

Virtual Tutor

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Abstract: Based on the research of [Stil 1998] [Maurer 1992] [Lennon 1994] [Elliot 1995] [Colbourn 1995] [Reeves 1997] [Lugner 1997], the application of an expert system as an interactive multimedia knowledge module with explanation features named Virtual Tutor (VT) was developed. For students, the individual dialogue based session with the VT, provides the possibility to apply the knowledge acquired in combination with indirect assessment. The VT was further embedded in the Web-based on-line learning environment. The reported research merges qualities of an expert system with advantages of multimedia, thus creating a variety of innovative ways of knowledge mediation.

Based on the evaluation results the conclusion can be drawn that dialog based system meets more accurate the requirements of the students in case of solving problems. Problem solution can be found easier and faster than using conventional literature. The possibility of accessing additional information related to the subject domain and explanation on request, VT is an interesting and different tool for knowledge transfer.

Introduction

Higher education has entered a transition from the Teaching Paradigm to the Learning Paradigm. Emerging from this process are powerful new teaching styles founded on principles of active-learning and improved insights on the cognitive development of learning. As outlined in [Buckley 1999], learning environments that exploit interactive multimedia are of special interest. The educational potential of this technology closely parallels the pedagogical goals of the Learning Paradigm. According to [Buckley] a simple pedagogical set of features that can foster transition to the Learning Paradigm is as follows: (1.) Interactivity fosters active learning, (2) The sensory-rich nature of technology facilitates the engagement of additional powerful cognitive processes, and (3) Integration of assessment tools into the environment can provide students with feedback and encouragement etc.

“From a pedagogic point of view, learning requires “a deep understanding of the subject content” through a cognitive re-elaboration of the information” [Colbourn 95]. Inspired by the work of Mark&Greer 1995, Chan 1996, Youngblut 1994, Nunez concludes [Núñez 1999] as follows: *“Knowledge-based learning environments have offered significant potential for fundamentally changing the educational process.”*

In general, classical Web-based tutoring systems rely on memory and do not take into account the cognitive information treatment process. In order to overcome this problem, the intelligent tutoring systems came into being, as described in [Han 1999]. The use of multimedia objects in educational systems can enhance their efficacy to a great extent in facilitating cognitive skills besides other components of domain competence as shown in research by Kinshuk [Kinshuk 1999].

Idea of the Virtual Tutor

The aim of the research presented in this paper was to apply an expert system as a knowledge module within the on-line learning environment. There are many benefits for the students within the on-line learning environment independent from the course content and style, like e.g. tools for asynchronous and synchronous communication and collaboration, search facility within a background library, a progress indicator monitoring the learning success etc. The application of ES makes it possible to use different knowledge representation and explanation approach. The individual session

with the VT provides also the possibility for students to apply the knowledge acquired in combination with indirect assessment.

With interactive sessions with the VT, various students' activities could be increased as follows: raising the learning motivation, research work, stimulating the creativity by carrying out analysis and synthesis, searching for solutions, interdisciplinary learning.

VT system requirements are as follows: (1) the interaction and the communication should be performed by a question-answer dialog, (2) the system has to explain why a particular question is asked (i.e. why a certain fact is questioned) and the influence of the fact on the problem solution, (3) the VT must be capable of explaining reasons for the suggestion of a solution or a particular ranking of possible solutions, (4) descriptions and illustrations of items concerning the problem domain have to be provided by hyperlinks connecting the multimedia information within the static and dynamic background library, (5) the system has to run at least under Netscape 4.x and MSIE 5.x, (6) the VT has to be designed and implemented considering the possibility of the easy change of the problem domain as well as easy enhancement within the same problem domain.

The Concept and the Architecture of the VT System

Following the requirements stated so far, we have decided to combine the properties of expert systems with the advantages of Web-based information transforming and multimedia information structures. Because of this, as well as following also the ideas of platform independence and usage without installing the VT, the system was implemented in Java. The VT is built on JESS (Java Expert System Shell), a Java implementation based on Clips. [JESS] This makes it possible to provide the VT system as a Java applet within the GENTLE-WBT environment. It must be mentioned that the entire system (VT system, UI and the JESS system) has to be loaded by the client. To reduce network loads, a future implementation will be done by splitting the VT into a client-server architecture.

Within the following sections, the system and the working principle are discussed.

