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ABSTRACT

The field of Artificial Intelligence (AI) and Education has traditionally a technology-based focus, looking at the ways in which AI can be used in building intelligent educational software. In addition AI can also provide an excellent methodology for learning and reasoning from the human experiences. This paper presents the potential role of AI in the various aspects of education. Six AI fields are presented. The first presents the knowledge representation (KR) which includes ontologies; new concepts for representing, storing and accessing knowledge; and schemes for representing knowledge. The second is related to the use of Case-Based Reasoning (CBR) methodology in developing interactive intelligent educational systems for learning and teaching. The third topic is related to the use of Natural Language Processing (NLP) for analyzing the educational Web pages. The fourth is concerned with the Intelligent Tutoring Systems (ITSs), which are capable of adaptive instruction by means of multiple representations of domain knowledge. The fifth is the Intelligent Tutoring System Authoring Sheels (ITSASs), which allow a course instructor to easily enter domain and other knowledge without requiring computer programming skills. The last area deals with the learning in Distributed Artificial Intelligence (DAI). Moreover, the paper will explore a proposal for a master's degree in artificial intelligence in education. (Author)

The Potential Role of Artificial Intelligence Technology in Education

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The Potential Role of Artificial Intelligence Technology in Education.

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ABSTRACT

The field of Artificial Intelligence (AI) and Education has traditionally a technology-based focus, looking at the ways in which AI can be used in building intelligent educational software. In addition AI can also provide an excellent methodology for learning and reasoning from the human experiences. This paper presents the potential role of AI in the various aspects of education. Six AI fields are presented. The first presents the knowledge representation (KR) which includes ontologies; new concepts for representing, storing and accessing knowledge; and schemes for representing knowledge. The second is related to the use of Case-Based Reasoning (CBR) methodology in developing interactive intelligent educational systems for learning and teaching. The third topic is related to the use of Natural Language Processing (NLP) for analyzing the educational Web pages. The fourth is concerned with the Intelligent Tutoring Systems (ITSs), which are capable of adaptive instruction by means of multiple representations of domain knowledge. The fifth is the Intelligent Tutoring Systems Authoring Sheels (ITSASs), which allow a course instructor to easily enter domain and other knowledge without requiring computer programming skills. The last area deals with the learning in Distributed Artificial Intelligence (DAI). Moreover, the paper will explore a proposal for master degree in artificial intelligence in education

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Introduction:

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, artificial intelligence, computer science, empirical psychology, software engineering and education. 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.
The paper is structured as follows, section 2 presents a brief overview of the knowledge representation schemes and some learning concepts for representing episodic information. The importance of case-based reasoning methodology in teaching and training systems is discussed in section 3. Section 4 gives a brief discussion of the role of the natural language processing in the internet-based learning systems. Sections 5 and 6 are dedicated to the intelligent tutoring systems and authoring shells respectively. The area of learning in distributed artificial intelligence systems is discussed in section 7. In section 8, the paper presents a proposal for master degree in IA in education. Finally, section 9 summarizes the paper and raises some conclusions.

Knowledge Representation and Learning Concepts:

The two main parts of any AI software (or any AI-based educational software) are (1) a knowledge base and (2) an inferencing system. The knowledge base is made up of facts, concepts, theories, procedures and relationships representing real world knowledge about objects, places, events, people, etc. The inference system or thinking mechanism is a method of using the knowledge base, that is, reasoning with it to solve problems.

Knowledge Representation Schemes:

To build the knowledge base, a variety of knowledge representation schemes are used including logic, lists, trees, semantic networks, frames, scripts and production rules (See figure 1).

Declarative KR Schemes	Procedural KR Schemes
Are used to represent facts and assertions, e.g. Logic Semantic networks. Frames. Scripts.	Deal with actions or procedures, e.g. Subroutines Production rules

Figure 1: Knowledge Representation Schemes

Learning Concepts of Representing Episodic Knowledge:

Schank (1982) has advanced a number of concepts to deal with text analysis, human memory, and learning. Schank's concepts include: Script, Memory Organization Packets (MOP), and Reminding and Explanation Patterns (XPS). A brief overview of each of these concepts is presented in this section.

Scripts: Scripts accounted for information about stereotypical events, (e.g. going to a restaurant, taking a bus and visiting the dentist). In stereotypical event (common situations) a person has a set of expectations concerning the default setting, goals, props, and behaviors of the other people involved. Scripts are inherently episodic in origin and us, i.e., scripts arise from experience and are applied to understand new events. The acquisition of script is the result of repeated exposure to a given situation. (e.g. children learn the restaurant script by going to restaurant over and over again). As a psychological theory of memory, scripts suggested that people would remember an event in terms of its associated script.

