A REVIEW OF INTELLIGENT TUTORING SYSTEMS IN E-LEARNING

Predrag DAŠIĆ1,2, Jovan DAŠIĆ2, Bojan CRVENKOVIĆ2, Veis ŠERIFI2
1High Technical Mechanical School of Professional Studies, Trstenik, dasicp58@gmail.com
2SaTCIP Publisher Ltd., Vrnjačka Banja

Abstract—An ITS (Intelligent Tutoring System) is a complex, integrated software system that applies the principles and methods of artificial intelligence (AI) to the problems and needs of teaching and learning. They allow searching the student level of knowledge and learning strategies used to increase or correct the students' knowledge. They are intended to support and improve the teaching and learning process in a selected area of knowledge while respecting the individuality of the learner. In the paper a review of intelligent tutoring systems (ITS) is given from the aspect of their application and usability in modern learning concepts.

Keywords—Intelligent Tutoring System, Education, e-learning

I. INTRODUCTION

In order to support the learning process of traditional teaching, or as a replacement for such a teaching with one of the new methods and ways of realization of the teaching learning process, information and communication technologies have become an essential part of the system. In that direction, multimedia, computer networking and programming engineering, have led to the emergence of a new generation of computer systems to learn. Modern information technology, especially computer networks, intranet, internet, and in particular hypermedia together contributed to the establishment of Advanced Learning Technology (ALT), Budin [1], Murray [2], Phobun and Vicheanpanya [3], Rosatelli and Self [4], Zhang, Ren and Chen [5].

The new educational paradigm is oriented towards students or in other words learner-centered paradigm, Bruce and Bruce [6], Handa [7], Reigeluth, Aslan, Chen, Dutta, Huh, Lee et al. [8]. The student is placed in the center, while the surrounding learning resources (people, knowledge, technology, media, organizations, etc.) in terms of time, place and manner of learning (Fig. 1).

Fig. 1. The transition from traditional to new advanced teaching paradigm

Services of World Wide Web (WWW), primarily informational, allowed the formation of thousands of systems that can be considered as direct applications of information technology. Due to their limited opportunities for learning, which is based on a static view of the teaching content, a good part of the system should be able to be increased by adding interactive, adaptable and intelligent functions.
Web content that is dynamically generated can be utilized for the implementation and response. Using these technologies enables the development of tutoring shells for building intelligent tutoring systems (ITS), and access is provided by standard Web browsers. Web based intelligent tutoring systems have been discussed in papers by Nakabayashi, Koike, Maruyama, Touhei, Ishiuchi and Fukuhara [9].

The term e-learning paradigm does not put out the use of existing application software, on the contrary, examples of student administration, human resources, business administration, are critical components of e-learning environment that poses a real challenge to all existing applications to be integrated into the service e-learning. Today there are various classifications and different names are applied for open, flexible and distributed activities in the process of teaching and learning, which includes, Brusilovsky [10], Brusilovsky, J. Eklund, and E. Schwarz [11], Brusilovsky and Peylo, [12], Dašić, Dašić and Šerifi [13], Dašić Nedeff and Šehović [14], Phobun and Vicheanpanya [3], Reigeluth et al. [8], Wasson [15]: Advanced Distributed Learning (ADL), Adaptive Hypermedia (AH), Distance Learning (DL), Distributed Learning (DL), Electronic Learning (e-Learning) (Web site: http://elearning.europa.info/), Intelligent Learning Environments (ILE), Learning Content Management Systems (LCMS), Learning Environments (LE), Learning Management Systems (LMS), Mobile Learning (m-learning), Online Learning (OL), Open and Distance Learning (ODL), Remote Learning (RL), Tele-Learning (TL), Virtual Learning Environments (VLE), Web-Based Education (WBE), Web-Based Instruction (WBI), Web-Based Learning (WBL), Web-Based Training (WBT) or Internet-Based Training (IBT), Web-Based Learning Environments (WBLE or WLE), Web-Based Virtual Learning Environments (WB-VLE or WVLE) etc.

