INTELLIGENT TUTORING SYSTEM: AN ASSESSMENT STRATEGY FOR TUTORING ON-LINE

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Abstract: In this paper we introduce a tutoring approach for E-Learning formative process. This approach is strictly related to the assessment phase. Assessment in the context of education is the process of characterizing what a student knows. The reasons to perform evaluation are quite varied, ranging from a need to informally understand student learning progress in a course to a need to characterize student expertise in a subject. Otherwise finding an appropriate assessment tool is a central challenge in designing a tutoring approach. In this paper we propose an assessment method based on the use of ontologies and their representation through a Bayesian Networks. The aim of our approach is the generation of adapted questionnaires in order to test the student's knowledge in every phase of learning process. Analyzing the results of the evaluation an intelligent tutoring system can help students offering an effective support to learning process and adapting their learning paths.

1 INTRODUCTION

Our "information-oriented" society shows an increasing demand of life-long learning. In such framework, on-line learning is becoming a real solution that allows flexibility and quality in the learning process. In this field the assessment phase is acquiring a strategic interest. In fact, assessment is an important and difficult task in the whole teaching and learning process (Dahlgren, 1984). In fact it can furnish timely feedback through just-in-time problem solving aid that turns the learning process into a highly interactive learning experience. On the other hand the implementation of an effectiveness on-line evaluation strategy can be very difficult. In fact experts consider the evaluation phase as the weak point in an E-learning process. Many of currently existing assessment systems focus on simple assessment strategies, e.g. only on single or multiple-choice questions with several answers, and radio-buttons to select the correct answer. Furthermore most of them are unable to support the different needs of individual users and focus mainly on the assessment of the "average user". In this way teachers can give only a mere quantitative evaluation of students' knowledge and can not fill in the gaps in their learning approach. Assessment provides an effective method to gather information about student's learning and it is a good starting point in order to arrange feedback's strategy. Finding an appropriate assessment tool is a central challenge in designing an assessment approach (Royer, 1993). The difficulty arises because of the diversity of learning objectives, the diversity in what counts as evidence of learning, the diversity of tools available, the varying resources available, and the varying assessment contexts. One way to address these various assessment goals and challenges is through the use of concept maps (Turns, 2000). So starting from this general framework in this paper we describe our system for assessment and tutoring based on Ontology formalism (the generalization of concept maps) and metadata standards. In this paper we represent ontology through Bayesian Networks formalism because in this way we can depict and estimate the preparatory links between the various subjects belonging to knowledge domain. In this way it is easier to understand the real knowledge shortage of students (Colace, 2003). In this paper we design and implement a tool that arranges the best assessment strategy according to the information inferred by the analysis of questionnaires. Our tool can test the knowledge of students on every subject of ontology adopting various approaches. The Bayesian approach allows quantizing the probability of correct answer of students in a particular subject. In this way tool can propose to the student the question with the lower (or higher) probabilities of correct answer. At the end of the assessment

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student's profile is updated. The paper is organized as follows: in Section 2, we provide the motivations and the details of the proposed assessment tool. In particular we give some details on ontologies and their mapping through Bayesian Networks. In section 3 we describe the proposed approach. In section 4 the experimental results are reported. Finally, in the last section we draw conclusions and indicate future directions of our research.

2 THE TRACKING AND ASSESSMENT PROBLEM

Some of the tasks that an E-Learning platform should carry out aim to allow people to find, evaluate and acquire adapted learning objects. These activities are common and easy to carry out in traditional learning processes: we can not say the same in distance learning field. In the designing and organizing phase of a course, a teacher has to choose the most appropriate contents: this selection shows notable difficulties, also due to the huge amount of information available, of which only a minimum part really meets teachers' needs. The possibility of accessing to contents that could be useless or not related to the subjects of interest is considerable. In this framework a very important role is played by the assessment phase. Assessment gives to the learning environment the most direct information about the student's knowledge. The best assessment approach provides questionnaires that are built dynamically on the basis of the student model. Questions have to cover the topics most recently completed, as well as those that should be reviewed. Each question has a level of difficulty, which is also used in the updating phase of student model. Correctly answering a harder question demonstrates greater ability than correctly answering an easier one (Shang, 2001). The assessment framework combines researches from two major research disciplines: adaptive educational hypermedia and semantic web technologies. In this paper we focus our attention on the assessment phase and in particular in the designing of an adapted assessment generator and assessment module.

