A Web-based Intelligent Tutoring System to teach students basis terminology on cascading style sheets

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Abstract

In this paper, we present the architecture of a Web-based Intelligent Tutoring System for distance learning and individualized instruction of students about common terminology on cascading style sheets. It offers course units covering the needs of users with different knowledge levels. Besides, it tailors the presentation of the educational material to the users’ needs by using artificial intelligence techniques. The aims of this project are to make teaching and learning more productive and efficient and to find new methods to teach large numbers of students with no increase in staff. The system provides a functional interacting set of theory and problems, and supports students’ progress through monitoring and assessment. Students of computer science who found this software easy to use and understand have successfully used the intelligent system, and it has become an extra teaching tool.

Keywords: e-learning, adaptive system, intelligent tutoring system, individualized instruction, pedagogical model.
1 Introduction

Rapid growth of quality and quantity demands in engineering education of technologically competitive societies makes computer-based multimedia education crucial [6]. During the last few years computer-based education has been improved by the introduction of intelligent tutoring systems. Its key feature is its ability to provide a user-adapted presentation of the teaching material [5, 8]. This is accomplished by using artificial intelligence techniques to represent the pedagogical decisions and the information regarding each student.

The teaching tool we propose is intended to support, but not to replace, traditional teaching techniques such as lectures and laboratory sessions. Variety in educational techniques and materials promotes a better understanding of a subject. Simply applying theory is ineffective. Examples can influence learning process much more than the presentation of concepts and rules.

Therefore, we have designed and implemented a web-based intelligent tutoring system which simulates a real educational centre with its administrative and educational components. The administrative components are easy to tackle with classic software engineering methods (consulting teaching material, enrolling students on courses, registering and un registering teachers and students, managing academic certification in line with the ISO 9001 standard, etc.). The educational components, however, are no minor concern because the tutor simulates the teacher’s decision-making and this is carried out using a psychopedagogical approach. For this, we have resorted to knowledge engineering and artificial intelligence techniques to develop an intelligent tutor which is similar to a real tutor.

Besides, the system developed encompasses two types of education: distance learning and individualized instruction. Distance learning is aimed at those people who cannot attend classes in person. On the other hand, individualized instruction differs from this because it reproduces an instructor’s behaviour (making decisions that a teacher makes when supervising each student’s individualized education). Taking this into account, our system is based in e-learning (used to carry out the distance learning) and b-learning (to achieve an individualized instruction) technologies.

The intelligent tutoring system presented interacts with the student, using course units constituted of theory, examples, exercises, exams and basic concepts, and providing immediate explanations and feedback to students. Based on this information, it constructs lesson plans and selects the appropriate course units for each individual user. It is also accessible every time.

Thus, this system combines face-to-face classes with an online tutor (providing face-to-face and distance training, b-learning). In addition we present the architecture of a web-based intelligent tutoring system to teach any kind of subject or course. Hence the system is addressed to all the users such as students or professionals.

First of all, we will show the difference between the traditional teaching and computer aided education. Thus, we will talk about several technologies of learning: e-learning and b-learning. These technologies only include the distance education, but not an individualized tutoring which could be carried out by using the teaching methodology proposed in this paper. Next, we will present the architecture of the web-based intelligent tutoring system, its implementation aspects and its functionality. We will conclude with a series of conclusions and future works.

2 Computer Aided Education

At the moment, education is based on lectures, tutorials, laboratory sessions and workshops. Due to the fact that there are usually many students in a classroom, lectures are not adapted for an individualized learning. Tutorials and laboratory sessions are a good opportunity for the teacher to pay an individualized attention to each student, but even so there are difficulties to take care of them individually.

Computer aided education is able to solve most of these problems [3, 5, 16]. It can introduce a wider range of materials, assess the knowledge level of a student, present additional information, provide the student explanations about his mistakes and, if it is necessary, change the learning format. Modern
computer-based systems can also include sophisticated multimedia representations of learning materials [4, 12, 20]. We well try to accomplish all this aspect with our intelligent tutoring system.