Memory Organization Packets: MOP is a more general knowledge structure accounts for the diverse and heterogeneous nature of episodic knowledge. MOPs can be viewed as metascripts; e.g. instead of a dentist script or a doctor script, there might be a professional-office-visit MOP that can be instantiated and specified for both the doctor and dentist episodes. This MOP would contain a generic waiting room scene, thus providing the basis for confusion between doctor and dentist episodes.

Reminding and Explanation Patterns: Schank (1986) proposed a theory of learning based on reminding. The main features of this theory can be summarized in the following points.

(1) Conform-Driven Learning: When the new situations (or experiences) conform the past cases and events. Thus, we can classify a new episode in terms of past cases. The knowledge of the past case, like a script, can guide our behaviour.

(2) Failure-Driven Learning: When the new situations does not conform to the prior case, we have a failure. That is, we had an expectation based on a prior event that did not occur in the new situation. Thus, we must classify this new situation as different from the previous episode, we must remember this new experience and we must learn.

(3) Discrepancy-Driven Learning: When we observe a discrepancy between our predictions and some event. Thus, we have something to learn and we need to revise our knowledge structure.
The mechanism for updating our knowledge often requires explanation. Schank proposed an explicit knowledge structure, called "explanation patterns", that is used to generate, index, and test explanations in conjunction with an episodic memory.

Case-Based Reasoning (CBR):

The field of reasoning is very important for the development of AI-based educational software. The research area in this field covers a variety of topics (See Fig. 2). This section is dealing with the case-based reasoning which receives increasing attention within the AI in education community.

Automated reasoning.	Model-based reasoning.
Case-based reasoning.	Probabilistic reasoning.
Commonsense reasoning.	Causal reasoning.
Fuzzy reasoning.	Qualitative reasoning.
Geometric reasoning.	Spatial reasoning.
Nonmonotonic reasoning.	Temporal reasoning.

Figure 2: Reasoning Techniques

CBR is a general paradigm for reasoning from experience. It assumes a memory model for representing, indexing, and organizing past cases and a process model for retrieving and modifying old cases and assimilating new ones (Kolodner, 1993; Barletta, 1991; Salde, 1991). CBR has already been applied in a number of application areas, such as legal reasoning, dispute mediation, and customer support. A typical functional diagram of a CBR system is shown in Figure 3, adapted from Salde (1991). When a new problem is introduced in the system, the problem is indexed, and subsequently, the indexes are used to retrieve past cases from memory. These past cases lead to a set of prior solutions. Subsequently, the previous solutions are modified to adapt to the new situation. Then the proposed solution is tried out: If the solution succeeds, then it is stored as a working solution; if it fails, the working solution must be repaired and tested again.
CBR community have began to build CBR systems in education. (Kolodner, 1995). Examples of case-based educational and training systems are:
Schank's ASK systems (Ferguson, et al., 1992) take on the role of expert and guide a user dialog in which the system tells stories to make its points.
Archie-2 (Domeshek & Kolodner, 1993), is used in several architecture studios at Georgia Tech to help student designers with their projects.
Design Muse authoring tool (Domeshek, et al., 1994), is used in classes as well, both to build useful case libraries for several of engineering calsses and to give students the opportunity to learn more about some area by preparing and indexing well-articulated cases.
CBTS (Salem, 1997), is used for automatic generation of educational web pages for teaching sea creatures.
TAO is used for training Navy Tactical Action Officers in making effective tactical decision under battle conditions (AI @work, 1999).

