Published in the Proceedings of the IEEE ICALT-2001, Madison, Wisconsin, USA, 6-8 Aug. 2001, 239-40.

A Web-Based ITS Controlled by a Hybrid Expert System

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Abstract

In this paper, we present the architecture of a Web-based Intelligent Tutoring System (ITS) for teaching high school teachers how to use new technologies. It offers course units covering the needs of users with different knowledge levels and characteristics. It tailors the presentation of the educational material to the users' diverse needs by using AI techniques to specify each user's model as well as to make pedagogical decisions. This is achieved via an expert system that uses a hybrid knowledge representation formalism integrating symbolic rules with neurocomputing.

1. Introduction

Intelligent Tutoring Systems (ITSs) have become extremely popular during the last years and have been shown to be quite effective at increasing users' performance and motivation. The emergence of the WWW increased the usefulness of such systems [1].

In this paper, we present the architecture of a Web-based ITS for teaching the use of new technologies (e.g. Internet) to high school teachers. It is the output of a research project aiming to develop methods and tools dealing with the teletraining of persons with different knowledge backgrounds and skills.

Figure 1 depicts the basic architecture of the ITS. It consists of the following components: (i) the domain knowledge, containing the structure of the domain and the educational content, (ii) the user modeling component, which records information concerning the user, (iii) the pedagogical model, which encompasses knowledge regarding various pedagogical decisions and (iv) the user interface.

The ITS is based on an expert system aiming to control the teaching process. The expert system employs a hybrid knowledge representation formalism, called neurules [2]. In the following sections, we elaborate on the system's key aspects.

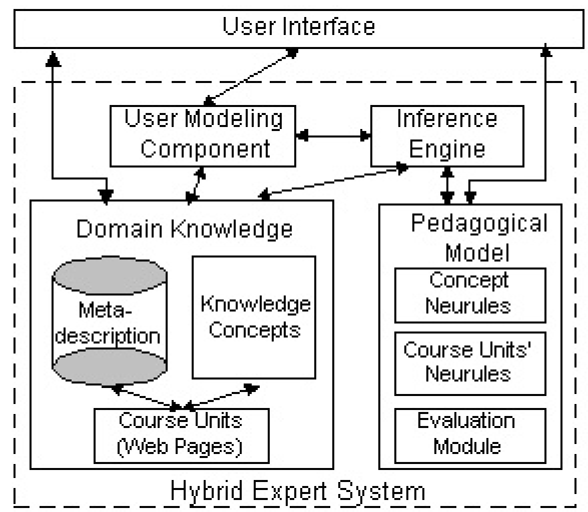

Figure 1. Architecture of the ITS

2. Domain Knowledge

The domain knowledge contains knowledge regarding the subject being taught as well as the actual teaching material. It consists of two parts: (a) the *knowledge concepts* and (b) the *course units*.

The knowledge concepts refer to basic pieces of knowledge concerning the domain. A concept can have links to other concepts. These links denote its prerequisite concepts. In this way, one or more *concept networks* are formed representing the pedagogical structure of the domain to be taught.

The course units constitute the teaching material presented to the system users as Web pages. Each course unit is associated with a number of knowledge concepts. The user is required to know the concept's prerequisite concepts in order to be able to grasp the knowledge contained in the corresponding course unit. A course unit may present theory, may be an example or an exercise.

The system keeps variants of the same page (course unit) with different presentations.

To facilitate the selection and ordering of the course units, the domain knowledge includes a *meta-description* of the course units based on their general attributes. Main such attributes for a course unit are its level of difficulty, its pedagogical type (theory, example, exercise), its multimedia type, the required Internet connection, etc.

3. User Modeling Component

The user modeling component is used to record information concerning the user which is vital for the system's user-adapted operation. It contains models of the system's users and mechanisms for creating these models.

The user model consists of four types of items: (i) *personal data* (e.g. name, email), (ii) *interaction parameters*, (iii) *knowledge of the concepts* and (iv) *student characteristics*. The student characteristics and the knowledge of the concepts directly affect the teaching process, whereas the interaction parameters indirectly.

The interaction parameters form the basis of the user model and constitute information recorded from the interaction with the system. They represent things like, the type and number of the units accessed, the type and the amount of help asked, the answers to the exercises etc.

The student characteristics include items such as the multimedia type preferences (e.g. text, images, or animations) regarding the presented course units, the domain knowledge level, the learning ability level, the available Internet connection, etc. The student characteristics are mainly represented with the stereotype model meaning that the user is assigned to predefined classes (stereotypes). Based on the way they acquire their values, student characteristics are discerned into two groups, *directly obtainable* or *inferable*. The directly obtainable characteristics obtain their values directly from the user whereas the values of the inferable ones are inferred by the system based on the interaction parameters and the knowledge of the concepts. A neurule base containing *classification neurules* is used to derive the values of the inferable characteristics. The user models are updated during the teaching process.

The user's knowledge of the domain is represented as a combination of a stereotype and an overlay model. The stereotype denotes the domain knowledge level. The overlay model is based on the concepts associated with the course learning units. More specifically, each concept is associated with a value denoting the user knowledge level of this concept.

4. Pedagogical Model

The pedagogical model represents the teaching process. It provides the knowledge infrastructure in order to tailor the presentation of the teaching material according to the information contained in the user model. As shown in Figure 1, the pedagogical model consists of three main components: (i) *concept neurules*, (ii) *course units' neurules* and (iii) *evaluation module*.

The task of the concept neurules is to construct a user-adapted lesson plan by selecting and ordering the appropriate concepts. This is based on the user's knowledge of the concepts, the user's domain knowledge level, the concepts' level of difficulty and the links connecting the concepts. According to the plan constructed by the concept neurules, the course units' neurules select and order the course units that are suitable for presentation. For this purpose, the student characteristics of the user model as well as the meta-description of the course units are taken into account.

The evaluation module evaluates the user's performance and updates accordingly the user model. More specifically, it assigns knowledge values to the concepts based on the interaction parameters and updates the inferable student characteristics based on the classification neurules of the user modeling component. When the user gains an acceptable knowledge level of the concepts belonging to the initial lesson plan, a new plan is created.

5. Expert System

The expert system's knowledge representation formalism is based on neurules, a type of hybrid rules integrating symbolic rules with neurocomputing. The attractive feature of neurules is that they improve the performance of symbolic rules [2] and simultaneously retain their naturalness and modularity [3] in contrast to other hybrid approaches.

Neurules are constructed either from empirical data (training patterns) or symbolic rules. Each neurule is individually trained via the LMS (Least Mean Square) algorithm. In case of inseparability in the training set, special techniques are used [2],[3]. In this way, the neurules contained in the pedagogical model and the user modeling component are constructed. The inference mechanism is based on a backward chaining strategy.

6. References

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Acknowledgements

This work is supported by the Greek GSRT within the framework of the research project PENED99ED234.