DOMUS TUTOR: A CBR TUTORING AGENT FOR STUDENT SUPPORT

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ABSTRACT

The changes introduced by the Bologna process in the educational paradigm, moving from a lecturer centered paradigm to a learner centered paradigm, involves a more supported learning process based on learning outcomes and the adoption of new pedagogical methodologies. In this paper we present our strategy of integration of tutoring agents in learning environments, using the features of intelligent tutoring systems adapted to collaborative environments. The Domus Tutor agent is the face of the adaptive learning environment that integrates Learning Design, groupware and collaborative work technologies. The adaptation of the system to the learner profile is based on case-based reasoning methodology; witch is one of the major reasoning paradigms in artificial intelligence.

1. INTRODUCTION

The Bologna Process, so debated lately, has the main goal to establish a European Higher Education Area by 2010. In Bergen communiqué it was included the importance of innovation in learning process: "we recognize that time is needed to optimize the impact of structural change on curricula and thus to ensure the introduction of the innovative teaching and learning processes that Europe needs."

The institutions are faced with new challenges in the structural change on curricula and the adoption of innovative teaching and learning processes.

To face this challenge, the curricula design must be based on learning outcomes and less in the classical teaching model, integrating e-learning technologies and new pedagogical models.

The pedagogical model is centered on the student and the lecturer has the mission to support his learning process in the contact hours as so in the other learning activities (e.g. practical work, seminars, fieldwork, private study and projects). The European Credit Transfer System (ECTS) system provides an instrument to measure the full student workload, not restrictedly only to contact hours. In this context the lecturer has to support more effectively all the students according to their learning needs.

To improve the learning process and facilitate the student support, we propose the adoption of tutoring agents in learning environments, with the mission to support the student in their learning activities, coaching, advertising for difficulties, adapting the context to the learner profile, and making a bridge between the student and the lecturer.

2.   TUTORING AGENTS

The adoption of artificial intelligence in education has the goal to improve the learning process adapting the contents and the learning environment to the student profile. The student profile is based on her learning style, learning needs, goals and choices.

The first system that adopts artificial intelligence techniques was the Intelligent Tutoring Systems (ITS). Kearsley defined an intelligent tutoring system as an application of artificial intelligence techniques to teach students (Kearsley, 1987). Sleeman and Brown defined an intelligent tutoring system as a program that uses artificial intelligence techniques to represent knowledge and carrying on an interaction with a student. According to Sleeman and Brown, an intelligent tutoring system must have its own problem-solving expertise, its own diagnostic or student modeling capabilities, and its own explanatory capabilities (Sleeman & Brown, 1982).

One of the first architectures of a ITS system was presented by Burn and Caps in 1988. This architecture was based on four main components: curriculum module, student module, tutor (pedagogical module) and the interface module between the student and the system. This basic architecture was improved by several researchers, including Ong and Ramachandran in 2003, Thomas in 2003, Bass in 1998, Choquet et al. in 1998, Titter and Blessing in 1998 and Nkambou and Gauthier in 1996.

The student has the main role in the intelligent tutoring system. All the features of the system have the mission to adapt the interface and the pedagogical material to the student profile and his preferences.

The domain module is a knowledge management system, storing all the concepts that the system pretends to transmit to the student.

Connected to the domain module are the student model and the pedagogical module. The student model represents the learner behavior, his profile, learning style, motivation level and his interests. This model is based on artificial intelligence skills that simulate the human behavior. All the student behavior is recorded in the system and used for "reasoning" and adapt the domain module to the leaner needs.

The pedagogical module acts has a virtual instructor, presenting the contents in an appropriate sequence, based on the student skills and his learning style. This is an interactive process and this module has the mission to explain the concepts to the student given several points of view and supporting all the learning process.

With the capacity to communicate and interact with the student, the interface module has an extremely important mission. If one ITS has a powerful pedagogical and domain module, but the interface module is very poor, the ITS will not be effective because the interface is the front of all the system and has the ability to cap all the attention of the learner. To develop a good interface module is necessary to consider the usability issues of a user computer interface, because this module interacts with the user and the other components of the system. If the interface fails all the other modules fail too.

The type of intervention of the pedagogical module in the system is very important for the student creativity and motivation. Wenger consider that is more efficient to let the student search for the solution for one problem before make any intervention (Wenger, 1987).

ITS are systems based on computer based training (CBT) technologies and are learner centric. The main disadvantage appointed to these systems is the limitation of the student creativity, because the student needs some autonomy in process of construction of their knowledge. In the other side if the system is very passive the motivation of the student can decrease quickly.

The evolution of the ITS to a multi-agent based learning environment was pressed by the new distributed learning environments. This learning environments based on the Web or in other distributed technologies is the new generation of intelligence learning environments.