The Working Principle

The aims of the VT system within the course "Knowledge processing" are: (1) To provide Decision support of using proper AI techniques related to a particular problem. The first implementation takes into account expert systems, neuronal nets, fuzzy logic and neuro fuzzy. (2) An interactive system has to be provided. (3) The suggestion has to be explained by the system. (4) Additional descriptions and illustrations have to be provided by a static and dynamic background library of multimedia information.

To meet the aims stated above, the VT - in general expert systems - has to comprise three types of knowledge: Problem Domain Knowledge (PDK), the Description Knowledge (DK), and the Subject Domain Knowledge (SDK). Within the PDK the system has to know about various problem types that can be covered by the four AI systems, and thus to provide the proper questions (collect information about facts) for the user interaction. The DK is used to describe the results (suggestions of AI systems) and influences of facts on the particular problem. The SDK is responsible for reasoning and building suggestions. Furthermore, it controls the sequence of the questions related to already known facts[Pivec 1997].

The procedure of the working principle can be subdivided into three tasks (see also Figure 1): (1) Dialog between the user and the VT system. The student has to answer questions about the problem domain. (2) Internal representation of the problem. Related to the problem domain, an internal image of a particular problem is built by a set of attributes. For the first implementation the following properties are used to describe the AI problem domain: modularity, extensibility, mathematics model, expert knowledge, training sets, explanation, adaptive system, uncertainty, black box. The PDK and SDK components control the sequence of questions and change the internal representation. Weightiness of the attributes are changed (increase, equal or decrease) depending on the questions and the answers. That means that the properties are changed with respect to the facts questioned and the answers given by the students. (3) Suggestion of possible solutions. Based on the internal representation of the problem, the SDK determines a ranked output of the AI techniques. It is to be mentioned that it is easy to extend (e.g. enlarge the subject domain) or change the knowledge (e.g. to use the system for another course placed in another subject domain), because of the use of a knowledge-based system (expert system JESS). This makes it possible to change and maintains knowledge without changing the entire program.

The Architecture

The architecture of the VT system is illustrated in Figure 2. The JESS system contains three types of knowledge (PDK, DK, SDK) and manages the internal representation of the problem as well as processes the input and output stream of information. The parser within the output stream handles hyperlink information for the user interface (UI) of the applet. The hyperlinks are references to the static and the dynamic background library. For further work, it is planned that the pre-knowledge of the students is taken into account. This will make it possible to provide background information related to the current knowledge level of each particular student. A novice in AI will receive basic information, and an advanced student will get much deeper information. The UI represents the dialog between the students and the VT system.

As already stated, the VT system is integrated in the GENTLE-WBT [GENTLE] learning environment, as illustrated in Figure 3. The learning environment allows compiling courseware (lecture notes, exercises, etc.) and provides also diverse communication features (asynchronous discussion forum, chat, etc). The decision was made to place the static background library into the GENTLE-WBT system. The static background library contains descriptions, definitions and illustrations concerning items of the AI techniques handled by the VT system. The information is prepared in multimedia modules using textual information, graphics, video files, and flash presentations. The later presentation form is used for an interactive information transfer.

Figure 3 also shows the interaction between the VT system and the lecture notes. For the first implementation of VT the existing lecture notes of "Knowledge processing" were applied. Hints at proper pieces of information refer to the VT system. Vice versa, explanations by the VT system also provide hyperlinks to subjects of AI techniques within the lecture notes. Students are enabled to work with the VT system and can get information or re-read topics of the lecture notes to get familiar with the relation and influences of a particular (given) problem.

The third part of referred information provided by the VT system is the dynamic background library. A huge amount of useful information is available on the Internet. The intention is to collect trustworthy information from university institutes, research centres, online libraries, company information, etc. related to the subject of the course. One of the advantages of including such a dynamic background library is that the students are supplied with up-to-date information. The xFIND (extended Framework for Information Discovery) system, an open source project developed also at the IICM, perfectly meets the requirements for such a dynamic background library. The dynamic background library has already been used in the course "Knowledge processing" for more than a year. The xFIND system is a highly scalable and distributed system for the management of online resources that consists of three components, the Gatherer, the Indexer and the Knowledge Broker. The system manages the content of Internet resources, and in addition a broad spectrum of meta information (xFIND quality metadata) about the resources. Thus, e.g. the topics, target audience, quality level, etc. of Web pages or entire structures of Web pages can be managed [xFIND]. The VT system requests information by a somewhat predefined dynamically compiled search query related to the topic or subject of interest. It is planned that the dynamic background library should provide different information related to the student overall performance. Such a feature has been already implemented in the xFIND system.