3 Learning Technologies

There are two learning modalities: e-learning and b-learning.

In e-learning (electronic learning), the role of the teacher is the one of an online tutor. Like a conventional teacher, it solves the doubts of the students, corrects his exercises and proposes works, but all these actions use Internet. Nevertheless, the most of these e-learning providers do not offer individualized instruction (which guides each learning process of the student) because it is more expensive, difficult and time-consuming to implement.

In b-learning (blended learning), the teacher practices his work in two ways like: online tutor (distance guidance) and traditional educator (face-to-face courses). In other words, b-learning combines both strategies which depend on the specific necessities of the course, thus provides with a great flexibility the online formation.

4 Review of e-learning Tools

E-learning technology, online instruction, or virtual education is widely used by educational establishments, schools, academies and even universities to offer all types of online courses. These synonymous concepts respond to a type of distance education where the physical gap between staff and students is narrowed by means of computing aids (Internet), with a greater two-way communication between teacher and pupil. Nevertheless, the majority of these e-learning providers do not offer individualized instruction which guides each student’s learning process as it is more expensive and time-consuming to implement.

Despite the fact that a number of e-learning tools that have been developed, most of them do not use to incorporate artificial intelligence techniques. The teacher uploads the material which will be read by the student at any time. This type of systems treat all the students the same. And so, if a student has some difficulties to learn a lesson, he will have to read it the same again, ask the teacher or look for additional information by himself. It is obvious that this kind of tool is not appropriate when the goal is adapting the learning process to every student. A tutor system capable of simulate the behaviour of a real teacher will be preferred. Several well-known tools with this philosophy are WebCT (http://www.webct.com) and Blackboard (http://www.blackboard.com/).

On the other hand, other more specific tools have been developed. The aim of these tools is teaching a certain knowledge to a certain group of people, for example: to teach to the students of a school of nursing [10, 15], to teach electrical circuits to university students by means of graphical exercises [24], to instruct air traffic controllers [14], to teach mathematics [1], to analyze mistakes made by the student in order to help him [18], to diagnose the errors of the answers of the student [11], to develop a methodology for oriented-objects analysis and design [7], to design and to implement the Dijkstra-Gries methodology [19], etc.

In spite of the high number of existing tools, currently they are not developed for helping to the personalized and individualized formation of the students adapting the lessons of a course their necessities. By this we have designed and developed a tool that we will denominate as intelligent tutoring system. This tool controls the teaching process. It has a friendly graphical interface to represent its functionality (such as: the lesson of the course that is studying, the knowledge that has assimilated, the concepts that has failed and must reinforce, the number of courses in which it is registered, etc.) and can be used from any place thanks to the advantages of the technology Web.

5 Intelligent Tutoring System

An intelligent tutoring system is a system which is able to help the student during the learning process. It could be also said that the system becomes a kind of a semi-face-to-face system, because the teacher is
absent and the system is the one that guides the student in the assimilation of the different concepts which let him to learn a subject [21, 22, 23].

The main objective of an intelligent tutoring system is to adapt the hypermedia courses to each user by means of: the control of the learning level, the control of navigation, the adaptation of the teaching methodology and the teaching material and the explanation of the mistakes of the student, etc. [1, 4, 12].

A tutoring system helps to each individual student in its process of learning. Thereby, it facilitates to the pupil two forms of study: remote education and adaptive education. The first modality is simplest because the own student is the one who decides his own process of education. Whereas the second option is more complex because the system is the one that guides and adapts the educative material (provided by the teacher) to the level of each student. This process of learning is carried out using a psychopedagogical approach that corresponds with the individualized tutoring.

6 Description of the System

The intelligent tutoring system developed tries to solve the deficiencies we have previously described. By means of the simulation of a training centre is able to integrate the student and the teacher in a system with an approach which is different from the traditional one. Thus our system builds instructional programs that incorporate well-prepared course materials in lessons which are optimized and adapted for each student. Furthermore the system is capable of drawing conclusions from the student’s problem-solving behaviour and supervising the sequence in which material is presented to the student.

