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Dynamic Student Modeling Intelligent Tutoring System

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Abstract - This paper reviews a system used to models students' comprehension level in a typical learning environment while the teaching process is still going on. This system is tagged dynamic and not static because it can teach and at the same determine the best way or path (learning styles) that the student could be taught with as against the previous authors which is likened to be static or case based which will first of all embark on studying the student and get the student behavior in terms of their response and now use it to provide a learning solution for the student. This system finds out the best way a student can learn before the commencement of the tutoring process based on the student responses. We are proposing this new system because of its capability to get the student responses as the teaching process is going and at the same time forming policies and taking decision at once on the best path to teach student. This will help reduce the student long learning curve associated to the previous system. This system when adapted for students in developing countries as Nigeria would facilitate the learning process and reduction in students long learning curve.

Keywords: Intelligent Learning Environments (ILE), Case-Based Reasoning (CBR), Intelligent Tutoring Systems (ITS), Case-Based Modeling (CSBM), Intelligent Computer-Assisted Language Learning (ICALL), Natural Language Processing (NLP), Intelligent Language Tutoring Systems (ILTS), Student Model (SM), Domain Specific Information (DSI), Student Knowledge Model (SKM), Domain Independent Information (DII).

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1 INTRODUCTION

Many developers of educational systems consider Intelligent Tutoring Systems (ITS) and Learning Environments as different and even contradictory ways of using computers in education. The recent success of such well-known Intelligent Learning Environments [1] showed that these ways are not contradictory, but rather complementary. ITS's are able to control learning adaptively at various levels, but generally do not provide tools to support free exploration. Learning environments support exploratory learning [2], but they lack the control of an intelligent tutor. Without such control the student often works inefficiently and may never discover important features of the subject. ILEs can monitor students, help them to perform their tasks and provide them with feedback in a manner that contributes to their learning process. For the students to learn electively and efficiently, ILEs should provide teaching strategies according to the specific domain knowledge and objectives. The Student Model is the main component within the Intelligent Learning Environment and, contains information about the student knowledge. It obtains the information by dynamically observing and recording the student's behaviour, answers, problem-solving strategies, and analyzing them in order to deduct their level of understanding about the domain. This dynamic modeling is achieved by proving several paths which in this case are several learning styles so as to be able to determine the best path to each student knowledge. This information the students learning as modeled by the system will now be stored against each student and used to individually adapt the system to each student. Intelligent agents have been quite successful at observing student's behavior and, therefore, they have been widely used in learning environments in order to capture the characteristics of the student and perform student modeling tasks [3]. Building a student model involves defining; the "who", is modeled; the "what", or the goals, plans, attitudes, capabilities, knowledge, and beliefs of the student; the "how" the model is to be acquired and maintained; and the "why" , including student's information to give assistance, to provide feedback, or to interpret the student behaviour [4]. The need for simplicity and ease of understanding in Student Models is very high. It is deduced from the fact that distance education is addressed to students who vary greatly in their educational background. Due to the lack of physical tutor-student contact, sometimes the distance student has the feeling that the teacher is unreachable when needed. This is the reason why Student Models should provide bi-directional benefit to both instructors and students, by enabling students to monitor their own progress and utilise the feedback provided by the model on a continuous basis. There are many techniques for generating student models; however most of these techniques are computationally complex and time consuming for example: Bayesian Networks [5], Fuzzy student modeling approach [6], the Dempster Shafer theory [7]. Other techniques can only record what a student knows and not the students' behaviour and features. Examples are: overlay model [8], stereotype and combination model [9]. A comparison of Case-Based Reasoning and Bayesian Networks for student modeling is realized in [10]. This study shows that CBR is the best and easiest approach for constructing a student modeling. Therefore to enable us achieve our new system, we proposed a multi-agent approach to student modeling in which each student model has a corresponding four learning styles as paths to the student knowledge and each learning style is now referred to as case. This case 1 to 4 as used in the work represents the four learning paths and they are: Auditory Learners(through hearing), Visual Learners(through Seeing), Kinesthetic Learners(through Touching) and hybrid learners (combination of one or more learning styles). This agent uses the CBR paradigm as in Craw at. el, [11] to generate the student profile. The CBR paradigm is simple and do not require complex inference algorithms, moreover offers well-founded methodologies and experiences with respect to both mathematic and algorithmic aspects. In our approach, we included an Orientator Agent to customize the learning considering the psychological characteristics of the student. In order to constructing the knowledge of the students, we used CaseML as used by Huajan and Zhaohui, [12] a semantic enriched markup language. In our work the student model is improved because: it is easy to handle and to maintain beneficiating to both the tutor and the student; to promote student reflection because reporting the student's misconceptions and the reasons why they have happened; and to facilitate the supervision of the students by enabling the tutor to have a solid and continuous view of the student performance.

