are the ability of inference, reasoning, perception, learning, and knowledge-based systems. This research demonstrates how learning systems can benefit from the innovative knowledge engineering techniques. In this paper we focus our discussion around the challenges faced by application developers and knowledge engineers designers in developing and deploying efficient and robust e-learning/education applications. Several specific examples show the applicability and efficacy of knowledge engineering techniques to e-learning in medical domain.

Keywords— knowledge engineering, e-learning, machine learning, medical e-learning, AI in education.

I. INTRODUCTION

E-learning represents a collection of e-services that employ digital media and information and communication technologies for supporting educational processes. E-learning is interdisciplinary area, encompassing many aspects of the educational technologies that cover instruction, training, teaching, learning, pedagogy, communication and collaboration. On the other side, the field of AI in education has become the most challenging area in the last several years. It includes the disciplines; cognitive and social psychology, computer science, empirical psychology, software and knowledge engineering[5] The goal of the field is to deliver computer-based systems (or knowledge-based software) which can be used in real teaching, learning and training situations.

Using AI concepts, theories and techniques, new forms of educational software can be created that allow the computer to act as an intelligent tutor. Such AI-based intelligent tutoring system (ITS) can adjust its tutorial to the student’s knowledge, experience, strengths, and weaknesses. It may even be able to carry on a natural language dialogue. In addition, automatic generation of exercises and tests is an important feature of ITS. Moreover, intelligent e-Learning systems (IeLS) are complex to build and complex to maintain. IeLS face the knowledge-acquisition difficulty. Efficiency of IeLS is based on the selection and determination of the appropriate knowledge representation techniques and reasoning methodologies. This paper discusses the benefits of knowledge engineering techniques for medical e-Learning systems. Also, the paper addresses the challenges facing the designing of the IeLSs.

II. KNOWLEDGE REPRESENTATION TECHNIQUES FOR INTELLIGENT E-LEARNING SYSTEMS

Knowledge can be a vague term. Research is still being done on about how can knowledge be represented so it can be manipulated and processed by a computer. From the knowledge engineering point of view, the main two components in developing an efficient and intelligent learning/educational system in any domain are the “knowledge base” and the “inference mechanism/engine”. Concerning the knowledge base, there are many knowledge representation and management techniques, e.g.; lists, trees, semantic networks, frames, scripts, production rules, cases, and ontologies[12]. The key to the success of such systems is the selection of the appropriate technique that best fits the domain knowledge and the problem to be solved. That choice is depends on the experience of the knowledge engineer. Regarding the inference engine, there are many methodologies and approaches of reasoning, e.g.; automated reasoning, case-based reasoning, commonsense reasoning, fuzzy reasoning, geometric reasoning, non-monotonic reasoning, model-based reasoning, probabilistic reasoning, causal reasoning, qualitative reasoning, spatial reasoning and temporal reasoning. In fact these methodologies receive increasing attention within the community of artificial intelligence in education. Fig 1 shows the different knowledge representation Techniques.

Fig 1(a) KR Techniques for static knowledge (Hierarchical Knowledge)

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A. Cases as knowledge representation for e-learning systems

The “case” is a list of features that lead to a particular outcome, e.g. the information on a patient history and the associated diagnosis. The complex form of the “case” is a connected set of sub-cases that form the problem solving task’s structure (e.g. The design of an airplane). Fig 2 shows the ideal components of the case. The “Case” composed of three major parts: (1) problem description, (2) solution, and (3) outcome. Problem description refers to the state of the world at the time the case is happening. Case solution refers to the stated or retrieved solution to the problem specified in the problem description. Case outcome defines the resulting state of the world when the solution was carried out. Depending on the case structure, the case can be used for a variety of purposes as shown in Fig 2.

Figure 2. Depending on the case structure, the case can be used for a variety of purposes

In e-learning systems, the case can include: (a) A multi-media description of the problem, (b) A description of the correct actions to take including optimal and alternative steps, (c) A multi-media explanation of why these steps are correct, and (d) A list of methods to determine whether students correctly executed the steps. Determining the appropriate case features is the main knowledge engineering task in case-based AI software[7]. This task involves defining the terminology of the domain and gathering representative cases of problem solving by the expert. Representation of cases can be in any of several forms (predicate, frames, scribes). Fig 3 shows one case of an Egyptian liver cancer case description.

Patient: 65-years old female not working, with nausea and vomiting.
Medical History: cancer head of pancreas.
Physical Exam: tender hepatomegaly liver, large amount of inflammatory about 3 liters, multiple liver pyogenic abscesses and large pancreatic head mass.
Laboratory Findings: total bilirubin 1.3 mg/dl, direct bilirubin 0.4 mg/dl, sgot (ast) 28 IU/L, sgpt (alt) 26 IU/L.

