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Modeling Student/Tutor Components of Intelligent Tutoring Systems: A Review

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ABSTRACT

The intelligent tutoring system (ITS) is an educational software system that provides personalized and adaptive tutoring to students based on their needs, profiles and preferences. The tutor model and student model are two dependent components of any ITS system. The goal of any ITS system is to help the students to achieve maximum learning gain and improve their engagements to the systems by capturing the student's interests through the system's adaptive behavior. In other words an ITS system is always developed with the aim of providing an immediate and efficient solution to student's learning problems. In recent years a lot of work has been devoted to improving student and tutor models in order enhance the teaching and learning activities within the ITS systems. The aim of this paper is to investigate the most recent state of art in the development of these two vital components of the intelligent tutoring systems.

Keywors: ITS;Tutor model; Student model;

1. INTRODUCTION

The emergence of the intelligent tutoring systems in the last three decades has significantly changes the content and practice of teaching and learning in our today's educational environments. The most significant of this change is redefining the concept of education far from been just a traditional school setting and has greatly increased the number of participants seeking knowledge from children to almost all adults from various age groups [1]. Before the advent of intelligent tutoring system, the trend in the teaching use to be the traditional one-on-one approach between a human teacher and student, then comes the one-to-many classroom approach which later gave birth to the e-learning and computer aided instruction (CAI) approaches. Both the e-learning and CAI systems have a major short comings compared to the ITS because of their one size fits all approach to teaching and learning that is to say they are not adaptive by design, same content is always provided to different users irrespective of the individual differences that commonly exist among the learners. But ITS is adaptive in the sense that students can be tutored according to their profiles and preferences. Each individual student will be provided with learning content and instructional methodology that will suit his/her personal need. Unlike in the traditional one-to-one human student/teacher tutoring environment, in any typical ITS system setting, the interaction between the tutor (software system) and the student is not under the control of a human tutor who normally enjoys the total control of the learning environment, there is no such humanly face-to-face session between the student and the tutor in an ITS setting and the resulting consequence here is that the system's control over the learner is going to be weak to the extent that if at any stage of the learning activities the atmosphere becomes boring to the student he/she may decides to leave the session with the computers because he doesn't need the consent of the tutor. To address this kind of issues facing student-tutor interaction in ITS, the systems must be design in such a way that it has the ability to attract the student's interest and engage them in the learning process from the beginning to the end of each session. Designing the ITS system to be adaptive to each individual is one best approach to handle such problems [2]. The student model is the base for making any ITS adaptive. Student modeling is the process of handling several cognitive issues such as investigating students performance, current knowledge state of each individual student, student's learning styles, checking and eliminating any underlying misconception as well as identifying any personality trait that describe each student's characteristics. The student model is an important factor for designing an adaptive ITS [3].

2. RELATED LITERATURE

2.1 Overview of Intelligent Tutoring Systems

Human tutoring is believed to be the most effective form of instructional technique on earth. The one-to-one human tutoring in particular is even more powerful and effective when compared to the standard one-to-many classroom tutoring [39]. But despite its effectiveness, empirical studies have shown that implementing one-to-one human tutoring in our educational environments looks practically impossible considering the large number of the knowledge consumer (learners), the financial implications and the small number of experienced instructors available. So the

idea of developing intelligent tutoring systems is to realize the benefit of the one-to-one tutoring using intelligent software agents to provide the needed personalized tutoring services to a large audience [4]. The integration of computer technology inform of ITS into the educational environments has significantly changed the concept of student learning far from normal classroom tutoring by accommodating all levels of participants both the children and the elderly persons [5].

2.2 Architecture of an Intelligent Tutoring System

A standard ITS system is composed of four basic modules or components namely; student module, tutor/pedagogical module, domain module and interface module. We will briefly explain each of these modules as this:

2.2.1 Student Model

The student module (knowledge of who to teach), the student module is responsible for managing the cognitive state through creating the student profile that includes such information like the student personal data, learning style, preference, current knowledge state of each individual student. The goal of student model is to provide adaptive and personalized tutoring to each individual student based on his/her profile. This model is considered as the base for making the ITS adaptive and also the most important decision making tool in any ITS system.

2.2.2 Tutor/Pedagogical Model

The tutor/pedagogical module (how to teach), the goal of the tutor module in any ITS is to handle instructional decisions on a number of issues like the correct choice of the teaching methods that will suit each individual learner base on the learner's profile from the student model, choosing the right learning content for the students and deciding the right time to study the content as well as assessing the cognitive state of each learner to be able to understand each student level of understanding in order to decides whether a student is to proceed to the next learning stage or to revised the previous stage.

