Fuzzy Student Modelling to Advise Teachers in Web-Based Distance Courses

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Abstract. Many educational organizations use Web Course Management Systems (WCMS) to build distance courses. In such environments facilitators often face difficulties to monitor and understand the problems of their distant students. TADV (Teacher ADVisor) is a framework that uses the tracking information generated by a WCMS about individual students to build fuzzy student, group, and class models which are used to provide teachers with appropriate advice to help them manage their distance courses. This paper introduces and shortly describes this framework.

1. Background

Although Web-Based Distance Education (WBDE) has many advantages, several barriers still remain. Among these barriers are the students' feeling of isolation and disorientation in the course hyperspace and the facilitators' communication overhead and difficulty to address the needs of each individual student ([1], [2]). Recent successes in web-based intelligent tutoring systems ([3], [4], [5]) have demonstrated advanced methods to support students by dynamically generating suitable courseware and providing adaptive feedback. Distinct to these systems, our research focuses on supporting the course facilitators in WBDE by generating appropriate advice to help them manage effective distance learning courses. We consider distance courses built with Web Course Management Systems (WCMS) (e.g., WebCT, Blackboard, CentraOne, etc.) Usually WCMS provide rich information from tracking the students' actions but this information is scarcely used by the facilitators for it contains detailed, complex, unstructured data. We have developed the TADV (Teacher ADVisor) framework which builds student, group, and class models based on the information generated by WCMS and uses these models for generating advice to help facilitators manage and guide distant students on individual and group bases. It is expected that the advice will enable the facilitators to keep close to their distant students and make it possible for the students to receive more effective guidance and, hence, feel less isolated and disoriented in the course hyperspace. Incorporating student modelling techniques [6] into Web-based courseware allows students' actions to be monitored and their needs to be addressed [3]. The student modelling task is fraught with uncertainty [7]. One approach to deal with such uncertainty is to build fuzzy student models using certainty factors and fuzzy sets, see for example ([4], [7], [8], [9]).

2. The TADV Framework

TADV is a computer-based advice generating framework designed to deliver certain type of advice to facilitators in a WBDE environment developed by WCMS. TADV considers three levels of advice that correspond to the performance of: (1) individual students; (2) groups of students; and (3) the whole class. Figure (1) shows the architecture of TADV. It consists of two parts. PART-I represents the conventional structure of a course developed by WCMS. The course designers are responsible for preparing the material and organizing it in a way they believe is effective for their students. This material is incorporated in a ***Domain Knowledge Base (DKB)***. In TADV, a course is defined in a hierarchical way and divided into a set of *Lessons*, where each lesson is decomposed into a set of *Domain Concepts* that comprise the knowledge building blocks. The items associated with a concept *c* can be classified into three sets: *Learning objects* which contain didactic materials used to explain and exemplify the *c*, *Assessment quizzes* used to assess the students' levels of understanding of *c*, and *Communication activities* or collaborative tools (e-mail, discussion forums) used to discuss and negotiate *c*. All information WCMS collects about the students, including their registration and the records of the students' actions throughout the course, is accumulated in a ***Student Database (SDB)*** and used as the main source for modelling students and generating advice to the facilitators.

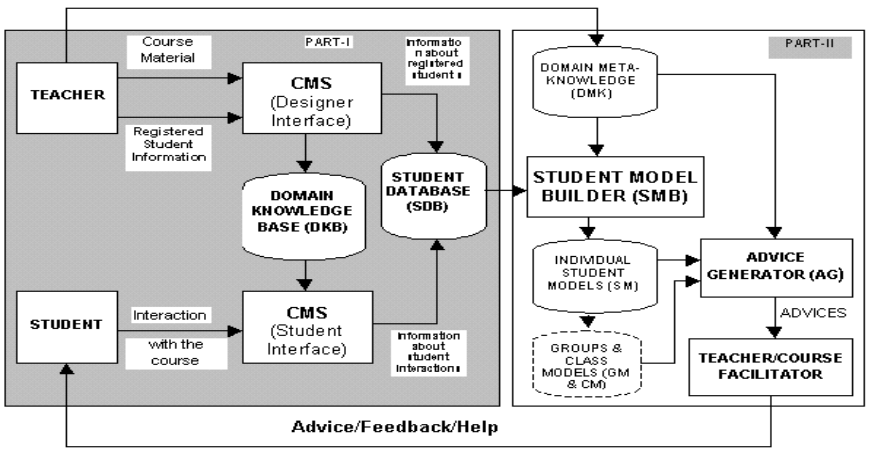

Figure (1): The TADV architecture.

PART-II represents the proposed extension to generate advice from the information provided by WCMS in SDB. Appropriate ***Domain Meta-Knowledge (DMK)*** is added as a layer upon DKB to describe the course and how the concepts are related. TADV follows the IEEE LOM metadata standards in describing the learning objects [10]. In addition, new attributes are added to represent the teacher's judgment of possible changes in the student's knowledge after visiting the learning objects. These attributes are used in the fuzzy approach to reason about the students' knowledge. DMK also includes attributes to describe assessment quizzes and communication activities.