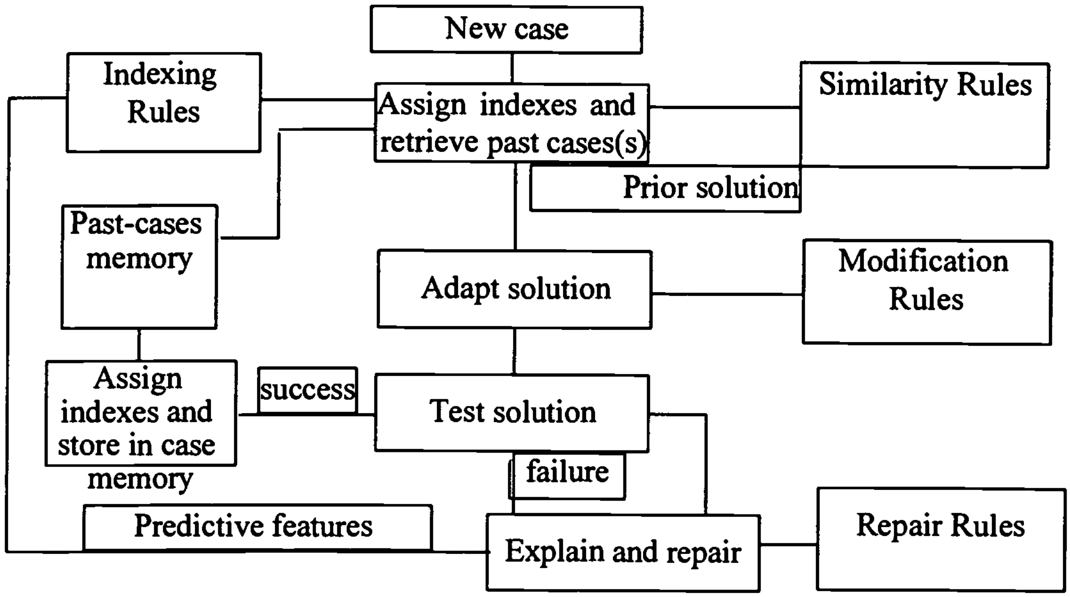

Figure 3. Case-based reasoning flow chart. Boxes represent processes and ovals knowledge structure.

Natural Language Processing (NLP):

NLP has become one of the most challenging area in the last several years. The research covers the fields: corpus-based methods, discourse methods, formal models, machine translation, natural language generation, natural language understanding, spoken language generation and spoken language understanding. NLP techniques, based on syntax and semantics of natural languages, play essential role in the internet-based learning systems and analyzing the educational web pages. The following research problems are very important:

- NLP for improved precision in document retrieval.
- Natural language interfaces for better document search.
- Semantic indexing of web pages.
- Summarization and information extraction.
- Machine translation of foreign-language web pages.
- Question answering on the web.
- Speech interfaces to web services.
- Dynamic creation of web pages using natural language generation techniques.
- The nature of the web for linguistic processing.
- Automatic creation of hypertext links between related passage

Intelligent Tutoring Systems (ITSs):

ITSs are smart computer tutors and typically have an expert model, student model, instructional module, and interface. ITS must organize their knowledge in a lesson-oriented manner. This organization must be dynamically adjusted by the system according to student models. Automatic generation of exercises and tests is an important feature of ITS. Additionally, ITS enhances instructor productivity, enabling them to cope with generating more complex training systems required to provide higher skill levels to today's high-tech trainees. It also provides tailored instruction and remediation, while allowing flexibility in teaching methods, achieving many of the same benefits as one-on-one instruction. ITS face the knowledge-acquisition difficulty, productivity of ITS development is determined by the efficiency of their knowledge methods/facilities.

ITS may have their greatest impact in complex or "enigmatic" domains Koedinger (1991). These are learning domains which typically use notation or other means of representation that do not promote problem solutions and which typically are not transparent in their use (e.g., geometric proofs). As computer programs are able to offer students alternative mental models for representing mathematical concepts, power and flexibility will be afforded the student in problem solving (ANGLE and OPERA are good examples). ANGLE (Koedinger, 1991) is a geometric proof tutor which emphasizes student use of schemas in addition to knowledge of rules. Students are encouraged to parse geometric diagrams into meaningful chunks, or Diagram Configuration schemas, which can assist them in planning their proofs. OPERA (Schwarz, 1992) is an environment in which students can investigate the properties of algebraic operators. Through the use of various schematic representations, students are able to form mental models of concepts such as mappings, functions, and structures of algebraic expressions.

Intelligent Tutoring Systems Authoring Shells (ITSASs):

An ITSAS has been developed that allows a course instructor to easily enter domain and other knowledge without requiring computer programming skills. The authoring shell automatically generates an ITS focusing on the specified knowledge. It also facilitates the entry of examples/exercises, including problem descriptions, solutions steps, and explanations. The examples may be in the form of scenarios or simulations. It allows organized entry of the course principles and the integration of multi-media courseware (developed with well-known authoring tools) which includes descriptions of the principles or motivational passages. In addition to course knowledge, the instructor specifies pedagogical knowledge (how best to teach a particular student), and student modeling knowledge (how to assess actions and determine mastery).

The most recent ITSAS are DIAG, RIDES-VIVIDS, XAIDA, REDEEM, EON, INTELLIGENT TUTOR, D3 TRAINER, CALAT, INTERBOOK, and PERSUADE (Redfield, 1998). Some tools were meant for select authors or students and others were designed for a wide set of authors. Some tools were designed to work with a limited area of domain expertise, and some were designed for a wide range of domains. Some tools had one main instructional strategy, but others had many. Each tool had their own way of representing the student's knowledge and understanding of the material being taught. Some tools generated instruction directly from domain knowledge. Some relied on pedagogical knowledge about the domain to create instruction. Some provided simulation environments for practice and exploration. For example, KONGZI (Lu et al., 1995) is an automatic generation tool and composed of two main systems: knowledge acquisition system and ITS generation system. Using KONGZI, Lu et al. (1995) developed three systems of domains: mineralogy, medicine and botany. The first system for detecting and processing faults of drills; the second one is for teaching diagnosis of heart diseases; and the third is a system of teaching botanical classification.