The intelligent tutoring system developed accomplishes the following tasks:

- It presents the educative material with theory, graphs and/or exercises to the students.
- It models the state of knowledge and the students’ ability.
- It teaches, examines and evaluates each student individually.
- It obtains the successes and the mistakes of the answers given by the student through a template (when the exam it is a test) or through teacher corrections (when the exam is theoretical).
- It allows searching the previous lessons.
- The training of the student is managed by constructing an adaptive plan of units which integrate the appropriate lessons of reinforcement for each learning unit of the course.
- Due to the use of Internet, the system lets the student learn from anywhere.
- The system is able to store logs about the student interaction with the courses.

Other relevant functions of the system are:

- To predict the mark that a registered student will obtain in a course (pass or fail).
- To show the teacher how a pupil is responding to his courses.
- To show the student a plan of lessons that must be reviewed (which is based on the lessons that have been studied).
- To study the performance of each student with each unit of the course. If the system detects some unit which is continuously reviewed, this means that the unit must be divided in order to present the concepts in a better way. Furthermore, the system provides the teacher an interface to see this new material produced by the Adaptive learning.

Immediately, we will go into the educative material and we will describe the educational behaviour of the intelligent tutoring system, its architecture and its resolution with multi-agent systems.
6.1 Educative Material

A course consists of lessons or units which are associated with one or several pieces of knowledge. The learning units constitute the training material that is showed to the students as Web pages. This training material is composed of a variety of courses that cover from the introduction and scale to more advanced units. Therefore a learning unit is an elementary block of knowledge which consists of a set of attributes such as: title, name, location, level of difficulty and type of unit (theory, examples, graphs, diagrams, test or exam). The attributes of the learning units are filled up with a set of forms provided by the system to the teacher.

Examples, graphs and diagrams assist the student to understand the key points of the theory. Tests or quizzes are based on the examples and are used to evaluate the student’s knowledge level. Besides, when the student is solving a test, he can ask the system for help in order to view related concepts. Each test is associated with an explanation that assists the student in case of a wrong answer. After studying a complete course, the student must do an exam in order to obtain a mark.

In the methodology of individualized instruction, the learning unit can be: a lesson, a test of lesson, a lesson of reinforcement, a test of lesson of reinforcement and an exam, and in the methodology of remote education can be: a lesson, a work and an exam.

The knowledge concepts refer to basis pieces of knowledge concerning the domain of the course. Every concept has a number of general attributes such as, its name, its level of difficulty, etc. Furthermore, it 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 student is required to know some prerequisite concepts in order to be able to understand the knowledge contained in the corresponding course unit. The representation of the domain’s pedagogical structure (concepts) and the teaching content (course units) facilities the update of the system.

6.2 Teaching Methodology

The teaching methodology of the intelligent tutoring system consists of guiding the navigation of each student by using learning units so that he acquires the theoretical knowledge of the course [2, 7, 9, 17]. This methodology allows the adaptive learning (also called individualized instruction).

The teaching methodology for each student consists of browsing the concepts required in each learning unit of the registered course and doing a test to determine if they have been correctly understood. Tests can be done more than once, but the system only registers the latest mark. The student fails the test when a mark which is lower than the percentage given by the teacher is obtained. When a test is done it is corrected by the intelligent tutoring system (which uses the solution template given by the teacher). In addition, the student can see his marks and mistakes, and also the concepts and the lessons that must reviewed. If the student fails the test, the system will show an explanation and will give him a chance to reinforce these concepts and to be examined again.

The student can do the test and reinforcement lessons when he wants. Besides, the student can see the lessons of the registered courses in the order that wants. Nevertheless, when he makes an exam, the tutor associates a maximum score that the students must reach. Therefore, to pass an exam, the student must have correctly answered the 50% of the proposed questions. These questions must be solved in the time fixed by the teacher.

6.3 Architecture

The intelligent tutoring system is based on an intelligent system that controls the teaching process. The intelligent system employs a knowledge representation formalism, called symbolic rules.