Student Model (SM) is an overlay model which contains fuzzy information about student's knowledge and his/her communication activities. A SM is composed of four parts: ***Student Profile*** (personal details and educational background), ***Student Behaviour*** (learning interactions), ***Student Preferences*** (preferred types of learning objects, and quizzes), and ***Student Knowledge*** which indicates the student's levels of understanding of the concepts. The approach used in TADV to compute these levels is a variant of the MYCIN model of reasoning in uncertain environments [11]. ***Group models and Class Model (GMs & CM)*** are derived from the individual SMs to represent information about specific groups of students and the whole class considered as one group.

The ***Student Model Builder (SMB)*** analyses the students' information generated by WCMS and builds individual SMs, GMs, and a CM. SMB uses two main sources of information - the analysis of the students' performance recorded by WCMS and a human-teacher's judgments represented in DMK. The ***Advice Generator (AG)*** uses the SMs, GMs, and CM together with relevant information in DMK to produce appropriate advice. The reasoning used in AG is based on the assumption that the students' actions provide the main source for inferring roughly about the students' knowledge and misconceptions, which is sufficient for highlighting potential problems in distance learning courses and, if appropriate, recommending possible actions that teachers may undertake to overcome these problems. For example, if a student is found to struggle with a specific concept and the SM indicates that this student has visited little course material about the concept, the facilitator will be informed of the problem and will be advised to encourage the student to read the material related to this concept. If, however, the student has visited most of the material for a concept and still struggles, AG will advise the teacher to encourage the student to discuss the concept either in a personal communication with the tutor (e.g., via e-mail) or by attending appropriate discussion forums. Similar problems can be analysed at group/class levels. The advice in TADV is based on our analysis of problems with distance courses as discussed in the literature and has been confirmed in interviews with several web-based course facilitators. More details of TADV including a thorough description of the fuzzy student modelling and the mechanism for advice generating are provided in [12].

3. Current Status and Future Work

The TADV design is based on an extensive study of information provided by WCMS, including practical experience with several platforms, such as WebCT, Nathan Bodington, and CentraOne. The last has been employed in the current demonstration of the framework in a Discrete Mathematics distance course run in the Arab Academy of Science and Technology, Alexandria, Egypt. In the immediate future, we plan to conduct an empirical study to examine possible advantages of incorporating TADV in web-based distance learning courses. The study will compare two versions of the Discrete Mathematics course: with and without TADV respectively. We expect that in the second case the teachers will have a better understanding of their classes which may lead to improved course management and may overcome some of the current problems in distance learning.

4. References

[1] Smith, C., Grech, C. & Gillham, D. (2000). Online Delivery of a Professional Practice Course: An Opportunity to Enhance Life-long Learning for Asian Nurses. **In the Proceedings of Distance Education: An Open Question? Conference, Adelaide, Australia**, 11-13 September.

[2] Carro, R., Pulido, E. & Rodriguez, P. (1999). An Adaptive Driving Course Based on HTML Dynamic Generation. World Conference on the WWW and Internet, WebNet'99 Proceedings, Hawaii-USA, October 25-30, v. 1, pp.171-176.

[3] Brusilovsky, P. (1999). Adaptive and Intelligent Technologies for Web-Based Education. **In: C. Rollinger and C. Peylo (eds.) Künstliche Intelligenz, Special Issue on Intelligent Systems & Teleteaching, 4, 19-25.**

[4] Capuano, N., Marsella, M. & Salerno, S. (2000). ABITS: An Agent Based Intelligent Tutoring System for Distance Learning. **Proceedings of ITS'2000**, Montreal, June 19-23.

[5] Brusilovsky, P. and Peylo, C. (2001/2002). **Special Issue on Adaptive and Intelligent Web-Based Systems. International Journal of AI in Education. 12/13**.

[6] Self, J. (1999). The Defining Characteristics of Intelligent Tutoring Systems Research: ITS Care, Precisely. **International Journal of Artificial Intelligence in Education**, 10,350-364.

[7] Katz, S., Lesgold, A., Eggan, G., and Gordin, M. (1994). Modelling the Student in SHERLOCK II. In Greer, J., and McCalla, G. (eds.), Student Modelling: The Key To individualized Knowledge-based Instruction. **Springer-Verlag Berlin Heidelberg**, pp. 99-125.

[8] Hawkes, L., Derry, S., and Rundensteiner, E., (1990). Individualizing Tutoring Using an Intelligent Fuzzy Temporal relational Database. **International Journal of Man-Machine Studies**, 33:409-429.

[9] Warendorf, K. and Tsao, S. (1997). Application of Fuzzy Logic in the BSS1 tutoring system. Journal of Artificial Intelligence in Education, 8, 1, 113-146.

[10] Wayne, H. et al. (2002). Draft Standard for Learning Object Metadata (Final Draft Document IEEE 1484.12.1). **Copyright © 2002 by the Institute of Electrical and Electronics Engineers, Inc**. http://ltsc.ieees.org/doc/wg12/LOM_1484_12_1_v1_Final_Draft.pdf.

[11] Buchanan, B., and Shortliffe, E. (eds.) (1984). Rule-Based Expert Systems: The MYCIN Experiments of the Stanford Heuristic Programming Project. **MA: Addison-Wesley**.

[12] Kosba, E. (2002). Generating Computer-Based Advice in Web-Based Distance Education Environments. **Internal Report, School of Computing, Leeds University**.