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PROPOSED FRAME-BASED EXPERT SYSTEM TO CONSTRUCT STUDENT'S KNOWLEDGE MODEL IN INTELLIGENT TUTORING SYSTEMS

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Abstract: During the last decade, many of the Intelligent Tutoring Systems (ITS) have been developed in different domains. ITS deliver important learning gains outside classroom environments. Expert systems have been extensively used to implement ITS in education. Frames are widely used as a knowledge representation for the expert systems. This paper proposes and discusses the construction of student's knowledge model in ITS using a frame-based expert system that can adapt to the students' cognitive characteristics.

Keywords: intelligent tutoring systems; expert system; frame-based expert system; adaptive.

2010 AMS Subject Classification: 68T35.

1. INTRODUCTION

Intelligent Tutoring Systems (ITS) are computer teaching systems that can communicate with students, provide new materials, monitor their knowledge, provide feedback, and constantly adjusts to the students' levels of knowledge and cognitive properties [1-3].

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ITS perform the following actions during the interaction with students:

- Determine the cognitive characteristics of the student.
- Perform a test in order to determine the students' level of knowledge.
- Select a teaching material depending on the students' level of knowledge and/or their level of understanding.
- Find the best method to implement the process of learning, taking into account the cognitive characteristics of the student.

Generally, ITS have the following components: domain module, student module, tutor module, and interface [2-8].

The domain module contains concepts, rules and strategies for the subject matter to be learned. The student module contains the student cognitive state and development as the learning process progresses. The tutor module receives information from the domain and student modules and makes selections about teaching strategies and actions. The interface is used to display the necessary information to the student, and to obtain their answers.

When developing the ITS architecture, it is rational to use the directions that exist in the use of the expert systems for educational purposes [9].

2. EXPERT SYSTEMS

Expert systems are computer systems that imitate a human expert decision-making process [10-14]. Expert systems have played a large role in many fields such as healthcare, customer service, manufacturing, transportation.

Expert Systems consist of three main parts: the knowledge base, the working memory, and the inference engine. The knowledge base consists of facts and rules for certain domain knowledge. The working memory contains information which relates to the current consultation. The inference engine manipulates the information in the knowledge base by applying the rules to the known facts to infer new facts.

Among different types of expert systems, frame-based expert systems are widely used as a knowledge representation for expert systems with large knowledge base [15].

Frames are widely used as data structure representing knowledge about concepts or entities [16-18]. It contains information about how to use the frame, what to expect next, and what to do when these expectations are not met. Each piece of information about a particular frame is held in a slot. The information can contain facts, procedures, default values, and other frames.

The structure of frames makes the reasoning easier, which is a very important feature in any ITS. The procedures provided by frames allow a degree of flexibility that results in a more accurate representation and gives a natural affordance for developing ITS.

The advantages of using frames are:

- Knowledge domain can be naturally structured.
- It is easy to include default values, to add further slots to the frames, include specialized procedures, and detect missing values.
- Can store specific and generic descriptions.

The inference engine in frame-based expert systems searches for the goal. Frames represent a major source of knowledge, and both methods and demons are used to add actions to the frames.

Frame-based expert systems process the information in working memory with a set of frames included in the knowledge base. They associate the knowledge with objects of interest and reasoning consists of confirming expectations for slot values. Such systems often include rules that play a secondary role.

3. The Architecture of ITS

To ensure a high quality learning process, the expert system must have knowledge in three areas: knowledge of the subject matter, teaching methods, and students' personal characteristics. Therefore, the ITS modules should contain knowledge bases. The architecture of the ITS is given in Figure 1.

The student module contains knowledge about the students' personality. This knowledge is constantly updated during the learning process. The student module consists of two main components: personal characteristics model and knowledge model. The personal characteristics model reflects fairly stable cognitive characteristics of the student, while the knowledge model is a pattern of knowledge and skills of the student on studying the course at any given time.

The student module is used by the tutor module to adapt the learning process to the specific level and cognitive properties of the student. Methods of measuring the student's style and performance characteristics can be used to build a model of personal characteristics.