Symbolic rules are used to help to the student with the management of his learning process. For example: if the pupil does not know the concept i or the concept j, the system return him the lesson of reinforcement and the test of reinforcement for evaluating again this concept. More concretely,
IF concept_i is failed OR concept_j is failed THEN
Return lesson of reinforcement_m, test of reinforcement_n

As well, the intelligent tutoring system has been solved by means of multi-agent systems with a blackboard architecture where various agents exchange information on a common blackboard [21, 22, 23]. The functionality of these agents is to emulate the behaviour of an instructor by using a teaching model which includes: evaluating the student’s test and exam answers, drawing up a plan of units to revise, predicting the student’s grade, and designing the syllabus according to the evaluation obtained by the students.

Therefore, the educational architecture of the intelligent tutoring system is composed of the intelligent system and the graphic interface [2, 11, 15, 18, 25]. The intelligent system consists of several components (see figure 1): domain model, student model, teacher model and pedagogical model [17].

- **Domain model**: this provides the knowledge of domain, the student teaching knowledge’s, and this provides intelligence to the tutor. This model consists of declarative knowledge and procedural knowledge. The declarative knowledge represents the facts of the knowledge base and includes information related with the teaching material (lessons, tests, exams, etc.). On the other hand, the procedural knowledge is referred to the set of rules to execute a task.

- **Student model**: this registers information relating to the pupil like: personal information, parameters of interaction and knowledge of the failed concepts.

- **Teacher model**: this registers information relating to the teacher like the personal information.

- **Pedagogical model**: this is the heart of the intelligent tutoring system because it represents the learning process and consequently controls the operation of the system providing communication among component. Further, the pedagogical model adapts the presentation of the teaching material to the educational knowledge of every student by using the information contained in the student model. Thus it personalizes his training elaborating a plan of units which is based on the pupil’s knowledge. This plan of units refers to the plan of lessons that the student should read again. The pedagogical model consists of seven components:
  - **Evaluation model**. It assesses the student’s performance and updates interaction parameters of the student model.
  - **Problem generation model**. It generates the problem or the learning unit of the course that the student requires in his process of training.
  - **Problem-solving model**. It deduces the correct solution of the problem. In addition, it prepares advice when this one wants to review some of previous concepts to the lesson that is studying.
  - **Model for analyzing students’ answers**. It does the analysis of the answers of the student to find out if it is correct or not.
  - **Model for generating plan of revision units**. It obtains the plan of the lessons that would have to review a student because he has some lagoons in these lessons (he does not know his concepts).
  - **Model for predicting students’ grades**. It is a model for guessing the mark that it will be obtained in a course.
  - **Syllabus generation model**. It finds out which will be the new syllabus of the course of a teacher.

- **Graphic interface**: this is the responsible of the interaction between the system and the user (student, teacher, administrator and user). Due to the fact that it is a layer of the system that communicates directly with the user it should be carefully designed [12].
7 Implementation Aspects

The intelligent tutoring system has been implemented with a client/server architecture (see figure 2). The server distributes the web pages to clients and it is mounted on Apache with SSL secure protocol and OpenSSL certificates. In order to provide the dynamic behaviour of the system, the PHP programming language is used. The repository of information has been implemented with MySQL. Hence, the system is dynamic because it is possible adding or removing services in real time without interrupting the execution of the client and server.

The graphic interface is an application developed with web pages that are visualized with an Internet browser. Therefore, this application must be stored in a web server and. In addition, the service of FTP is used to upload and to download the teaching material such as web pages.
8 Functionality of the System

The intelligent tutoring system is used by the following types of user: administrator, teacher, student and user (see figure 2). Each user has several roles:

- **Administrator** manages and maintains the web site. He manages the information of the teachers and the students (users accounts, passwords, logs about accesses, personal information), eliminates teachers and students, queries registered students’ courses, queries students’ marks, etc.

