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TEx-Sys model for building intelligent tutoring systems

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Abstract

Special classes of asynchronous e-learning systems are the intelligent tutoring systems which represent an advanced learning and teaching environment adaptable to individual student's characteristics. Authoring shells have an environment that enables development of the intelligent tutoring systems. In this paper we present, in entirety, for the first time, our approach to research, development and implementation related to intelligent tutoring systems and ITS authoring shells. Our research relies on the traditional intelligent tutoring system, the consideration that teaching is control of learning and principles of good human tutoring in order to develop the Tutor–Expert System model for building intelligent tutoring systems in freely chosen domain knowledge. In this way we can wrap up an ongoing process that has lasted for the previous fifteen years. Prototype tests with the implemented systems have been carried out with students from a primary education to an academic level. Results of those tests are advantageous, according to surveys, and the implemented and deployed software satisfies functionalities and actors' demands.

Keywords: Architectures for educational technology system; Authoring tools and methods; Distributed learning environments; Evaluation methodologies; Intelligent tutoring systems

1. Introduction

E-learning is a revolutionary educational paradigm based on the information and communication technology that is being dynamically researched, developed and applied as a part of the traditional instruction and as a complementary mechanism for lifelong and distance learning. E-learning is enabled by the e-learning systems that can be observed as synchronous or asynchronous, regarding their implementation technology for delivering educational contents. A special class of asynchronous e-learning systems is the intelligent tutoring systems (ITSs) which represent an advanced learning and teaching environment adaptable to individual student's characteristics.

Intelligent tutoring systems are generation of computer systems aimed to support and improve learning and teaching process in certain domain knowledge, considering individuality of a student like in traditional

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one-to-one instructional process. This process, also known as human tutoring, has been confirmed to be successful and presents the most efficient learning and teaching process (i.e. Bloom, 1984; Cohen, Kulik, & Kulik, 1982). The development of ITSs is, therefore, related to a number of serious problems, because proper implementation of "human" tutor can be done only in relation to cognitive psychology, artificial intelligence and education. Knowledge is a key to intelligent behavior and, therefore, ITSs are said to be knowledge-based because they have: (a) domain knowledge; (b) knowledge about teaching principles and about methods for applying those principles and (c) knowledge about methods and techniques for student modeling.

In this paper we present, in entirety, for the first time, our approach to research, development and implementation related to intelligent tutoring systems and ITS authoring shells. Our research relies on the traditional intelligent tutoring system (presented in Section 1.1), the consideration that "teaching is control of learning" (Pask, 1965) and principles of good human tutoring (Merrill, Reiser, Ranney, & Trafton, 1992) in order to develop the Tutor–Expert System (TEx-Sys) model (Stankov, 1997) for building intelligent tutoring systems in freely chosen domain knowledge (presented in Section 1.2). In this way we can wrap up an ongoing process that has lasted for the previous 15 years.

1.1. From intelligent tutoring systems to authoring shells

Intelligent tutoring systems present outgrowth of computer aided instruction (CAI) systems that were created in the late fifties of the last century based on the programmed instruction (Skinner, 1954). When talking about conjunction of computers and programmed teaching, Skinner said that micro computer is ideal hardware for programmed instruction (Skinner, 1986). The most productive and the most long-lasting example of programmed instruction is the PLATO system (www.plato.com) for teaching learners of every age and occupation. In the early 1970s, an artificial intelligence has just started to be applied into the CAI systems. Carbonell in Scholar (Carbonell, 1970) defines other type of CAI that is today known as knowledge-based or intelligent CAI (ICAI). The Scholar developers have done a pioneering effort while creating a computer tutor that is able to handle unexpected student question and is able to generate instructional material with changeable levels of detail, depending on the context of the dialog (Barr & Feigenbaum, 1986).

Sleeman and Brown edited in 1979 a special issue of the IEEE International Journal of Man–Machine Studies (Sleeman & Brown, 1979) in order to summarize and point up research in this area. Later on, they have published some of those papers in a book titled "Intelligent Tutoring Systems" where they reviewed the state of the art in computer aided instruction and first created the term intelligent tutoring systems to portray these systems and to distinguish them from the previous CAI and ICAI systems (Sleeman & Brown, 1982).

An interesting approach to this field of research is presented by Ohlsson (1986) in his analysis of some principles of intelligent tutoring where he uses terms "teaching", "tutoring" and "instruction" as synonyms. This, of course, is an issue for another very interesting discussion about consequences of very different terminology related to ICAI and ITS. For example, Hartley and Sleeman indicate the problem of mechanizing the teaching process and introduce and develop a term "teaching intelligence" (Hartley & Sleeman, 1973). Besides, they believe that a intelligent decision-making system for computer-based teaching needs four educational components: a representation of the teaching task, a representation of the student, a set of teaching operations instruction, and, finally, a set mean-ends guidance rules. Anderson and others (Anderson, Boyle, & Reiser, 1985) believes that computer systems for intelligent tutoring must provide the student with the same instructional advantages as a sophisticated human tutor. Moreover, they emphasis that this area is interdisciplinary as it has arisen on the intersection of cognitive psychology, artificial intelligence and computer technology. Wenger in his book continues to review the ITSs state of the art (Wenger, 1987). He highlights that many other scientific fields, such as artificial intelligence, education linguistics, psychology, and philosophy, contributed from research on ITS. Rickel (1989) presents excellent analysis of researches related to ICAI systems based on following system component: learning scenario, domain knowledge representation, student modeling, pedagogical knowledge, user interface.

Self writes about existence of a consensus on the standard ITS architecture: it consists of components which know about the subject matter, know about the student, and know about tutoring (Self, 1990), better known as "the what, the who and the how" components (Self, 1974). Nevertheless, a fourth component, called