2.1 Ontologies

The concept of ontology was taken from philosophy where it means a systematic explanation of being. In recent years, however, this concept has been introduced and used in different contexts, thereby playing a predominant role in knowledge engineering and in artificial intelligence. Ontologies could be represented as taxonomic trees of conceptualizations: they are general and domain-independent at a superior level, but become more and more specific when one goes down the hierarchy. In other words, when we move from the highest taxonomic levels to the lowest ones, characteristics and aspects typical of the domain under examination are showed. In order to point out this difference in literature we call them heavyweight (deeper ontology) and lightweight (advances taxonomy) ontology respectively. In this paper we will adopt the last one approach keeping in mind this definition of ontology: "ontology may take a variety of forms, but it will necessarily include a vocabulary of terms and some specification of their meaning.

2.2 Ontologies and Bayesian Networks

Bayesian networks have been successfully used to model knowledge under conditions of uncertainty within expert systems, and methods have been developed from data combination and expert system knowledge in order to learn them. A Bayesian network is a graph-based model encoding the joint probability distribution of a set of random variables $X = \{X_1, \ldots, X_n\}$. It consists of a directed acyclic graph S where each node is associated with one random variable Xi and each arc represents the conditional dependence among the nodes that it joints and a set P of local probability distributions, each of which is associated with a random variable Xi and conditioned by the variables corresponding to the source nodes of the arcs entering the node with which Xi is associated. The lack of an arc between two nodes involves conditional independence. On the other hand, the presence of an arc from the node Xi to the node Xj represents that Xi is considered a direct cause of Xj. In this paper we use an algorithm, based on the formalism of the Bayesian networks, able to infer propaedeutic relationships among different subjects belonging to the knowledge domain of a course (Colace, 2003). The first step of this algorithm is the introduction of a mapping between Ontology and Bayesian Network. In our ontology model nodes represent the subjects belonging to the course knowledge domain and the arcs mean a propaedeutic relationship among the nodes. We can map this ontology graph in a Bayesian network in the following way: the Bayesian networks nodes can model the subjects belonging to the course Knowledge Domain and the knowledge of subject by students while arcs in the same way can mean the propaedeutic relationships

among the nodes. Given the previous mapping strategy our aim is to use and update the ontology used by teacher in his/her course. Obviously we must define data type and data set for this approach. As previously said the student's answers to the end course evaluation tests represent a source of implicit evidence. In fact, teachers through the end-of-course evaluation tests not only assess student's knowledge for every subject, but describe the course ontology and outline the propaedeutic aspects that relate subjects each other. In this way we can use an updated ontology and we can measure the effective propaedeutic links between the various topics of a course.

3 THE PROPOSED SYSTEM

In this section we will describe in detail the architecture of our tool (named Virtual Teacher) and the proposed assessment tutoring strategy. As previously said we aimed to design a tool for assessment able to assist students and teachers in the formative process. We designed our tool keeping in mind the main needs of students and teachers. From a technological point of view we designed the tool according these constraints: Web based approach, aesthetic and minimalist design, flexibility and efficiency of use, help users recognize, diagnose, and recover from errors. In the first phase of the designing we pointed out the actors of the system and the use cases. We identified three typologies of actors in the system: Administrators, Teachers and Students. Each of these figures has a well defined role and tasks. In particular Administrators can introduce new courses, describe new ontologies and manage the accesses to the tool. Teachers can design the reference ontology, describe the learning objects and the questions linked to the nodes of ontology. Teachers can also manage the reports of every student in order to better supervise the learning process. Students can use tool in three different ways: Exam, Normal test, Bayesian test. In the Exam way our tool arranges a classical final test exam according to the teacher's strategy. At the end of the exam the system produces a report analyzing the performance of student in every subject. The normal test approach can be used during some module of the course. The more interesting service offered by our tool is the Bayesian test. This service makes the most of the matching between ontology and Bayesian network. In fact the first step is the introduction of a mapping strategy between Ontology and Bayesian Network. In our ontology model nodes represent the subjects belonging to the knowledge domain of the course and the arcs mean a preparatory relationship among the nodes. In this way we can map the ontology graph in a Bayesian network in the following way: the nodes of Bayesian Network model the subjects belonging to the course. The states (two: yes and not) of nodes represent the knowledge of student in the subject. The arcs mean the propaedeutic relationships among the nodes. In other words a node of Bayesian network-ontology represents the Knowledge domain of a course and quantizes student's knowledge of this node. First of all the system select a set of questions associated to every network node. At the end of this first phase system, through a Bayesian approach infers what subjects the students knows better than others. In fact through the Bayesian analysis the system can measure the percentage of correct answer in a subject. In particular it can predict the percentage of correct answer to a subject after a correct (or not) answer to questions related to propaedeutic subjects. At this point it can apply various strategies: for example it can select and propose to the student the question with the smaller percentage of correct answer. At the end of Bayesian test a detailed report on the knowledge of student in the various subjects is sent to teacher and to student himself. In particular after the Bayesian test the system proposes to the student some learning object for deepening some subjects. At the end of Bayesian Test the system updates the user profile of students.