3.   CASE BASED REASONING APPLIED TO TUTORING AGENTS

Case-based reasoning (CBR) is one of the major reasoning paradigms in artificial intelligence and had been applied to several research areas. Kolodner defined CBR as adapting old solutions to meet new demands, using old cases to explain new situations, using old cases to critique new solutions, or reasoning from precedents to interpret a new situation (much as lawers do) or create an equitable solution to a new problem (much as labor mediators do) (Kolodner, 1993).

CBR has the advantage of the low initial training of the system, compared with other expert systems like rule-based reasoning (Yang, 2001) and model-based reasoning; witch needs a set of rules that related the problems with their solutions. In CBR the relation of the problems with their solutions is obtained from past experiences and the system can start operate with few stored cases and the reasoning capacity increases with the number of new cases stored.

The problem-solving life cycle in a CBR systems described by Aamodt and Plaza (Aamodt & Plaza, 1994) consists essentially of the following four parts:

1. *Retrieving* similar cases experienced in the past
2. *Reusing* the cases copying or integrating the solutions from the cases retrieved
3. *Revising* or adapting the solution(s) retrieved to solve the new problem
4. *Retaining* the new validated solution

CBR has been widely adopted in several domains, such as medicine, diagnoses, knowledge acquisition, help-desk, design, planning, scheduling, robot navigation, image processing, electronic commerce, and maintenance.

The use of CBR in education has several advantages, like supporting the lecturers in the design of more effective learning activities, and students in the improvement of their knowledge. The CBR methodology is more effective in learning scenarios where the learning process is based on constructive approaches like project-based learning and problem based-learning, where they are putted in situations where they must make hypotheses, collect data, and determine which data to use in the process of solving a problem or participating in some kind of realistic investigation (Kolodner, 96)

We use this approach to develop a CBR tutor agent, using the past experiences to solve new problems in the learning process. This tutor has the characteristic of an advisor that alerts the student for all the events and to simulate the behavior of a real personal instructor, coaching the student and coordinating the collaborative activities. The agent has also the mission to support the student in the agenda management, assessment, project management, and on the search and selection of Web resources.

4. DOMUS TUTOR

With the mission to improve the student knowledge, and to supply a more effective learning process according to the Bologna goals, we develop the Domus Tutor integrated in our learning management system. The Domus Tutor is a CBR tutoring agent with the mission to support the student in the learning process, using previous experience to solve new cases.

The architecture of the system (Fig 2) has seven main components: The Learning Design repository, collaboration and assessment, Web resources, communication services, agenda, the tutoring agents and the domain knowledge.

The Learning Design repository is the base of all the learning activities and contents. This component has the features of the domain model of an intelligent tutoring system. The domain module explained previously, has all the concepts that the system pretends to transmit to the student. In the Learning Design repository the concepts are structured in learning activities and the subjects are organized in learning units. We use the IMS Learning Design framework (IMS, 2003) to represent the learning activities because it has the follow features:

- Completeness: The specification can describe the teaching-learning process in a unit of learning, including reference to the digital and non-digital learning objects and services needed during the process
- Pedagogical Flexibility: Supports the description of all different kinds of pedagogies
- Personalization: The content of an learning unit can be adapted based on preferences, portfolio, pre-knowledge, educational needs, and situational circumstances of users
- Formalization: The specification can describe a learning design in the context of a unit of learning in a formal way, so that automatic processing is possible
- Reproducibility: The repeated execution in different settings with different persons is possible
- Interoperability: The specification supports interoperability of learning designs
- Compatibility: The specification uses several available standards

- Reusability: The specification permits to identify, isolate, de-contextualize and exchange useful learning artefacts, and to re-use these in other contexts

The Learning Design specification has the personalization feature; witch is the principal characteristic of the intelligent tutoring systems and adaptive hypermedia systems. This capacity of adaptation of the learning contents and contexts to the student profile is very important to achieve the goals of the learner centric paradigm.
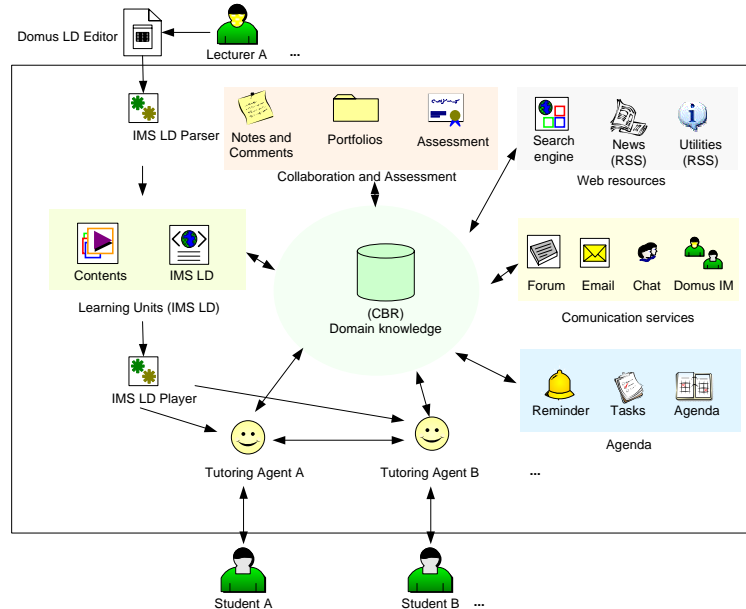

Figure 1. Architecture of Domus learning management system

Intelligent tutoring systems are very learner centric and they don't allow the cooperation in the learning process. The intervention of the lecturer is not supported and the collaboration with other students in the learning activities and projects is not typically available.

