Simulating Pedagogical Agents in a Virtual Learning Environment

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ABSTRACT
CoPAS (Collaboration Patterns Agent Simulation) is a simulation study carried out with the Wizard of Oz method. Students used a groupware system to solve a learning task in the domain of object-oriented analysis and design using UML (Unified Modelling Language) without meeting each other face-to-face. Simulated software agents (human experts) gave advice for various knowledge-intensive tasks, including tool use, domain (UML) understanding and peer-to-peer collaboration. Our findings indicate that agents can have an effect on collaboration by making users aware of collaboration patterns (division of labour, explicit roles, etc.) and by creating focus shifts in the users' interaction.

Keywords
Distributed collaborative learning, Wizard of Oz technique, software agent simulation, collaboration patterns

PEDAGOGICAL AGENTS
Pedagogical agents can interact with human learners in the context of their actions and activities in a virtual learning environment. It can sometimes even be difficult to distinguish an agent's actions from that of a user taking the role of an advising peer helping other users to solve a task in the environment (Johnson, Rickel & Lester, 2000).

We call our agents pedagogical interface agents, and our belief is that they should be developed on the basis of their perceived benefits for end users. Our interest is therefore not so much in development of algorithms or student models, but rather how the agents should intervene and behave in interaction with a group of collaborative peers.

There are different kinds of interface agents, including animated agents that simulate certain human behaviour, such as facial expression and body movement, and reactive agents that react to events in the environment and take action when they see an opportunity. The behaviour of reactive agents can be compared with a thermostat: when a certain temperature has been reached some action is taken (such as turning off the heat).

In CoPAS there are three types of reactive agents: 1) Tool agent, 2) Domain agent, and 3) Collaboration agent. The tool agent represents technical knowledge about how to use the groupware tools, and the domain agent gives advice about the concepts and relations in UML. The collaboration agent's knowledge base is built on theories of CSCL (Koshmann, 1996), principles of Genuine Interdependence (Salomon, 1992), and Collaboration Patterns (Wasson & Mørch, 2000).

SIMULATION STUDY
We used the Wizard of Oz technique to simulate the behaviour of pedagogical agents in a virtual learning environment (the TeamWave groupware). The participants were led to believe that they were using an implemented agent system, when in fact they were interacting with a simulation staged by human operators (Maulsby et al., 1993).

Three graduate students in our department acted as wizards. Each of them had a pre-assigned task to simulate one of the above agents. Their (perceived) participation in the learning environment were defined by a set of rules for when to act and what to say upon acting.

Six groups of students participated, and each group had three students. They were enrolled in the same undergraduate information systems class. The task for all groups was to create object-oriented analysis and design diagrams for an Internet banking system using UML (use case and class diagrams). Each group had 90 minutes at their disposal. The task constraints together with the constraints imposed by the Wizard of Oz technique were the main reasons for conducting a short duration experiment (i.e., the assignment was taken from a previous final exam, and the wizards may have revealed themselves if exposed for a longer period of time).

FINDINGS

The data was collected from notes, automatically recorded chat logs, and individual interviews conducted with the participants after the experiment.

Below is a chat log excerpt initiated by the wizard acting as collaboration agent (the wizard's messages was displayed in a pop-up window and not in the chat window). It was one of the most frequently issued messages:

Collaboration agent says: It can be useful to divide the work amongst yourself

B3.1 says: we should divide the tasks

B3.1 says: I can start with the class diagram...

B3.3 says: what about me, what should I do?

There were no obvious ways to divide the assignment equally among the group members (two tasks: use case diagram and class diagram; three members). The above comment by B3.3: *"what about me, what should I do?"* was discussed in the group interview. It turned out that two of the members knew each other well, whereas the third member did not know the others. She felt left out of much of the joint work. B3.2 gave the following comment when asked if knowing each other influenced division of work in their group. *"It certainly influenced our work, because one knows how to talk to a person you already know, and that can complicate collaboration with a third person who are supposed to be part in solving the same task"*

DISCUSSION AND IMPLICATIONS FOR DESIGN

Software agents are good at providing shared feedback when there are general principles that can be operationalized, but less useful for giving personalized assistance on the same principles. The feedback given to the students by the Collaboration agents was informed by such principles (e.g. Salomon, 1992, Koschmann, 1996, Wasson & Mørch, 2000), but it had sometimes unanticipated effects as illustrated in the above situation. One of the students felt excluded after a comment by the Collaboration agent. A human facilitator would have been able to resolve the situation more appropriately.

On the other hand, there were situations where the groups where happy to get feedback and to shift their focus of interaction. This can be explained by the term "breakdown". A breakdown makes room for learning and reflections about the joint work (e.g. Fischer 1994). Agents that create breakdowns may cause a shift in focus and indicate a new level of activity. We have found several indications of this, evidenced by a change in vocabulary after the intervention of an agent.

ACKNOWLEDGMENTS

We thank the three graduate students who acted as Wizards: Rune Baggetun, Karianne Omdahl and Trond Pedersen. This study is part of the DoCTA NSS project, and we are grateful for financial support from the ITU Program of the Norwegian Ministry of Church affairs, Education and Research.

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