Distributed Artificial Intelligence (DAI):

DAI is concerned with the study and design of systems consisting of several interacting entities which are logically and often spatially distributed and in some sense can be called autonomous and intelligent. Two primary types of DAI systems can be distinguished (Weiβ, 1996): distributed problem solving and planning systems, where the emphasis is on task decomposition and solution synthesis and multi-agent systems, where the emphasis is on behavior coordination. Many DAI systems of both types have been described in the literature, differing from each other in the entities involved (e.g., with respect to their number, the number of goals pursuit by them, their degree of autonomy, and their perceptual, cognitive and effectual skills) as well as in the interactions between the entities (e.g., with respect to frequency, level and purpose). Examples of DAI systems are collections of communicating expert systems and teams of cooperating assembly robots.
DAI systems typically are very complex and hard to specify in their dynamics. It is therefore commonly agreed that they should be equipped with the ability to learn, that is, to automatically improve their future performance. Today the area of learning in DAI systems receives steadily increasing attention within both the DAI and the machine learning (ML) communities. Fig. (4) shows the main aspects of the ML from AI point of view.

Analogical learning.	Inductive learning.
Bayesian learning.	Inductive logic programming.
Case-based learning.	Multistrategy learning.
Computational learning theory.	Reinforcement learning.
Connectionist learning.	Speedup learning.
Constructive induction.	Scientific discovery.
Decision-tree learning.	Theory refinement.
Explanation based learning.	Unsupervised learning.

Fig. (4): Machine learning area from AI point of view

A Proposal For Master Degree in Artificial Intelligence in Education:

This section presents a proposal for Master degree in "AI in education". The suggested topics of the program is based on the analysis of the abstracts of about 600 papers of the last four world conferences on "Artificial Intelligence in Education (AI-ED" which held during the period 1993 - 1999. The program consists of core courses, specialization tracks, and thesis. The total duration of the program is two-year (4 semesters). The first two semesters for theoretical study (equivalent 10 courses / 5 courses per semester) in addition graduate seminar and practical training. Semesters 3 and 4 for project and writing a thesis.

- Core Courses: (9 credits; 3 courses to be selected):
- Knowledge representation and Knowledge-Based Technology.
- Natural Language Processing.
- Reasoning Methodologies.

- Learning and Planning.
- Specialisation Tracks
- (18 credits, 2 courses from each track and 1 additional course in a track of specialisation plus graduate Seminar and practical training).
- First Track: Intelligent Tutoring Systems and Authoring Sheels
- Principle/Tools for Instruction Design.
- Collaboration Tools and Techniques.
- Evaluation of Instruction Systems.
- Authoring Systems and Tutoring Shells.
- Second Track: Intelligent Interfaces
- Visual and Graphical Interfaces.
- Human Factors and Interface Design.
- Non-Standard and Innovative Interfaces.
- Natural Language Interfaces.
- Third Track: Teaching Strategies and Student Modelling
- Theories of Teaching and Motivation.
- Student Modelling and Cognitive Diagnosis.
- Social and Cultural Aspects of Learning.
- Cognitive Issues in Knowledge Acquisition and Evaluation.

Conclusion and Summary:

Knowledge representation technology presents a number of learning concepts and techniques for representing the episodic information.
CBR methodology extends the power of ITSs. Case-based intelligent tutoring systems help students to analyze and repair their solutions. Also ITSs can analyze the outcomes to provide an accounting of why the proposed type of solution succeeded or failed.
NLP can contribute significantly as an effective interface for stating hints to educational algorithms and explaining knowledge derived by the intelligent tutoring and training systems. Also, NLP techniques, based on the syntax and semantics of natural languages, could improve the efficiency of the internet-based learning systems on the web.
ITS have their greatest impact in enigmatic learning domains. These domains use notation or other means of representation that do not promote problem solutions and typically are not transparent in their use. (e. g. geometric proofs)
ITSAS allows easy development and maintenance of training systems which are based on pedagogically sound instructional strategies. The software is domain-independent and thus useful for creating a wide array of intelligent tutoring systems for a variety of domains.
DAI technology offers a useful opportunity to distribute training across multiple sites while dramatically reducing travel-related training costs.
Machine learning area focus on developing algorithms that allow computers to refine the knowledge they are given and to learn from experience. In addition ML techniques could improve the search and retrieval accuracy and efficiency of the educational web pages.

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