To support the collaboration we add groupware and computer-supported cooperative work (CSCW) tools to the system. These tools include portfolio management, collaborative annotations, forum, chat, instant messaging, and Web references.

The learning units are designed in the Learning Design Editor and transferred to the system using a Learning Design parser. The Learning Design player loads the structure defined by the lecturer. The agent can perform some adaptation to the sequence based on the student knowledge and special needs.

The collaboration and assessment component has the main tools to the cooperation of students in the learning activities, development of projects, and sharing references. The assessment components allow the lecturer to mange the calendar and to publish assessment marks.

Web resource component provides a complement to the contents and resources available in the Learning Design repository. The agent automatically searches the Web using the Google web service and giving suggestions about a concrete subject. The CBR is used to select the most effective resources based on relevance and student evaluation.

The portfolio component is integrated in the collaboration features because has the possibility to manage group portfolios, an essential tool for group projects development. The students of one group can plan and manage their projects, publishing reports, sharing contents and receiving feedback.

The communication services are another important component in the collaboration. The main services like forum, email, chat and instant messaging can be integrated in the Learning Design or used autonomously.

The agenda component is essentially the calendar, tasks management and the reminder feature. This component has the feature to plan all the learning activities and events of the class, as so the personal student activities.

The last and the more important component is the Domus Tutor agent. This multi-agent architecture uses the CBR methodology based on structured cases of the domain knowledge to perform adaptation of the

learning sequences, recommend the accomplishment of learning activities, collect opinions about a subject, suggest Web resources, alert the student for events, and give support in the agenda management. Each student has his own tutor agent; witch is cloned based on the student profile.

The tutor agent has the mission to support the learning activities and has the autonomy to cooperate with other agents to help the student to overcome his difficulties.

5. CONCLUSION

The use of intelligent systems has several advantages in the support and personalization of e-learning. The intelligent tutoring systems are typically used in computer-based training (CBT) and don't support the collaboration and cooperation like groupware and cooperative work technologies. We propose a CBR tutoring agent that uses the features of intelligent tutoring systems, with the functionality of groupware and collaborative work tools, integrated in a Web-based learning environment.

The Domus Tutor agent supports the student in their learning activities, collaborative work, portfolio management, agenda management, and shows several points of view of some subjects, suggesting Web resources to complement the student knowledge.

REFERENCES

Agnar Aamodt and Enric Plaza. 1994, Case-based reasoning: Foundational issues, methodological variations, and system approaches. *Artificial Intelligence Communications*, 7(1):39(59)

Ally M., 2004, *Designing Distributed Environments with Intelligent Software Agents*, Idea Group Publishing

Burn and Caps., 1988, *Intelligent Tutoring Systems*. Lawrence Erlbaum Associates, Hillsdale, NJ

IMS LD, 2003, Learning Design specification v1. (http://www.imsglobal.org/learningdesign)

Joint declaration of the European Ministers of Education, 1999, The Bologna Declaration (available at http://www.bologna-bergen2005.no/Docs/00-Main_doc/990719bologna_declaration.pdf)

Kearsley, G. P., 1987, *Artificial intelligence and education: Applications and methods*, Addison-Wesley

Kolodner, J., 1993, *Case-based Reasoning*, Morgan Kaufman

Kolodner, J. L., Hmelo, C. E., & Narayanan, N. H., 1996, Problem-based learning meets case-based reasoning. *Proceedings of the Second International Conference on the Learning Science*

Nwana, H. S., 1996, *Software agents: An overview. The Knowledge Engineering Review*, 11(3), 1–40

Pal, S., Shiu, S., 2004, *Foundations of Soft Case-Based Reasoning*, Wiley

Sleeman, D., & Brown J. S., 1982, *Intelligent tutoring systems*. New York: Academic Press

The European Higher Education Area - Achieving the Goals, Communiqué of the Conference of European Ministers Responsible for Higher Education, 2005, (available at http://www.bologna-bergen2005.no/), Bergen

Wenger, E., 1987, *Artificial intelligence and tutoring systems: Computational and cognitive approaches to the communication of knowledge*. Los Altos, CA: Morgan Kaufman

Yang, C. et al., 2001, Applying collision avoidance expert system to navigation training systems as an intelligent tutor. *Proceedings of IEA/AIE 14th International Conference* (pp. 941–947), Budapest, Hungary, June