Chapter 2.8
Enhancing Intelligent Tutoring Systems with the Agent Paradigm

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ABSTRACT

A cognitive framework called REflective Agent Learning environment (REAL) is developed in this study. REAL is a reusable framework that allows researchers to develop a simulation-based learning environment where users can learn through passing their thoughts to some computer-based agents and observe how the agents embodying their knowledge behave as the result of their instruction. Our research benefits from the research in Intelligent Tutoring Systems, game based learning systems, and agent technologies, stressing reflection as part of the thinking processes. It focuses on the design of the framework and the testing of its usability. The external evaluation of specific implementations serves as the guidance for the future design of the REAL applications. We hope, by grounding themselves in the needs of local practice, the REAL applications can give us opportunities to understand how theoretical claims about teaching and learning can be effectively transformed into meaningful learning.

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INTRODUCTION

Using computers to provide personalized instruction as an alternative to human tutors has drawn the attention of researchers in the fields of education, psychology, computer science, and cognitive science. Thanks to their cooperative efforts, we have

Intelligent Tutoring Systems (ITSs), or Intelligent Computer-Assisted Instruction (ICAI), embodying the computer-as-tutor paradigm. In this sense, ITSs/ICAI can be considered as Pedagogical Agents, which have a set of normative teaching goals and plans for achieving these goals (e.g., teaching strategies), and associated resources in the learning environment (Thalmann, 1997). The agent paradigm now allows researchers to collaborate effectively in an effort to develop other efficient user-centered learning environments. Examples include the computer as a collaborator (Blandford, 1994; Dillenbourg & Self, 1992), the computer as a learning companion (Chan & Baskin, 1990), and the computer as a teachable agent (Biswas, 2005), to name a few.

However, the design and development of computer-based instruction systems are costly (Murray, 1999; Anderson, 1993). Adaptive and broadly applicable cognitive tools are needed to reduce the development cycle time and the level of the required expertise. This will allow for computer-based intelligent tutoring systems to become affordable learning environments in traditional classroom settings.

The primary goal of this research is to design and prototype an intelligent reflective agent situated in an educational gaming environment based upon a cognitive framework, called REAL (REflective Agent Learning Environment). Attempts were made to encourage reflective thinking through having users explicitly externalize their internal knowledge representations by instructing the agent, which, ideally, generates a sequence of behaviors analogous to those generated by the users' imaginary worlds. It is our hope that when users begin to recognize relationships between their prior knowledge and the newly presented meanings, learning occurs, thus making the new information accessible as part of the learners' active reservoirs of knowledge. The tangible results of this research are some prototypes of the REAL applications.

BACKGROUND

Our research is inspired by our observations of teenagers highly motivated to control the computer-generated characters. It would be ideal if we could create a reusable framework that allows researchers to develop such a motivational computer-based learning environment where users could learn through passing their thoughts to some computer-based agents and observe how the agents embodying their knowledge behave as the result of their instruction. These agents can use the knowledge acquired from the students to achieve intelligent behaviors. For instance, an agent can predict how events will unfold and plan accordingly. When prediction fails or conflicts with reality, students will need to revise the knowledge to help the agent get out of the problematic situation. Learning will occur when they succeed. Some of the procedures they go through will be compiled and available in their long-term memory to aid their understanding. Those steps are missing in traditional learning practices where, most of the time, students are only dealing with the initial problem state and the final outcome state based upon certain solutions. Students do not have opportunities to search through the problem space and apply operators to change the environment and observe the change during which a deeper understanding of "how thing happens" and "why it has happened" is generated. As Black and Bower (1980) stated (pages 247-248),

In a story world,… the subject can up-date and "see" dynamic changes of characters, objects, and locations in his storyworld: he has available for inspection not only the starting and ending state of a character's motion but also intermediate points along the dynamic path. The reader can "see" that objects afford or suggest certain actions and prevent others. Furthermore, the reader's storyworld model allows him to experiment with hypothetical changes in his imagination. So he can imagine