2 RELATEDR RESEARCH

This paper presents a review of the literature related to this research. Moreover it provides a finding of the current theoretical and methodological contributions to the field of natural language intelligent tutoring systems.

Background

While existing Intelligent Tutoring Systems (ITSs) vary in their structure, they typically consist of at least three basic components or subsystems. Hartley and Sleeman [13] in their work described the requirements of an ITS for the first time. An ITS relies on three components which can be described as follows:

1. The Domain model (or Domain knowledge) that contains the knowledge of certain domain (e.g. Physics).
2. The Learner model that contains the learner knowledge and behaviour.
3. The Pedagogical model that contains the expertise and teaching strategy of the human teacher in the area of the domain. Figure 1 shows the components of an ITS. The interaction between the learner and the ITS is provided via a user interface.

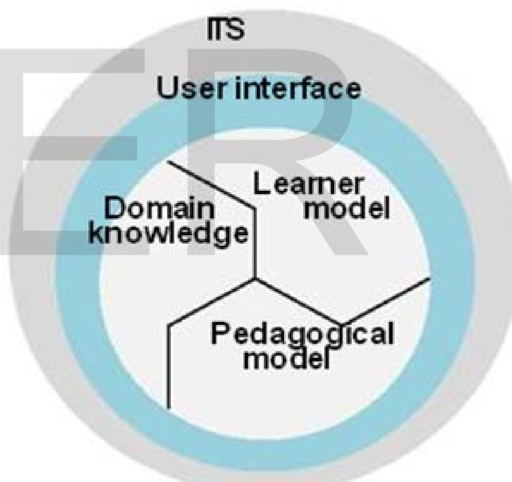

Figure1: The components of an ITS

There has been continuous research in ITS over the past thirty years with some notable successes [14]. ITSs have provided a remarkable educational gain for learners from different knowledge domains [15]. Researchers have investigated ITSs as the means of providing one-to-one tutoring. ITSs have improved learning for students in difficult subject domains such as mathematics (i.e. algebra and geometry) as compared with traditional class-room instruction [16]. ITSs have been used in a variety of applications such as virtual reality educational games [17], and physics [18]. Different computational techniques such as artificial neural networks, production systems, Bayesian networks, and fuzzy systems have been used in these systems [19]. ITSs contain models and strategies that specify what and how to teach and simulate the teacher's behaviour during the learning process. Broadly defined, ITSs fall into the "problem-based learning" or "learning by doing" categories. ITSs provide learners with a series of tasks to accomplish and as the learner works through the system, the ITS tracks his/her learning and provides him/her with personalised guidance when he/she needs it.

3 CASE-BASED MODELING

Case-Based Modeling (CSBM) is another learner modeling technique which solves new problems by using or adapting solutions similar to the learning domain of a past learner history. A case-based reasoning approach to Adaptive Web-based Educational Systems using fuzzy logic is presented by [20]. The system adapts its contents according to the learner learning style and individual needs. Rishi and Govil, [21] in their work presented the design of an agent-based distributed Case-Based ITS for online learning. However, complex cases require huge time to design and large quantity of resources since the quality of the system depends on the number of well-defined stored cases. This implies that this system will first of all examine the student learning first to find out the learning style that suits the student before learning solution is provided for the student. This is the current state of modeling system and each student modeled are referred to as a case and stored in the system. It is from this system that this present system is working on, to dynamically model student while learning is going on.

3.1 Proposed system vs. Existing solutions

The advent of the Web has made it the preferred platform for delivery of the learning materials. Web-based tutoring systems have the advantages of providing self-paced instructions for learners based on any-time, anywhere and on-demand learning. E-learning delivers web-based educational content to online learners and it is widely used by higher educational institution. However most of E-learning systems are based on static web-based tutoring systems and do not provide one-to-one and intelligent interaction with the students. Moreover these systems lack the personalised system's support such as feedback and hinting.