Figure 3: Example of an Egyptian liver cancer case description[1]

B. Ontological Approach

The term “ontology” is inherited from philosophy, in which it is a branch of metaphysics concerned with the nature of being. It began being used in AI in the 1980s, and is now frequently used by computing and information science communities. Ontological Engineering refers to the set of activities that concern the ontology development process, the ontology life cycle, the methods and methodologies for building ontologies, and the tools suites and languages that support them. During the last decade, increasing attention has been focused on ontologies [2]. At present, there are applications of ontologies with commercial, industrial, medical, academic and research focuses [13]. Ontologies’ usage in learning and educational systems may be approached from various points of view: as a common vocabulary for multi-agent system, as a chain between heterogeneous educational systems, ontologies for pedagogical resources sharing or for sharing data and ontologies used to mediate the search of the learning materials on the internet [25].

The abstract specification of a system is composed of functional interconnected elements. These elements communicate using an interface and a common vocabulary. The online instructional process can be implemented successfully using artificial Intelligence techniques. Sophistical software programs with the following features give the intelligence of the machine: adaptability, flexibility. Learning capacity, reactive capacity, autonomy, collaboration and understanding capacity. This approach enables to solve the complexity and the incertitude of the instructional systems. An intelligent learning system based on a multi-agent approach consists in a set of intelligent agents, which have to communicate. They collaborate through messages. Software agents can understand and interpret the messages due to a common ontology or the interoperability of the private ontologies. Figure 4 shows the breast cancer ontology encoded in OWL-DL format using the Protégé-OWL editing environment [3]. From this figure, it can be seen that, The breast cancers are described in terms of its symptoms, causes, stages, pathological category, diagnosis and treatment. In this context, we described causes, stages, and symptoms as
references. While diagnosis and treatment are described as medical interventions.

Figure 4: The Developed Breast Cancer Ontology [2].

III. DATA MINING APPROACH FOR E-LEARNING SYSTEMS

A. Data Mining Concepts

Data mining deals with the discovery of hidden knowledge, unexpected patterns and new rules from large databases [5]. Data mining (DM) and knowledge discovery (KD) is not a coherent field, it is a dwells upon already well established technologies including data cleaning, data preprocessing, machine learning, pattern recognition, statistics, neural networks, fuzzy sets, rough sets, clustering, etc. KD in databases process involves the following three processes; (i) using the database along with any required selection, preprocessing, sub-sampling, and transformations of it, (ii) applying DM methods (algorithms) to enumerate patterns from it, and (iii) evaluating the products of data mining to identify the subset of the enumerated patterns deemed knowledge. The data mining components of the KD process is concerned with the algorithmic means by which patterns are extracted and enumerated from data [6]. The overall KD process includes the evaluation and possible interpretation of the mined patterns to determine which patterns can be considered new knowledge. Fundamental issues in KD arise from the very nature of databases and the objects (data) they deal with. They are characterized as follows: (a) huge amounts of data, (b) dynamic nature of data, (c) incomplete or imprecise data, (d) noisy data, (e) missing attribute values and (f) redundant or insignificant data. Table 1 shows the DM tasks and the appropriate techniques for each task.

B. Benefits of Data Mining Approach in e-Learning

Recently, researchers have begun to investigate various DM methods to help instructors and administrators to improve e-learning systems [10], [14]. These methods discover new, interesting and useful knowledge based on students’ usage data. Some of the main e-learning problems or subjects to which data mining techniques have been applied are dealing with the assessment of student’s learning performance, provide course adaptation and learning recommendations based on the students’ learning behavior, dealing with the evaluation of learning material and educational web-based courses, provide feedback to both teachers and students of e-learning courses, and detection of atypical student’s learning behavior.

In what follows, we can summarize the benefits of clustering and classification in e-learning. Clustering has been used for the following e-learning tasks:

i. Finding clusters of students with similar learning characteristics and to promote group-based collaborative learning as well as to provide incremental learner diagnosis.

ii. Discovering patterns reflecting user behaviors and for collaboration management to characterize similar behavior groups in unstructured collaboration spaces.

iii. Grouping students and personalized itineraries for courses based on learning objects.

iv. Grouping students in order to give them differentiated guiding according to their skills and other characteristics.

v. Grouping tests and questions into related groups based on the data in the score matrix.

vi. Grouping users based on the time-framed navigation sessions.

While, classification has been used to perform the following e-learning tasks:

i. Discovering potential student groups with similar characteristics and reactions to a specific pedagogical strategy.

ii. Predicting students’ performance and their final grade.

iii. Detecting students’ misuse or students playing around.

iv. Predicting the students’ performance as well as to assess the relevance of the attributes involved.

v. Grouping students as hint-driven or failure-driven and finding students’ common misconceptions.

vi. Identifying learners with little motivation and finding remedial actions in order to lower drop-out rates.

vii. Predicting course success

Data mining is a very promising approach towards the analysis of the data of student activities and behavior which accumulated by learning management systems. Data mining techniques can enhance on-line education for the educators as well as the learners. The big challenge in this respect is, while some tools using data mining techniques to help educators and
learners are being developed, the research is still in its infancy. Most of the current data mining tools are too complex for educators to use their features go well beyond the scope of what an educator might require.