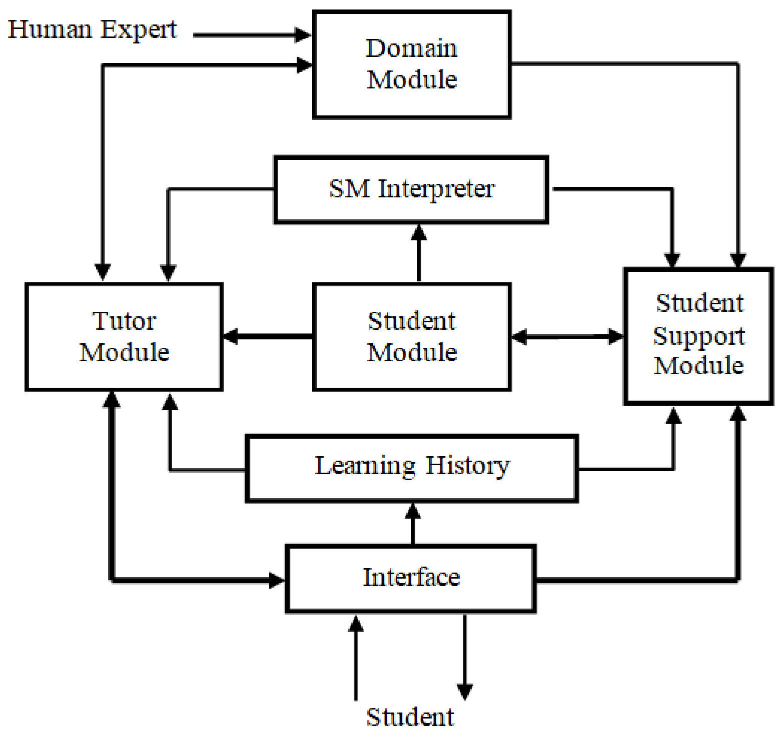

Figure 1. The architecture of ITS

The student module must be kept up to date. For this purpose, a support module is used in the ITS, which has its own knowledge base about the student. The knowledge base stores such information as typical errors, the range of personal characteristics, and so on. The student support module is constantly updated by the student module. The main function of student support module is to determine the students' current knowledge state based on their observed behavior. In the inference process, the student support module can use the full record of the student interaction with the system that is accumulated in the learning history. To infer the student current knowledge state, the student support module uses its own knowledge base about the student.

Furthermore, the student support module can use the capabilities of the domain module to compare the behavior of the student with the behavior of an expert in the same situation, which is an effective way to evaluate the student.

The domain module contains facts, procedures and other knowledge of the subject area. The tutor module contains the knowledge of the expert-teacher about the organization and methods of implementing a useful learning process.

The tutor module uses the students' current knowledge state and cognitive characteristics which are derived from the student support module to individualize the learning process. The student module is equipped with an interpreter, which is used by the inference engine of domain module. The system can simulate the behavior of the student, which is used by the tutor module to predict the student actions and student support module for the selection of the exact student model.

In order to adapt to a particular student, the tutor module can use the student module. The tutor module selects and implements the most optimal learning action for a particular student. The results of the student work with it are reflected in the learning history and are also used by student support module to update the pattern of student knowledge. The new state of the student module is used again by the tutor module and so on.

4. FRAME-BASED STUDENT'S KNOWLEDGE MODEL

To construct a student's knowledge model, the frame formalism is used. Frames store individual information fragments and relevant main concepts of subject area, which form a hierarchical structure-oriented graph with two types of nodes.

A frame containing information about a node of the first type contains the following slots:

- number
- type
- question
- list of possible answers
- help
- correct answer number
- the next frame numbers by the correct answer

- the next frame number by the wrong answer

A frame containing information about a node of the second type contains the following slots:

- number
- type
- a text that specifies the sequence of actions
- a list of control questions
- a list of possible answers
- correct answer number
- the next frame number