II. INTELLIGENT TUTORING SYSTEMS (ITS)

Intelligent tutoring systems (ITS) are complex, integrated software systems that apply the principles and methods of artificial intelligence (AI) to the problems and needs of teaching and learning. They enable searching models of student level of knowledge and use learning strategies to increase or correction of students' knowledge. They are based on the development and implementation of methods and techniques of artificial intelligence (AI), and on that basis the context and method of teaching presentations of topics can adjust to individual abilities of the students. They are intended to support and improve the teaching and learning process in the chosen field of knowledge while respecting the individuality of the learner.

Scientific field of research of artificial intelligence started in 1970s Zhang, Ren and Chen [5], intelligent tutoring systems are a direct product of such research. ITS is an informed process which supplies individualized tutoring or net established guide for scholars and is established on smart retailers. One of these procedures can respect the pupil characteristics like skills, behavior, and even emotions.

Traditional intelligent tutoring systems (ITSs) are focused on the area advantage they are imagined to reward and train, thus their management mechanisms are often domain based more up to date ITSs pay extra attention to well-known problems and concepts of the tutoring approach, trying to separate architectural, methodological, and manipulate disorders from the domain expertise as so much as viable. The mainstream of present study in the discipline is dominated with the aid of problems like collaborative studying, internet-established instructing and finding out, pedagogical agents, and the like Brusilovsky, Eklund and Schwarz [11], Vassileva [16].

ITSs are based on knowledge because they have:

1) knowledge they have about the domain knowledge;
2) knowledge of the principles by which the is taught;
3) Methods by which to apply these principles and knowledge of methods and techniques for modeling the flow of students to acquire knowledge and skills.

The traditional intelligent tutoring system (ITS) was built based on four interrelated software modules (Murray [17], Phobun and Vicheanpanya [3], Polson and Richardson [18], Psopta, Massey and Mutter [19], Sleeman and Brown [20], Zhang, Ren and Chen [5]), and they are:

1) Student module (SM) (student knowledge - dynamic model of acquiring knowledge and skills of students) covers all aspects of the student's acquisition of knowledge and skills in a given domain knowledge. Student module is the holder of students modeling procedure, which includes a student model and diagnostics of students' knowledge. Student model is a collection of data that shows the current level of knowledge and skills, while the diagnostic process controls such data and works with them in the evaluation of students' knowledge;
2) Teacher module (TM) (tutoring skills), the unit for controlling the process of acquiring knowledge and skills of students. In this sense, the teacher module is the holder of scenarios for teaching and pedagogical knowledge possessed by the “live” teacher;
3) Domain module (DM) (expert knowledge), as the holder of the domain knowledge, with which during learning and teaching the student will communicate. Expert module is "... the crown of every intelligent tutoring system" Anderson, [21] and
4) User Interface (UI) or Communication module
(CM) (system and the environment of students learning process - interaction "student-teacher-knowledge"), a global principle represents the principle of students and intelligent tutoring systems.

ITS was first mentioned as a term artificial intelligence (AI) for computer-aided instruction (CAI) in 1970 by Carbonell [22], in the development of the SCHOLAR system is the initial step in this area and therefore, quite often, in many discussions Carbonell [22] is called the "father" of intelligent systems for teaching and learning. A little later, in 1982, Sleeman and Brown [20], point out that the meaning of the term ITS, is identical with the meaning of the term ICAI (Intelligent Computer-Aided Instruction).

E-learning was introduced for the first time during the sixties, when a wide group of experts noticed the educational potential of computers (primarily psychologists and pedagogues), and engineers the possibilities of application, so that their research can be seen by observing them as:

1) group with the engineering approach, or applied researchers which today can be attributed to the merit of developing a system of teaching based on computers Computer-Based Instruction (CBI) and
2) group with the access to research or advanced researchers which today can be attributed contribution to development Intelligent Tutoring Systems (ITS).