- **Teacher** gets information of the templates of the courses, elaborates the proposed courses and the courses in project for the two types of education (individualized instruction and distance learning) (see figure 3), queries and modifies the information of the courses, queries his personal information and also the information of other teachers, looks for information of registered students in his courses (such as the spent time for each unit, the number accesses to each unit, the grades obtained, etc.), obtains information of all the registered students in his courses (such as the average of the spent time for each unit of a course, the average of the number of times that all the students access to each unit of a course, and the average of the grades obtained by all the students for each unit of a course, etc.), etc. Also, the system offers an exclusive service for the teacher which is the transfer of teaching material by FTP protocol.

- **Student** can get the information about the registered teachers, get information of the proposed courses and the courses in project of the teachers, enroll in a course (individualized instruction and distance learning), get information of the courses (see figure 4), see his fault concepts, study lessons and tests of reinforcement (see figure 5), query his marks and logs, etc.

- **User** is any person who accesses to the web site. A user can get information of the proposed courses and the courses in project, but he can not enroll in them. If a user wants to register in a course, then he needs to create a student’s account to enroll in it.

![Figure 3. Creating a personalized course.](image3)

![Figure 4. Information of the registered courses of a student.](image4)
The courses offered by the teacher in the two modes of learning (individualized instruction and distance learning) can be free or not. There are several ways of payment: banking domiciliation, banking transference, credit card, transference through PayPal, transference through MoneyBookers, shipment of money or check for certificated mail and cash on delivery.

In addition, the system provides services such as e-mail, telephone, forum, messenger, videoconferencing and intelligent tutor to the administrator, teacher, student and user so that they communicate among them.

And furthermore, it provides the teacher with templates to create the solutions to the multiple-choice course tests and exam, and this facilitates the introduction of the educational material data. In addition, the web tutor uses templates to save the students’ exam answers (multiple choice and theory/practical) and subsequently to show the results to the teacher. Templates have also been created to generate the course index, to time the exam, for security purposes, and to provide all the portal pages with the same format.

9 Conclusions

In this paper, we describe the design of a web-based intelligent tutoring system for teaching students fundamental topics of common terminology on cascading style sheets. The key points to highlight are:

- The system combines face-to-face classes with online tutor (mixture of face-to-face formation and distance formation, b-learning).
- It builds instructional programs that incorporate well-prepared course materials in lessons which are optimized and adapted for each student. Furthermore, the system is capable of drawing conclusions from the student’s problem-solving behaviour and supervising the sequence in which material is presented to the student.
- The system tailors the presentation of the teaching material to diverse needs of its students. Up to a point, the students can take part in the teaching process. The operation of the system is controlled by an intelligent system based on symbolic rules.
- The web technology will make easy the access to the system.
- The student can take part in the teaching process. An experienced student has the ability to set learning goals based on the concepts. For this purpose, the student can view a list of concepts and choose the concept he is more interested in. The list of concepts is sorted in decreasing order according to the student learning level. Therefore, the system provides the student motivation and some control on his own learning process. These features increase the usability of the system.
- Theory, examples, graphs, diagrams and explanations provided by the system help the student to understand in a better way the material. In order to achieve this, it must be prepared very carefully,
keeping in mind that the lecture cannot be accessed during every tutorial session to explain or clarify difficult points.

- Tests and exams help the student and the teacher to know the fault concepts.
- The system is always available. It is more interesting than traditional tutorial sessions because it aids, guides and adapts the educative material to the level of each student. This provides an individualized instruction. This process of learning is carried out using a psychopedagogical approach.
- Student assessment is a key element of the intelligent tutoring system developed. It allows to follow the progress of every student in the course and also the progress of the whole students registered in a course.
- On average, lectures need to allocate a percentage of their time to student assessment and examination. However, these activities can be now easily automated. With the developed system, a student can test his own knowledge any time with minimum help from the teacher.

All in all, the intelligent tutoring system provides a flexible, independent, individual and personalized e-learning process for each student.

In the future, we would like to implement this system into mobile devices (PDAs, Pocket-PC) to provide mobility to the students in the learning process. We want to eliminate the restriction of using the computer in a fixed site. This is known as M-learning (mobile learning).

References