<table>
<thead>
<tr>
<th>Data Mining Task</th>
<th>Data Mining Algorithm &amp; Technique</th>
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</thead>
<tbody>
<tr>
<td>Clustering</td>
<td>K-means</td>
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<tr>
<td>Classification</td>
<td>Support Vector Machines, Decision Trees, Neural Network, Rule induction, Genetic Algorithms</td>
</tr>
<tr>
<td>Regression and prediction</td>
<td>Support Vector Machine, Decision Trees, Rule induction, NN</td>
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<tr>
<td>Association and Link Analysis (finding correlation between items in a dataset)</td>
<td>Association Rule Mining</td>
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<tr>
<td>Summarization</td>
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</tr>
</tbody>
</table>

B. Benefits of CBR approach in e-Learning Systems

The idea of CBR is becoming popular in developing intelligent eLearning systems because it automates applications that are based on precedent or that contain incomplete causal models. Research reveals that students learn best when they are presented with examples of problem-solving knowledge and are then required to apply the knowledge to real situations. The case-memory of examples and exercises capture realistic problem-solving situations and presents them to the students as virtual simulations. On the other hand, there are several benefits where students/learners should be able to perform better using CBR methodology, e.g.,

1. With more cases available, students will be able to recognize more situations and he solutions that go with these cases include failure cases, students will be able to benefit from the failures of others.
2. Retrieval cases will allow students to better recognize what is important in a new situation. Cases indexed by experts would recall and will show the student ways of looking at a problem that he might not have the expertise for without the system.
3. Student will have access to obscure cases that they otherwise would not able to make use of. These obscure cases can help with any of the tasks previously listed.
4. During a training period CBR system provides the student with a model of the way decision making ought to be done, for example, what things ought to be considered and provides them with concrete examples on which to hang their more abstract knowledge.
5. For tasks where there is much to remember, CBR systems can augment the memories of even educators. Also, both educators and students tend to focus on too few possibilities when reasoning analogically or to focus on the wrong cases.

IV. Case Based Reasoning (CBR) for E-Learning Systems

A. CBR Concept

CBR means reasoning from experiences or “old cases” in an effort to solve problems, critique solutions, and explain anomalous situations[7,8]. CBR is an analogical reasoning method provides both a methodology for building case-based reasoning systems, and a cognitive model of people. It is consistent with much that psychologist have observed in the natural problem solving that people do. CBR is a preferred method of reasoning in dynamically changing situations and other situations where solutions are not clear cut. From the Psychological Point of, CBR refers to reasoning in which a human problem-solver relies on previous cases that he or she has encountered.

From the computational perspective, CBR refers to a number of concepts and techniques (e.g. data structures and algorithms) that can be used to perform the following operations: (a) record and index cases, (b) search cases to identify the ones that might be useful in solving new cases when they are presented,(c) modify earlier cases to better match new cases, and (c) synthesize new cases when they are needed.

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V. Agent-Based Approaches for E-Learning

Intelligent agents (IAs) are artificial entities that have several intelligent features, such as being autonomous, responding adequately to changes in their environment, persistently pursuing goals, flexible, robust, and social by interacting with other agents. IA mimics human interaction types, such as negotiation, coordination, cooperation, and teamwork.

IAs are defined as computer systems situated in an environment and that are able to achieve their objectives by: (i) acting autonomously, i.e. by deciding themselves what to do, and (ii) being sociable, i.e. by interacting with other software agents. Agents are often seen as incarnations of various forms of AI including machine learning, reasoning and data mining. Research interests in agent systems are spanning various topics like modeling, design and development of advanced software systems that are appealing for a number of computer applications.

During the last decade, agent technologies were proposed to enhance e-learning systems across at least two dimensions: (i) agents as a modeling and design paradigm for advanced human-computer interaction and (ii) agents for smart functional decomposition of complex systems.

Firstly, agents have been described as entities that exhibit several interesting properties that are very appealing for the
modeling and design of advanced user interfaces encountered in e-learning systems: teachers, tutors and students.

Secondly, generic agent types proven to be effective for the appropriate functional decomposition of e-learning systems. Dynamic and interoperability characteristics of agents are very suitable for supporting maintainability and extensibility of e-learning systems.

VI. CONCLUSIONS

In this concluding part, we identify some of the major open problems that must be addressed to ensure the success of developing robust intelligent e-learning systems. In summary, the development of intelligent e-Learning/educational systems is a very difficult and complex process that raises a lot of technological and research challenges that have to be addressed in an interdisciplinary way. Today's the fusion of computational intelligence and machine learning techniques with the knowledge acquisition techniques solves many of the technical problems and difficulties in designing new generation of intelligent e-Learning/educational systems. Further research however is needed to convergence the knowledge engineering, artificial intelligence, machine learning, educational technology with the web science. Such convergence will create a new generation of web-based intelligent e-learning and tutoring systems. The web based of such systems can enhance the online education/learning/training processes through the web. On the other hand, Intelligent agents technology, as a modern version of AI, where knowledge representation is enhanced with learning and social interaction. In the current environment of global wired and wireless networks, IAs may play the role of a universal carrier of distributed AI. So, the integration of software agents approaches and educational technologies is beneficial for designing efficient, robust and intelligent e-learning systems. In addition, ensuring the success of such systems to the cloud is an important challenge.

REFERENCES