A useful addition to ITS is the adaptive hypermedia which is used in educational hypermedia, information and online help systems, as well as institutional information systems. Adaptive educational hypermedia modifies what the student sees to adjust the content to his goals, abilities, needs, interests, and knowledge of the subject, by providing hyperlinks that are most relevant to the user in an effort to shape the user's cognitive load. The teaching tools "adapt" to the learner. On-line information systems provide reference access to information for users with a different knowledge level of the subject. An adaptive hypermedia system should satisfy three criteria: it should be a hypertext or hypermedia system, it should have a user model and it should be able to adapt the hypermedia using the model.

III. A REVIEW OF DEVELOPED INTELLIGENT TUTOR SYSTEMS (ITS) IN EDUCATION

Below is a list of intelligent tutoring system (ITS) arranged in alphabetical order.

**Adil** (Automated Debugger in Learning System) is a software system for automated debugging based on knowledge, designed as an intelligent tutoring system (ITS). It assists students in mastering basic debugging skills of their programs, as a target for the C programming language. It localizes bugs and explains to these programs. Given a syntax error-free program and its specification, this debugger called Adil (Automated Debugger in Learning system) will be able locate, pinpoint and explain logical errors of programs. If there are no errors, it will be able to explain the meaning of the program. Adil is based on the design of the Conceiver, an automated program understanding system. Developed by Syed Abdullah Mohd Zin, Ahmad Aljunied, Zarina Shukur and Mohd Jan Nordin, at Universiti Teknologi Mara (UiTM) / University Kebangsaan Malaysia (UKM), from Bangui (Selangor - Malaysia) in 2000 Zin, Aljunied, Shukur and Nordin [23].

**ADIS** (Animated Data Structure Intelligent Tutoring System) is a Java-based Web-enabled intelligent tutoring system (ITS) developed as a teaching support to enhance students' understanding of data structures such as linked-lists, stacks, queues, trees and graphs. ADIS has the capability to display data structures graphically on the computer screen as well as allowing graphical manipulation of the data structure created. There is a tutorial mode incorporating exercises, where students can learn basic algorithms (insertion, deletion etc.) of data structures visually. ADIS is completely implemented in Java to allow platform-independent standalone usage or internet delivery. Developed by Kai Warendorf and Colin Tan, at Intelligent Systems Laboratory (ISL), of School of Applied Science, of the Nanyang Technological University (NTU), from Singapore in 1997 (Warendorf, [24], Warendorf and Tan [25]).

**BITS** (Bayesian Intelligent Tutoring System) is a Web-based intelligent tutoring system (WITS) for computer programming. The decision making process conducted in BITS intelligent system is guided by a Bayesian network. BITS can help the student in navigation through the materials online, and also can suggest learning target and purpose and generate suitable learning sequences. As an example, a student may want to learn (adding operation) without having to learn every concept discussed in the previous materials. BITS can determine the minimum prerequisite knowledge needed in order to understand (adding operation) and display the links for these concepts in the correct learning sequence. Developed by C.J. Butz, S. Hua and R.B. Maguire, at Department of Computer Science, of the University of Regina, from Regina (Saskatchewan - Canada) in 2004 Butz, Hua and Maguire [26,27,28,29].

**DCG** (Dynamic Courseware Generation) is an intelligent tutoring system (ITS) based on an ITS-shell architecture, whose main idea is applying AI planning techniques to determine the content of instruction. The system dynamically generates instructional courses. The course-plan is created individually for a given student with a given teaching goal. Main advantage of this approach is that it allows automatically building goal-directed adaptive Computer Assisted Learning (CAL) courses which is impossible within the traditional CAL concept of courseware. Developed by Julita Vassileva and Ralph Deters, at Universität der Bundeswehr München (UniBwM) / Bundeswehr University Munich,
from Neubiberg (Germany) in 1992 (Vassileva [16]; Vassileva and Deters [30]).