ITSs have advantages over other techniques of language tutoring systems (i.e. CALL, ICALL, and NLP-based tutoring systems). ITSs can provide personalised and instructions that meet the needs of each individual learner. ITSs can provide intelligent and individualised feedback and hinting to each student. This is done via various components such as the student and the teacher models. The current language learning systems for teaching Arabic have many weaknesses and limitations. Most of these systems lack the adaptability and intelligence required to ensure effective learning. Thus, a new ITS for the teaching with learning is needed. In order to provide significant learning experiences for the diverse group of online learners different modes of teaching should be presented by the tutoring systems. ITSs designed with a particular class of learners in mind may not suit other learners. Therefore, a flexible or generic design that can be fine-tuned by a teacher who has no programming experience is preferable. Fuzzy logic has been successfully used in ITS as it handles uncertainty and offers mode of qualitative reasoning closer to the teacher's decision making process. It can also be easily modified to improve the learning outcomes. Hence incorporating fuzzy inference for estimating or modeling the student learning experience or process is preferred. ILTSs are difficult and expensive to build, hence, it is desirable to build an ITS that can be easily adapted to the learning and teaching of different subject matter with each student being modeled using several paths which in this case is the different learning styles. This has the advantages of reducing the student learning time and its worthwhile investing upon.

3.3 The Student Models

Many researchers have tried to classify and formalize the student model in a unified framework. VanhLehn [22] uses three dimensions (bandwidth, knowledge type and differences between student and expert) to construct the student model. Ragnemalm [23] regards the student modeling problem as a process to connect the student's input in the ILE, the conception of the system and the representation of the correct knowledge. Self [24] tries to provide a theoretical computational basis for student modeling, which is psychologically neutral and independent from the applications. Generally the student models are classified into three traditional model types according to the assumptions about the student's knowledge: (1) overlay, (2) analytical, and (3) predictive models [25]. Most ITS use the overlay model. It considers the student's knowledge as a part of the expert's knowledge and use a set of concept-value pairs to represent the student's knowledge. The analytical model makes a distinction between the student's knowledge and the expert's knowledge. The system determines whether students have knowledge or not by checking how the student uses the knowledge that the system defines. An experience using this model is West [26]. The predictive model takes into account that the student's knowledge can be extended beyond the expert knowledge. This model provides more flexibility as new perturbations can be added into an existing model when needed, while the overlay and differential models always consider the student's knowledge as a subset of the expert knowledge. However, the perturbation model brings more difficulty. This model was implemented in DEBUGGY and IDEBUGGY systems [27]. These traditional models have some disadvantages (1) the student may follow different problem solving approaches; (2) cannot predict what student knows; (3) may hold different beliefs that are not a subset of the domain knowledge; and (4) most models represent knowledge with procedural net increasing the complexity model. (5)May also be time consuming because of the so much time spent in studying the student first before tutoring commences for each student as seen in case based learning system where each student is seen as a case mostly applied in the health sector. Dynamic student modeling paradigm is another approach to student modeling, which has not been used by previous authors to conceive and develop a student model for Intelligent Tutoring Systems. This system has the advantage of not taking time to source information about the student to be modeled. It discovers the student as the tutoring exercise is on. We propose a dynamic student modeling (DSM) structured as a multi-agent system that takes into account several components that are essential for efficient adaptive teaching process as it is inherent in each student as the system automatically detects them as the learning goes on. They are: (1) knowledge level, (2) learning style, (3) learning goals, and (4) psychological characteristics.

3.4 Student Modeling Process

In order to construct the Student Model in this new system, information about student should be acquired automatically by the system and the other way round.

3.5 Content of the Student Model (SM)

A comprehensive student model should contain information about the previous student's knowledge, the student's progress, preferences, interests, goals, personal information and any other information related to the student. Based on the dependence upon the subject domain, the content held in student models consists of two parts: domain specific information and domain independent information. Domain specific information (DSI) which is also named student knowledge model (SKM) represents a reflection of the student's state and level of knowledge in term of a particular subject domain. Domain independent information (DII) is slightly different from system to system. The domain-independent information about a student may include learning goals, cognitive aptitudes, measures for motivation state, preferences about the presentation method, factual and historic data, etc. We propose a student model that includes individual and cognitive characteristics grouped in a component named Knowledge Component. This component contains information related to the (1) knowledge level of the student, (2) personal information, (3) learning preferences, and (4) psychological characteristics with which the student will be modeled automatically by the system. Figure below shows the content of the student model.