Evaluation of the System and Conclusions

The evaluation of the VT was carried out with students, as a part of the practical work within the course Knowledge processing at the Graz University of Technology. The students were divided into two evaluation groups: one group worked with a printed version of lecture notes, whereas the other group used VT to provide the solution to the presented problem. The group that worked with the VT had also access to the background library. The evaluation was carried out in parallel sessions.

The evaluation showed that the application of the VT is easy and the on-line help is sufficient. The most often applied system features were as follows: (1) - application of the explanation component, (2) - inquiring about rules. All students that worked with the VT solved the task correctly. Taking into the consideration the students' comments outlined later in this chapter, the conclusion can be drawn that when using the VT students have the possibility to interact with the knowledge in a different way as when using only the classical lecture notes. This makes it possible to provide different points of view of a problem domain and introduce more complex ways of reflection.

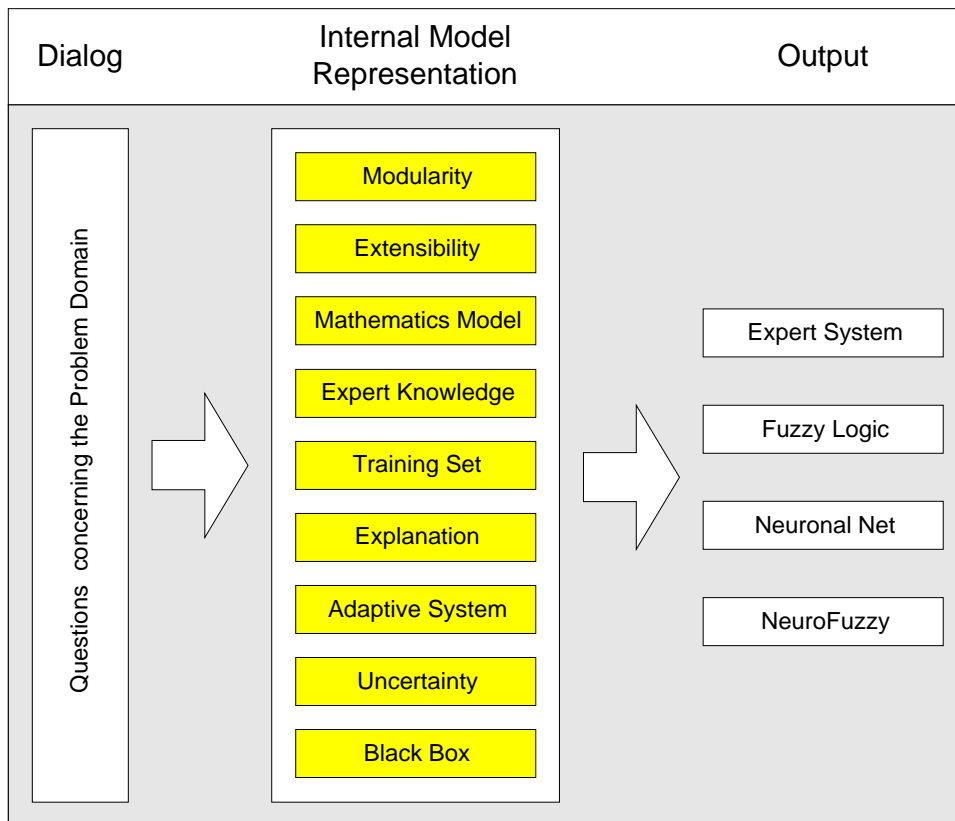


Figure 1: Working principle of the VT concept presented on the example of the AI domain of the course "Knowledge Processing". Students have to answer questions about facts, which describe the problem within the AI domain. The answers are used to build an internal knowledge representation. Based on the internal representation of the problem, the VT ranks suggestions of AI systems to be used for a particular problem.