2.2.3 Domain Model

The domain model (what to teach), this model is concerned with the knowledge of the particular domain to be taught. It coordinates the particular concepts within a particular domain.

2.2.4 Interface Model

The interface model (user-system interactive environment), this model is responsible for providing the environment for interaction between the system and the learner. Because ITSs are developed using computer system, the interactive interface that is usually created using graphical user interface provides the environment for which the students can interact with the system.

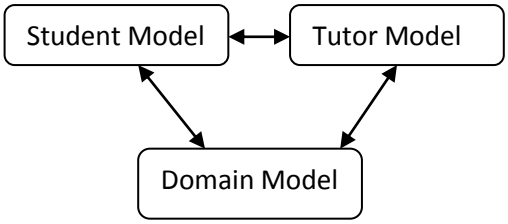


Figure 1. Architecture of Intelligent Tutoring System

2.3 Research Methodology

The aim of this our research is to investigate how the trend in tutor and student modeling is moving. To do this we have to search through published articles in order to enable the stake holders in the field of intelligent tutoring especially academics and educational administrators to understand the direction and the feature these two important components of ITS. We will examine the distribution of research articles on both two models by their year of publications and the distribution of the articles by the journals in which the research articles are published. And more importantly we will also examine the research papers by the artificial intelligence technique employed to model each paper in order to understand how the various techniques are pairing. But it should be understood that work on this two models have been spread across various journal databases and for this reason we have to confine our search within the following journals databases; Science Direct; ACM Portal; Springer ;Scopus and Elsevier.

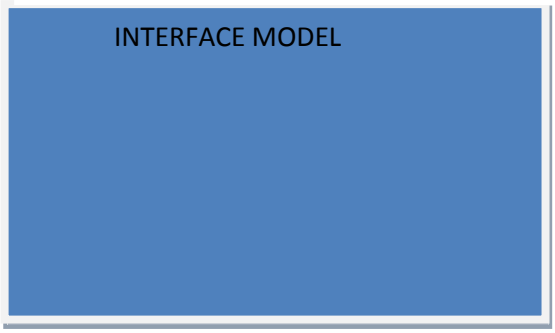
3.0 STUDENT/TUTOR MODELING TECHNIQUE

3.1 Bayesian Network

A Bayesian Network is a directed graph model that handles probabilistic relationships among entities of interest [7]. An important feature of Bayesian Network is that if a BN is combined with statistical techniques, this directed graph model can offer many advantages for computational data management such as solving problems of over fitting data, study the causal relationships among entities in a domain, managing missing data entries as well as encoding dependencies among variables in a domain. Student modeling is characterized by so many uncertainty issues and BN probability theory provides a basis for handling systems that reasons under uncertainty [8].

3.2 Fuzzy Logic

Fuzzy Logic was formerly discovered as a proposal born out of set theory [10]. But originally, the study of Fuzzy Logic as infinite-valued logic can be dated way back to 1920s by Lukasiewiez & Tarski,. Fuzzy logic is a many valued logic and it is used to handle reasoning that is not fixed and exact but approximate. The variables in fuzzy sets assume values within the range in degrees between 0 and 1. Fuzzy Logic usually appears in the form of fuzzy



reasoning system having the basic components inform of fuzzy variables; fuzzy rules and fuzzy inference engine.

3.3 Collaborative Filtering

Collaborative filtering (CF) one of the common and most successful data analysis techniques used in recommender systems models. Collaborative filtering approach use to rely mostly on the past interactions performed by a user without having to bother about creating any user profile. The CF technique use to trace any relationships that exist between users and the interdependencies among products with the aim of generating a new user-item association [6]. An important goal of CF is to generate better and accurate recommendations by relying primarily on previous user's behaviors like the items ratings from the users or information from the prior transactions with the aim of suggesting new items for a particular user.

3.4 Data Mining

Recently, the concepts of knowledge discoveries and data mining are considered synonymous to each other; this is because the term data mining can formerly be defined as the process of discovering knowledge from a very large homogeneous datasets [9]. Recent trends in the field of intelligent tutoring systems have shown how data mining techniques play active roles in the development of effective student/tutor models and the approach has contributed in widening and detecting the range of student's behaviors more than ever before.

