Cognitive Requirements for Agent-Based Learning Environments

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Abstract

While there has been a significant amount of research on technical issues regarding the development of agent-based learning environments, there is less information regarding cognitive requirements for these environments. The management of control is a prime issue with agent-based computer environments given the relative independence and autonomy of the agent from other system components. I discuss four dimensions of control that should be considered in designing agent-based learning environments. The first dimension of control involves instantiating the instructional purpose of the environment on a constructivist (high learner control) to instructivist (high program/agent control) continuum. The second dimension entails managing feedback, and several issues need to be considered: type, timing, amount, explicitness, and learner control of agent feedback. Third, agent vs learner control is further defined through the desired relationship of the learner to agent(s) (e.g., agent as learning companion, agent as mentor, multiple pedagogical agents, agent as personal assistant, or agent as resource). Fourth, to be instructionally effective, the agent(s) must assert enough control so that the learner develops confidence in the agent(s) in terms of believability, competence, and trust. Overall, an array of possible permutations of system versus learner control must be carefully considered.

1. Introduction

Part of the value of intelligent agents as a computing paradigm is that they act independently from each other and the systems in which they operate; this potential for autonomous agent control and reactivity is also a possible liability if not properly planned. Consequently, a prime cognitive consideration is the management of control within an agent-based learning environment (see [1]). In other words, who has the figurative “ball,” the agent(s) or the learner? How much and to what extent and in what capacities? These are important issues to consider because they impact learning and instruction.

2. Determining instructional purpose of environment

The first dimension of control involves instantiating the instructional purpose of the environment on a constructivist (high learner control) to instructivist (high program/agent control) continuum. A critical issue from a constructivist approach to agent-based learning environments is in moderating between the agent taking over thinking for the student with the agent training the student to think more effectively [2]. [3] refers to this as the difference between the effects “of” and “with” technology, with effects “with” technology being more desirable. In this sense, the computer technology in and of itself is of little interest whereas what activities it affords is of interest. Further, in terms of the amount of artificial intelligence that should be used by an agent, it is important to consider that more intelligence is not necessarily better from a pedagogical perspective [4]. Intelligent agents for learning can come in both varieties: constructivist and instructivist. Overall, in the instructivist approach, the role of the agent is to teach the student knowledge, similar to the role taken traditionally by human teachers. In the constructivist approach the agent would be a medium that does not teach the student directly.

3. Managing agent-learner feedback

The second dimension of control entails managing feedback, and several issues need to be considered: type, timing, amount, explicitness, and learner control of agent feedback. An important consideration in terms of feedback is that the pedagogical agent should not provide too many insights and thereby annoy the student. As [5] suggests, the human act of winking can connote a lot of information to others simply in the lack of information. This sort of familiarity is needed for the pedagogical agent to avoid relentless explicitness. To address this issue, part of the pedagogical task should...
include the monitoring of the timing and implementation of the advisements. With the principle of minimal help as the default, there could also be the possibility for the student to select a feedback option depending on the amount of structure, interaction, and feedback s/he desires when problem-solving. In this way the learner-agent relationship becomes mutually collaborative as each provide feedback for each other.

A related issue is in terms of how active the agents should be to provide explanations of their pedagogical behavior. Assuming that the agents do have some planning role in the instructional environment, does the learner needs understanding of what happened pedagogically and why? One advantage of providing explicit teaching strategy differences from the mentoring agents to the learner (as opposed to being built-in to the system and invisible to the learner) is that it can facilitate reflective thinking [6].

4. Defining the relationship of learner and agent(s)

Agent vs. learner control is further defined through the desired relationship of the learner to agent(s). Some examples of instantiating the learner-agent relationship include the agent as learning companion, agent as mentor, multiple pedagogical agents, agent as personal assistant, or agent as resource.

5. Establishing confidence

To be instructionally effective, the agent(s) must assert enough control so that the learner develops confidence in the agent(s) in terms of believability, competence, and trust. The Guides [7] project (as discussed by [8]) is an anecdotal study that investigated the issue of believability for agent-like computer programs. The project involved the design of an interface to a CD ROM encyclopedia (focusing on early American history) with a set of travel guides, each of which was biased towards a particular type of information (settler woman, Indian, inventor). They found that students tended to assume that the guides, which were presented as stock characters, embodied particular characters. For example, since many of the articles in the encyclopedia were biographies, learners would assume that the first biography suggested by a guide was its own! Students also wondered if they were seeing the article from the guide’s point of view (they weren’t). Further, they sometimes assumed that guides had specific reasons for suggesting each story and wanted to know what they were (in line with learners’ general wish to understand what adaptive functionality is actually doing). Some of the students got emotionally engaged with the guides; one student getting angry that the guide had betrayed her; in another case the guide inadvertently disappeared and the student interpreted this as “...the guide got mad, he disappeared.” As [8] comments, while no controlled experiment was involved in these findings, rather these findings are anecdotal, it is hard to believe that the learner would have made such an inference if the suggested articles had been presented in a floating window that had vanished.

6. Conclusion

Overall, an array of possible permutations of system versus learner control must be carefully considered: 1) instantiating the instructional purpose of the environment on a constructivist (high learner control) to instructivist (high program/agent control) continuum; 2) managing feedback (in terms of type, timing, amount, explicitness); 3) defining the desired relationship of the learner to agent(s) (e.g., agent as learning companion, agent as mentor, multiple pedagogical agents, agent as personal assistant, or agent as resource); and 4) establishing learner confidence in the agent(s) in terms of believability, competence, and trust [1].