**DM-Tutor** (Decision-Making Tutor) is a constraint-based tutor intelligent tutoring system (ITS) which is embedded within an existing system, the management information system (MIS) for oil palm plantation management. The goal of DM-Tutor is to provide scenario-based training using real-life operational data and actual plantation conditions. The goal of DM-Tutor is to help users apply theoretical concepts of plantation analyses into real-life plantation decision-making. Developed by Sagaya Amalathas and Antonija Mitrović, at Department of Computer Science and Software Engineering, University of Canterbury, from Christchurch (New Zealand), Saravanan Ravan, at RANN Consulting Sdn. Bhd., from Kuala Lumpur (Malaysia) and David Evison, at Department of Forestry, University of Canterbury, from Christchurch (New Zealand) in 2009 (Amalathas, Mitrović and Saravanan [31,32]).

**ELM-ART** (ELM (Episodic Learner Model) – ART (Adaptive Remote Tutor)) is a Web-based intelligent tutoring system (WITS) designed for teaching students programming in LISP (List Processing) programming language. It integrates intelligent educational system with electronic textbook program in a unique environment in which the user can broaden and deepen previously acquired knowledge. It was used as an intelligent interactive electronic textbook on programming in LISP programming language logic. ELM-ART system is developed based on ELM-PE programming environment based on knowledge. Originally developed by Peter Brusilovsky, at Carnegie Mellon University (CMU) from Pittsburgh (Pennsylvania - USA) and Elmar Schwarz and Gerhard Weber, at Department of Psychology, University of Trier, from Trier (Germany) in 1996 (Brusilovsky [11], Weber and Brusilovsky [33,34]).

**JITS** (Java Intelligent Tutoring System) is the research project that involves the development of a programming tutor designed for students in their first programming course in Java™ at the college and university level. This project is a prototype being constructed which will model the domain of a small subset of the Java™ programming language in a very specific context. Research is in progress and it is hypothesized that the completed prototype will be sufficient to prove the concept and that a fully developed Java™ intelligent tutoring system will provide an interactively-rich learning environment for students resulting in increased achievement. Developed by Edward R. Sykes, at School of Computing and Information Management, of the Sheridan College, from Oakville (Ontario - Canada) and Franya Franek, at Department of Computing and Software, of the Faculty of Science, of the McMaster University, from Hamilton (Ontario - Canada) in 2003 (Sykes, [35], Sykes and Franek [36]).

**KERMIT** (Knowledge-Based Entity Relationship Modelling Intelligent Tutoring) is an intelligent tutoring system (ITS) for entity-relationship (ER) modelling. Database design is an open-ended task: although there is an outcome defined in abstract terms, there is no procedure to use to find that outcome. So far, constraint based modelling has been used in a tutor that teaches a database language (SQL-Tutor) and a system that teaches punctuation and capitalization rules (CAPIT). KERMIT is implemented in Microsoft Visual Basic (VB) and supports the entity relationship data model. Developed by Pramuditha Suraweera and Antonija Mitrović, at Intelligent Computer Tutoring Group (ICTG), Department of Computer Science, of the University of Canterbury, from Christchurch (New Zealand) in 2002 (Mitrović Mayo, Suraweera and Martin [37], Suraweera and Mitrović [38,39], Weerasinghe and Mitrović [40]).

**MBITS** (Multicriteria Bayesian Intelligent Tutoring System) is Web-based intelligent tutoring system (WITS) which is supported by Bayesian Network (BN). It functions as a Web application which is interactive and easy to use. MBITS was intended to assist students to better understand the concept of the course using multicriteria approach to evaluate different solution and information gathering actions using the same set of criteria. Developed by Ettarres Yamna and Khaled Mellouli, at Laboratoire de Recherche Opérationnelle, de Décision et de Contrôle de Processus (LARODEC), of the University of Tunisie, Cité Bouchoucha (Le Bardo – Tunisie) and Pierre-Henri Wuillemin, at Laboratoire d'Informatique de Paris six departments (LIP-6), of the Université Pierre et Marie Curie (UPMC), from Paris (France) in 2010 (Yamna, Mellouli and Wuillemin [41]).