3.5 Neural Networks

Artificial neural networks techniques are techniques that are influenced by the way the human brain functions [40]. The way artificial neural network operates is defined by the network of simple elements operating in parallel to achieve their processing power. The ANN always tries to mimic the process of manipulating information in the human brain in order to use its information to solve problems by means of computers.

3.6 Intelligent Agents

An intelligent agent is a software system that perceived its environment and takes action based on the environmental condition [8]. The use of agents is one of AI's techniques for modeling both the student/tutor models.

3.7 Ontology

Ontology is defined as the shared knowledge and understanding of the relationship among entities and concepts within a domain of interest [31]. It can also be expressed as a vocabulary consisting of the formal definition of terms and the common relationship that exist among the relevant entities in the domain. The concept of ontologies has been used as an instrument to present and convey meanings to the semantically-enriched contents with Metadata. The study of ontologies has been going on for so many years, first by philosophers and then followed by logicians and recently in the field of artificial intelligence, particularly in student modeling aspect of an ITS for the designing and representation of knowledge base component.

Table 1. Summary of research papers by journal in which the research paper is published

JOURNAL NAME	FREQUENCY	PERCENTAGE (%)
Expert Systems and application	10	33.3
Computers & Education	6	20
Computers in Human Behaviors	2	6.6
Human Computer Studies	2	6.6
Artificial Intelligence in Education	1	3.3
Applied Intelligence	1	3.3
Educational Research Review	1	3.3
Knowledge Based Systems	1	3.3
Learning Technology	1	3.3
Precedia in Computer Science	1	3.3
Information Technology	1	3.3
Fuzzy sets & Systems	1	3.3
Engineering & Science	1	3.3
Information Science	1	3.3

Table 2. Summary of Research Papers by Artificial Intelligent Technique employed to Model the Paper

Model	Artificial Intelligent Technique							
	Bayesian N	Fuzzy LG	Ontology	Data Mining	Neural NW	Neuro-Fuzzy	Agents	Collab Filt
ATM							✓	
ABM	✓							
SCAF			✓					
Sarrafzadeh & Alexander, 2008							✓	
NFPR						✓		
Tex-Sys			✓					
Fazlollahtabar& Mahdavi, 2009		✓						
Woolf & Burleson, 2009							✓	
Zanebe & Norcio, 2009		✓						
Kumar, Gress & Winne, 2010			✓					
Conati, 2010	✓							
Porcel & Herrera-Viedme, 2010		✓						
Reineke,Walter &Moorsel2010				✓				
Beldagli & Adiguzel, 2010							✓	
Gaze-tutor							✓	
Mizoguchi & Hayashi, 2010			✓					
Thai-Nghe & Drumond, 2010				✓				
Alvi & Ali, 2010			✓					
EDUCA 2.0, 2011					✓			
Roll & Alven,2011				✓				
Burder & Schwind								✓
Oscar				✓				
Pena-Ayala, 2011		✓	✓					
Bobadilla & Ortega, 2012								✓
Sevarac & Davadzic, 2012						✓		
Detcher, 2012	✓							
Grubisic & Stankov,2013	✓							
FTCP-RS		✓						
ITS-C		✓						
Lin, Yeh, Hung & Chang, 2013				✓		✓		

4. DISCUSSION/CONCLUSION

The objective of this research is to investigate the state of art in the tutor/student model designs with a view of finding relevant information that can help us to understand a little of the past, present and more importantly the feature of the modeling designs of these two important components of intelligent tutoring systems. The review has succeeded in revealing the most recent computational techniques that are used to manipulates various research articles with a view to improve the performance and efficiency of the intelligent tutoring systems. A total of thirty student/tutor modeling research papers were reviewed within the period 2008 to 2013. This was presented in the table 1 above. The performance of techniques like Fuzzy logic, Ontology, Bayesian networks and data mining within the period of the review appears to be very pronounced. The reasons for the use of Fuzzy and Bayesian techniques are very clear, this is because modeling student/tutor domains of ITS has been found to be characterized with a lot of uncertainty issues and both fuzzy logic and Bayesian techniques have been found to be promising techniques to handle this uncertainty issue. Knowledge representation and management is a vital issue in both student/expert model designs and it is equally not surprising to see how the use of ontology is recently gaining popularity. The data mining techniques too appear to be pairing well recently, the use of such techniques like machine learning; association rule mining is equally getting stronger in these aspects. The use of agents is also making an impact. Some researchers are also employing hybrid approaches like use of neural networks and fuzzy or ontology and Bayesian as another alternative for modeling.

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