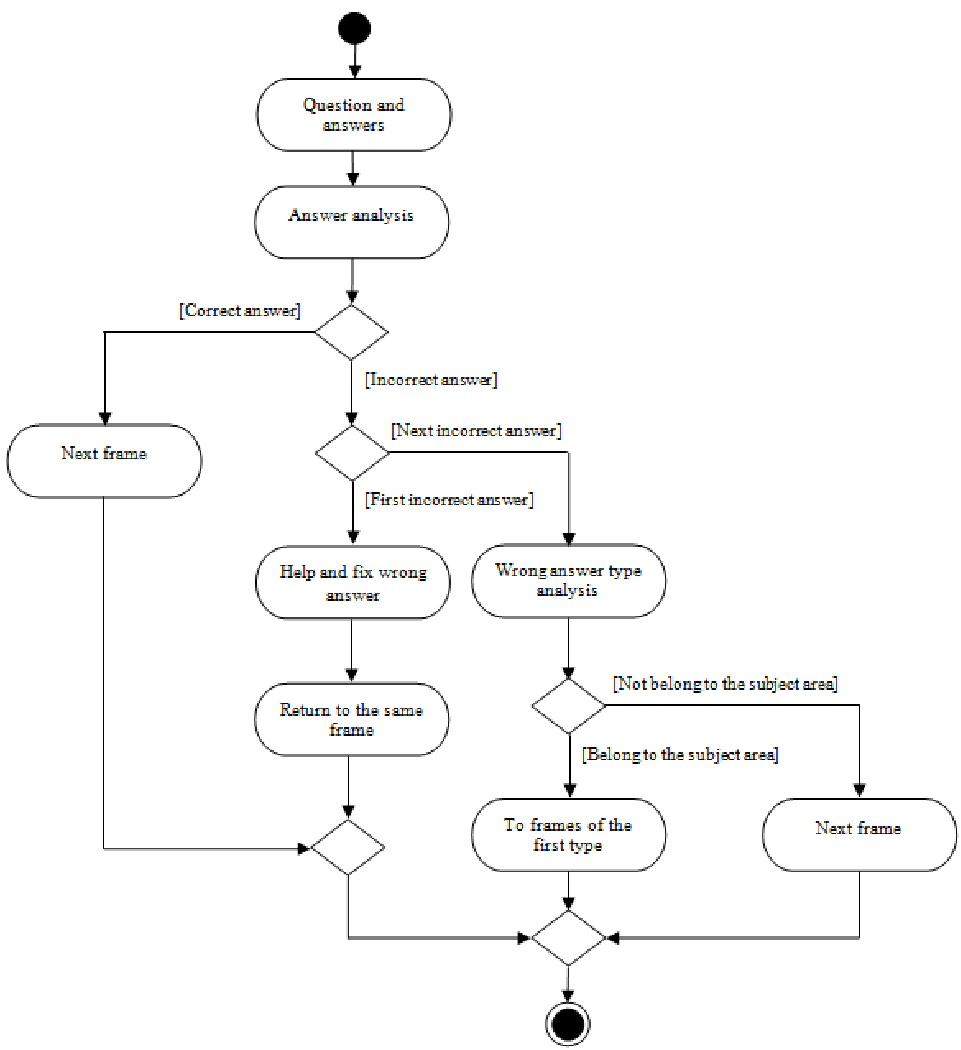

Figure 2. The processing of frames of the first type

The processing of frames of the first type is performed according to the UML activity diagram shown in Figure 2. At the beginning of the work the student is given a question and a set of answers. If they select the correct answer, they will go to the next level frame, which refers to the frames of the first type. If they select a wrong answer, then this event is recorded, the help is given and a return to the same frame is performed. If they select a wrong answer again, then there are two possible actions:

- If the wrong answer analysis shows that the lack of knowledge does not belong to the domain area, then the transition to a lower level node is performed.
- If the wrong answer analysis shows that the lack of knowledge belongs to the domain area, then a transition is made on the branch of the graph, which consists of frames of the second type.

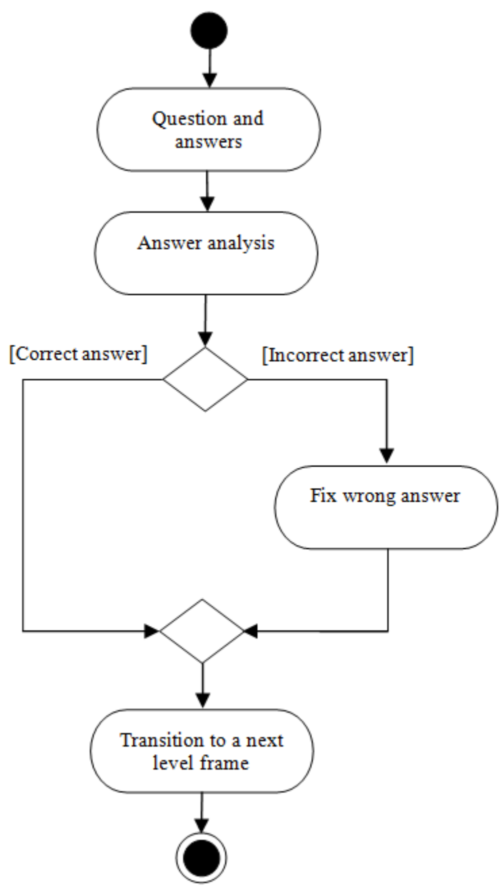

Figure 3. The processing of frames of the second type

The processing of frames of the second type is performed according to the UML activity diagram shown in Figure 3. At the start of the work the student is given a question and a set of answers. If they select the correct answer, they will go to the next level frame. If they select a wrong answer, the help is given and they will go to the next level frame.

5. CONCLUSIONS

ITS have become very important in the field of education. They become an integral part of education as a better way of teaching and learning. The paper shows that frame-based expert systems can be used to construct student's knowledge model in ITS. A frame-based expert system for student's knowledge model in ITS has been proposed due to its structure flexibility to solve various problems. The proposed system focuses on students’ cognitive characteristics and also keeps track of their learning progress.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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