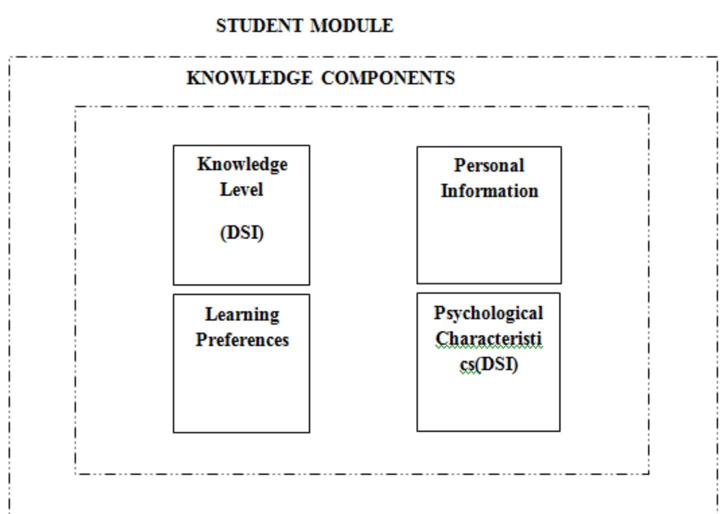

Fig 2 Components of a student model

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4 THE PROPOSED SYSTEM ARCHTECTURE

Below is the system diagram of the proposed system, showing the various components and how it works. The diagram shows the user of the system and the different knowledge sessions in the knowledge base as well as the different path to tutoring the student as adapted from Achi and Agwu, [28]. The Knowledge base is represented in the diagram as Knowledge database 1(KDB1) to Knowledge database N(KDBN) where N means any number of knowledge database or knowledge base with any number of path respectively. This system models student by trying several path and as well determine the best path to the student knowledge so as to use it whenever the student engages in any form of learning. In the diagram also, the paths are represented with various learning styles. Every student has their preferred learning styles but that will be determined by the system while modeling the student.

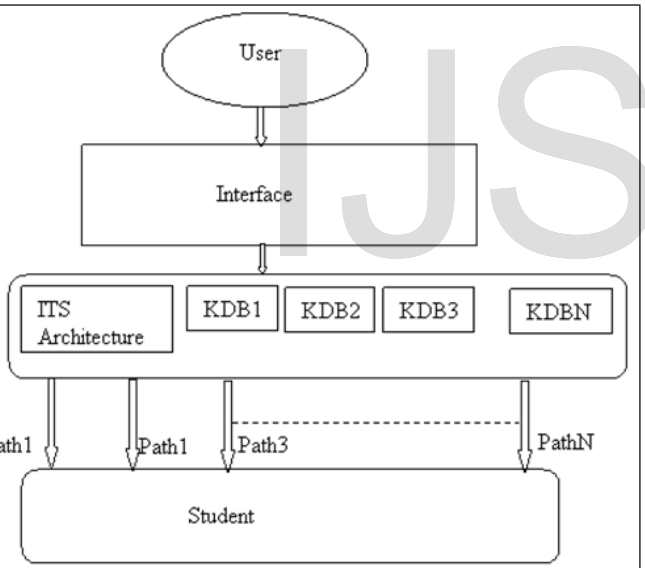

Fig 3: The New System Architecture (Adapted from Achi & Agwu)

5 CONCLUSION

The aim of this paper is to show the use of dynamic student modeling with multi-agent systems in student modeling within an Intelligent Learning Environment. With our approach it is possible to categorize students according to their knowledge level and learning preferences, to motivate them to learn in user friendly environments that suits with their learning style without having the knowledge of the student. The multi-agent system integrates a set of agents that realizes continuous student assistance and tutoring during the learning sessions. The use of an Orientator Agent is very important to give an emotional guide to the students when misconceptions or failures are reported.

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