DISTANCE LEARNING BY INTELLIGENT TUTORING SYSTEM
Agent-based architecture for user-centred adaptivity

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Abstract: Agent technology has been suggested by experts to be a promising approach to fully extend Intelligent Tutoring Systems (ITS). By using intelligent agents in an ITS architecture it is possible to obtain an individual tutoring system adaptive to the needs and characteristics of every student. The general architecture of the ITS proposed is formed by the three components that characterize an ITS – the Student Model, the Domain Model, and the Education Model. In the Student Model the knowledge about the student (profile and interaction with the system) is represented. In the Domain Model the knowledge about the contents to be taught is stored. Precisely, in this model four autonomous agents – the Preferences Agent, the Accounting Agent, the Exercises Agent and the Tests Agent - have been defined. Lastly, the Education Model provides the functionality that the teacher needs. Across this module, the teacher changes his preferences, gives reinforcement to the students, obtains statistics and consults the matter.

1 INTRODUCTION

Agent technology has been suggested by experts to be a promising approach to fully extend Intelligent Tutoring Systems (ITS). By using intelligent agents in an ITS architecture it is possible to obtain an individual tutoring system adapted to the needs and characteristics of every student (Frigo, Pozzebon & Bittencourt, 2004). In this article, an agent-based Intelligent Tutoring System architecture for user-centred adaptivity in e-learning/e-teaching of any matter is introduced. A detailed description of the agents which monitor the progress of the students and propose new tasks is also provided. The ITS proposed is not tied to any course in particular, being the only requisite that the course has to be divided into theory, exercises and tests.

Many learning/teaching computer-based environments framed in the form of ITS use agent technology. For example, Cheikes has developed GIA (Generic Instructional Architecture), an agent-based software infrastructure devoted to support rapid development of ITS applications (Cheikes, 1995). Tang carried out the implementation of a multi-agent intelligent tutoring system for the learning of computer programming (Tang & Wu, 2000). Capuano has described ABITS, a highly reusable Intelligent Tutoring Framework suitable to several knowledge domains (Capuano, Marsella & Salerno, 2000). A multi-agent system named MASPLANG developed for the adaptation of the so-called teaching support units has been introduced (Peña, Marzo & de la Rosa, 2002). Hospers et al. have presented an agent-based ITS for nurse education (Hospers et al., 2003). And there are many more approaches in distance learning (e.g., Bello & Bringsjord, 2003; Mota, Oliveira & Mouta, 2004; Kinshuk et al., 2001; de Antonio et al., 2003; Dorça, Lopes & Fernández, 2003; Pesty & Webber, 2004; Baldoni, Baroglio & Patti, 2004).

An ITS usually also incorporates pedagogical agents (animated characters) to do learning more attractive and effective. For example, there is Adele for medical education (Shaw et al., 1999), and AutoTutor for the students to learn the fundamentals of computer hardware, the operating system, and the Internet (Person & Graesser, 2000). SONIA is the animated agent incorporated in MASPLANG. The
architecture that we introduce in this article does not incorporate at present any animated agent.

The layout of the paper is as follows. In section 2 a definition of ITS is provided as its most common features are introduced. In section 3 we define what an agent is. In section 4 the aims of our agent-based ITS are explained. From section 5 on, the ITS architecture is introduced. Lastly, some conclusions are provided.

2 DEFINITION OF AN ITS

ITS are programs that possess a wide knowledge on a certain matter, and their intention is to transmit this knowledge to the students by means of an interactive individualized process, trying to emulate the form in which a tutor or human teacher would guide the student in his learning process (Millán, Agosta & Pérez, 1999).

Thus, ITS for sure are systems of knowledge communication. They can be defined that way because the principal emphasis in the development of these systems is to provide them with access to the representation of the knowledge that the system tries to communicate to the student.

In an ITS the emphasis is put in the knowledge (what) to being communicated to the student and not in the mechanism (how) of communication used to present the knowledge to the student.

Generally speaking, ITS are characterized for incorporating three models corresponding to three knowledge levels (see figure 1). Firstly, there is a Domain Model where the Knowledge of the Domain is gathered, that is to say the knowledge of what has to be taught. A Student Model represents the Knowledge of the Student, that is to say all things the student knows on the domain. Finally, there is a Pedagogical Model where the Knowledge of the Instructional strategies is described; that is to say, how to teach the Domain Knowledge.

3 DEFINITION OF AN AGENT

There is no universally accepted definition for the term agent, but there are is a wide range of perspectives in function of the application domain, the author, and so on.

Franklin and Graesser state: “An autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future.” (Franklin & Graesser, 1996).

Any agent, in accordance with this definition, satisfies the four properties as indicated next:

- **autonomy**: agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state;
- **social ability**: agents interact with other agents (and possibly humans) via some kind of agent-communication language; agents collaborate for the sake of performing tasks;
- **reactivity**: agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the Internet, or perhaps all of these combined), and respond in a timely fashion to changes that occur in it; in order to respond effectively to changes, agents have to know at each instant their surrounding “world”;
- **pro-activeness**: agents do not simply act in response to their environment, they are able to exhibit goal-directed behaviour by taking the initiative.

4 OBJECTIVES OF THE AGENT-BASED ITS

The ITS proposed in this paper creates an infrastructure for distance learning/teaching of a matter. In accordance with our experience, and in order to obtain good results, we propose to decompose the matter to be taught into theory, exercises and test questionnaires (see figure 2). The alumni study each topic of the matter reading theory first, then making exercises and finally answering to a test. The system will provide help the students whenever it will be felt necessary.

![Figure 1: Components of an ITS.](image-url)