4 EXPERIMENTAL RESULTS

In order to test the effectiveness of our tool we used it during the course of Introduction to Computer Science at Foreign Literature and Language Faculty of University of Salerno. This course is composed by seven modules: Introduction to PC Architecture, Introduction to Operative System, Microsoft Word, Microsoft Excel, Microsoft Access, Microsoft Power Point, and Internet. On the basis of the considerations of previous section, teacher designed the reference ontology. Each node of the networks has two states and shows the probability that a generic learner knows the subject associated with the same node. We have supposed that each node can assume only the following two states: state 'Yes' complete knowledge of the subject and state 'Not' total ignorance on the subject. The student level of knowledge could be evaluated on the basis of the answers given to the questions (a set of questions is proposed for each subject). At the end of the course students have to get through a final examination's test composed by forty questions. The questions

belong to every subject of knowledge domain. The number of student's course was about 50 and at the starting of the course we arranged them in two groups (named blue and red). The first group had a classical support to course activities and used only the normal test approach while the latter <group used also all functionalities of the tool as didactic support. At the beginning of the course teachers designed every module's ontology in order to organize the contents and an assessment test. The results are in the table 1. The aim of this test is to allow a first description of student through a metadata structure. In this way teachers can obtain information about the initial knowledge level of students. This information is very useful in order to describe for the first time the student profile. At this point the system organized for the student of red group a support material for every module of course. In particular it proposes the most suitable contents through a matching between the metadata of learning objects and the description of the student. As previously said during the course the students of the two groups attended to the lessons and used the virtual teacher tool. In particular students of red group at the end of every module sustained a Bayesian Test. At the end of course students had their final course exam. In the table we depicted the results:

Table 1: Results of Assessment Tool. The meaning of range are: [0-10]: inadequate, [11-15]: poor progress, [16-20]: adequate, [21-25]: good, [26-30]: very good.

Blue Group		Red Group	
Assessment Test	Students	Assessment Test	Students
0-10	10	0-10	12
11-15	11	11-15	10
16-20	9	16-20	8
21-25	3	21-25	3
26-30	3	26-30	2
Total	36	Total	35

Table 2: Results of Final Test.

Blue Group		Red Group	
Final Test	Students	FinalTest	Students
0-10	4	0-10	3
11-15	9	11-15	5
16-20	8	16-20	6
21-25	10	21-25	12
26-30	5	26-30	9
Total	36	Total	35

If we analyze the difference between the assessment and the final exam (table 1 and 2) we can note that the percentage of students that get through the assessment test is 37% in the red group and 42% in the blue group while in the case of the final examination the percentage is 77% in the red group and 64% in the blue group. We can note as more students of red group get through the final exam and improve their performance respect the assessment test (about 40%). In particular we can note that the students of the blue group have a minor improvement (about 22%) than the students of the red group. At the same time the percentage of red group's students that have a mark in the range 26-30 is higher than in the case of blue group: 26% to 8%. In order to collect more information about the effectiveness of our tool at the end of course we submitted a questionnaire to every student. In the questionnaire we asked the effectiveness of Bayesian test and of learning objects furnished by system at the end of the test. The 87 % of students said that the support of Virtual Teacher tool was very important in the learning process. In particular the 73% of students declared that the supporting learning object helped them in a better knowledge of the various subjects.

5 CONCLUSION

In this paper we proposed a tool for the assessment and tutoring of students during a learning process. This is based on the use of ontology and Bayesian Network. In particular through the matching between ontology and Bayesian Network our tool allow an effective tutoring and a better adaptation of learning path to demands of students. The assessment based on Bayesian approach allows a deeper analysis of student's knowledge. The experimental results seem to confirm our approach. As a future step of our research we intend to evaluate the performance of the proposed system when new features for tracking strategies are used.

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