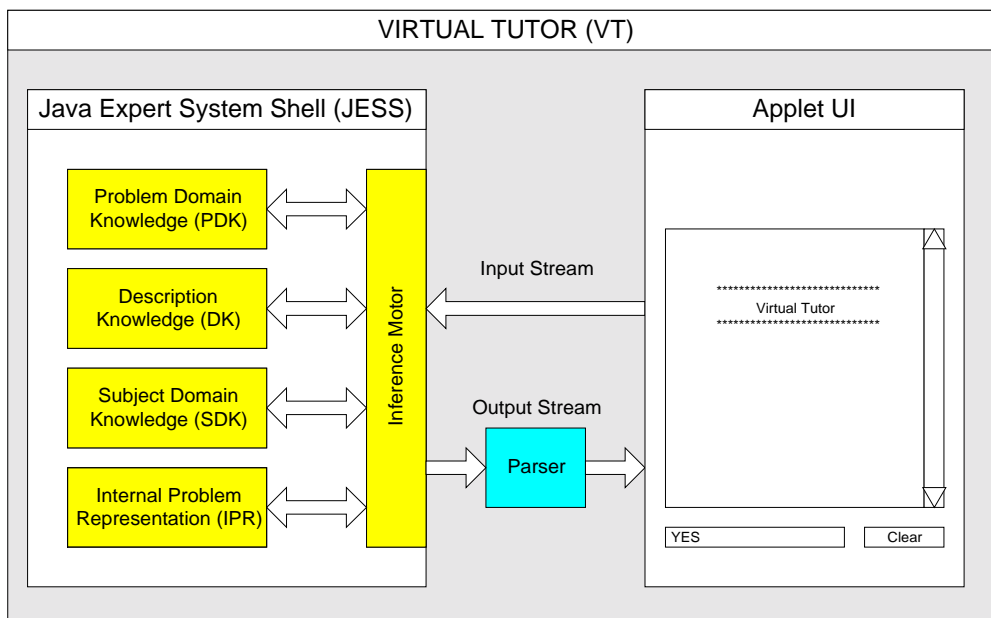


Figure 2: The architecture of the VT system. The expert shell JESS manages the knowledge (PDK, DK, SDK, and IPR) of the system. The parser handles the hyperlink management referencing information from the static and dynamic background library. The applet represents the interface to the user.

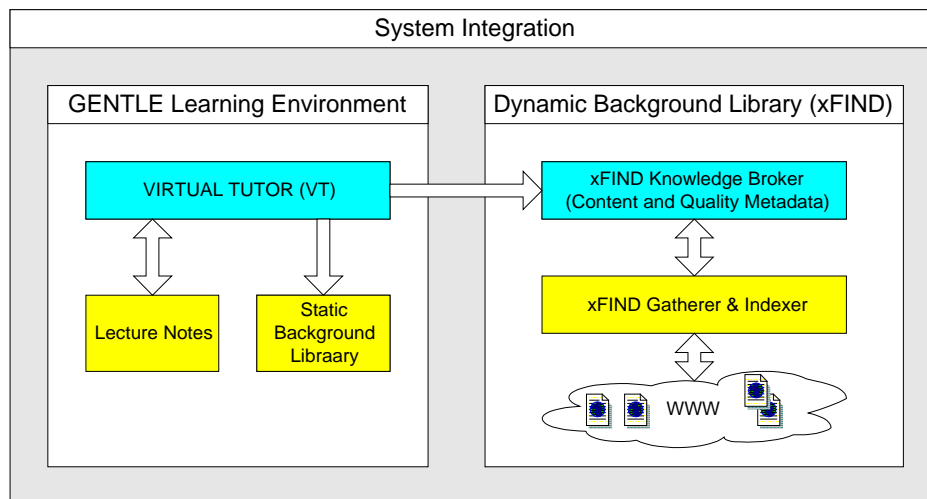


Figure 3: System integration. The VT system is embedded in the GENTLE-WBT learning environment. It is rendered via the GENTLE-WBT Web gateway as a Java applet.

From students collected comments indicated that the group that worked with the lecture notes had time problems. They expressed that within the time given it was very difficult to find various parameters that were necessary to solve the task. In general, the comments reflected that because of the time limit, the knowledge processing was insufficient and relatively shallow.

Based on the evaluation carried out, the conclusions can be drawn as follows. Dialog based system meets more accurate the requirements of the students in case of solving problems. VT is an interesting and different way for knowledge transfer that provides help by problem solving. Problem solution can be found easier and faster than using conventional literature. VT provides explanation of solutions suggested and makes it possible to access additional information related to the subject domain. Besides conventional lecture, speeches and lecture notes, a VT-based subject domain presentation proved to be very helpful. To improve the knowledge transfer a range of exercises that have to be solved by the VT should be provided to students.

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