**ML-Tutor** (Machine Learning Tutor) is a Web-based client server system which has been built with the intention of combining Internet technology with educational hypertext. The client component of the system incorporates the user interface and runs in a WWW browser. The client captures data which are transmitted to the server using Internet technology. The server component of the system is executed when requested by the client. The server contains a machine learning component (MLC) which analyses the received data and transmits results to the client. Developed by A. Serengul Smith-Atakan, at Middlesex University, School of Computing Science, from London (United Kingdom) and Ann Blandford, at University College London (UCL), Interaction Centre, from London (United Kingdom) in 2003 (Smith-Atakan and Blandford [42]).

**NORMIT** (Normalisation Intelligent Tutor) is an intelligent tutoring system (ITS) that teaches database normalization to university students. NORMIT is a Web-enabled system, and its architecture and techniques are used to deal with multiple students. NORMIT is the first in the series of constraint based tutors developed at ICTG that teaches a procedural task. It is written in Allegro Common Lisp (ACL) and uses the AllegroServe Web server which is open sourced as a way to demonstrate...
network programming in ACL as an extensible server. Developed by Antonija Mitrović, at University of Canterbury, Department of Computer Science, Intelligent Computer Tutoring Group (ICTG), from Christchurch (New Zealand) in 2002 (Mitrović [43,44]).

SQL-Tutor (SQL (Structured Query Language) Tutor) is a variant of an intelligent tutoring system (ITS), based on knowledge, learning and teaching SQL language databases. It is based on the CBM (modeling based on limitation) modeling approach to students. Implemented in Allegro Common Lisp (ACL) programming language. Developed by Antonija Mitrović, Pramuditha Suraweera, Brent Martin and Michael Mayo, at Intelligent Computer Tutoring Group (ICTG), Department of Computer Science, University of Canterbury, from Christchurch (New Zealand) in 1998 (Mathews and Mitrović [45], Mitrović [46,47], Mitrović and Ohlsson [48,49], Guia Rodrigo, Dagami, Sugay, Macam and Mitrović [50]).

SQLT-Web (SQL-Tutor (Structured Query Language Tutor) on the Web) is a software intelligent tutoring system (ITS), based on knowledge, which is a SQL-Tutor independent system for teaching and learning SQL query language databases. Developed by Antonija Mitrović et al., at University of Canterbury, Department of Computer Science, Intelligent Computer Tutoring Group (ICTG), from Christchurch (New Zealand) in 2003, Mitrović, [47].

TEx-Sys (Tutor-Expert System) is a software system for learning that represents copyright shell for building intelligent tutoring system (ITS), in an optionally selected area of knowledge. It was initially designed and implemented as an on-line system, using semantic networks with frames and production rules (PR). Developed by Slavomir Stankov and colleagues, at Faculty of Natural Science, Mathematics and Kinesiology, University of Split, from Split (Croatia) in 1997 (Glavinić, Stankov, Želić, and Rosić [51], Stankov, Rosić, Žitko, Grubišić [52]).

WITS (Whole-Course Intelligent Tutoring System) is an intelligent tutoring system (ITS) and expert system (ES) that teaches a course on solid state electronics independently of a human teacher. It is able to offer a learning environment that motivates learners and gives useful instant feedback to learners. Developed by David Callar, at University of Portsmouth, Department of Information Systems, from Portsmouth (United Kingdom) in 1999 (Callar [53]).

IV. CONCLUSION

E-learning is a cross-section of two worlds: the world of information and communication technology and world of education. This is valuable and especially when used as part of a well planned and organized environmental education. However, secure e-learning is not a "magic sphere" that will replace existing educational theories, principles and norms. E-learning is a new paradigm of learning with the help of different devices based on electronic technology, for individualized teaching and learning with the help of intelligent tutoring system. Intelligent tutoring systems during today’s application have helped improve the teaching process adapted to the individual needs of students and have proven usefulness in education. In relation to this a number of successes have been achieved especially in the detection of certain traditional teaching strategies (partnership, mentoring, development of collaborative software and learning through work).

REFERENCES


