Interaction Tactics for Socially Intelligent Pedagogical Agents

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ABSTRACT
Guidebots, or animated pedagogical agents, can enhance interactive learning environments by promoting deeper learning and improve the learner's subjective experience. Guidebots exploit a person's natural tendency to interact socially with computers, as documented by Reeves, Nass, and their colleagues. However they also raise expectations of social abilities, and failure to meet those expectations can have unintended negative effects. The Social Intelligence Project is developing improved social interaction skills for guidebots. This paper describes efforts to model and implement interaction tactics for guidebots, i.e., dialog exchanges that are intended to achieve particular communicative and motivational effects. These are based on analyses of student-tutor interaction during computer-based learning.

Categories and Subject Descriptors
H.5.2 [Info. Systems]: User interfaces; K.3.1[Computers and Education]: Computer uses in education; I.2.0 [Computing Methodologies]: Artificial intelligence

General Terms
Human factors

Keywords
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INTRODUCTION
Advances in agent and Web technologies are making it increasingly possible to incorporate guidebots, or animated pedagogical agents, in a wide range of Web-based learning materials. If designed properly these guidebots can promote deeper learning and improve the learner's subjective experience. Guidebots exploit a person's natural tendency to interact socially with computers, as documented by Reeves and Nass [6].

People not only interact socially with guidebots, they also tend to view them as social actors, with social interaction skills. This can cause problems when the guidebot lacks such skills. These problems are illustrated by earlier versions of Adele, described elsewhere in this volume [8]. Adele observes students work through simulated medical cases. If the student takes an inappropriate action, e.g., commence a patient examination without having adequately reviewed the patient's medical history, Adele would interrupt and critique the learner's action. This was acceptable in individual cases, however if the student made multiple mistakes Adele would repeatedly interrupt and criticize the learner's actions in the same fashion. This kind of treatment would give learners the unintended impression that Adele had a very stern personality and had low regard for the student's work.

The Social Intelligence Project at the Center for Advanced Research in Technology for Education (CARTE) is developing learner modeling and user interaction techniques to improve the social skills of guidebots, particularly in Web-based learning environments [4]. Our test application is the Virtual Factory Teaching System, an on-line simulation-based training system for teaching factory management skills [1]. The social intelligence component will augment and existing Automated Laboratory Instructor agent designed to coach learners as they work with scientific simulations [2]. An effective social intelligence capability will make it possible to offer the VFTS to a wider range of learners, particularly those in allied fields such as business administration who may be intimidated by complex engineering applications and therefore need the kind of tailored guidance that a socially intelligent guidebot can provide.

BACKGROUND STUDIES
To better understand the role of social intelligence in tutorial interaction, we videotaped students and human tutors working together through on-line tutorials and using the VFTS. Subjects read though an on-line tutorial in a Web browser, and performed actions on the VFTS system as indicated by the tutorial. Our goal was to draw lessons from such interactions that could be applied to the design of a guidebot that helps students with a system such as VFTS. We were interested in observing how the tutors respond to the student's actions on the computer,

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since an automated guidebot would need to respond in a similar way. For example, a tutor needs to be able to judge when is a good time to interrupt the student, based upon what the student is doing on the computer from moment to moment. The tutor needs to be able to fit his tutorial interactions into the context of the student's activities.

The tutor in this preliminary study was an industrial engineering professor who had won awards for excellence in teaching. We plan to study other tutors as needed, to obtain more examples of tutorial interaction.

INTERACTION TACTICS

Tutorial exchanges in these sessions can be characterized as a series of interaction tactics, where each tactic is intended to communicate particular information or have a particular effect on the listener. When a dialog exchange is initiated the speaker looks to see that the intended effect has been achieved, and if not rephrases the comment accordingly. We see this in the following exchange, where the tutor is trying to get the student perform a regression analysis as stated in the written tutorial.

> **Tutor:** So it's asking for regression
> **Student:** Right, that wasn't an option
> (*Student clicks a few times on the wrong button on the screen, then stops*)
> **Student:** There's no place...
> **Tutor:** You want to click on regression here and make sure that it matches the button that's up there.

Interaction tactics frequently fail to have the intended result, as in this example. People seem to be quite good at recovering from such failures, both to make communication more effective and to maintain a fluid social interaction between the dialog participants. Likewise a guidebot needs to be prepared for failures in interaction tactics, and adapt responses accordingly.

Some of the interaction exchanges involve multiple interactions regardless of the responses of the learner. For example, at the beginning of the second lesson the tutor reviewed what was accomplished in the previous lesson, and multiple utterances were required to do this. Thus we sometimes need to organize individual interaction tactics into higher-level dialog structures. We can model such interactions as complex plans composed of multiple individual interaction tactics. Each interaction tactic may or may not achieved the intended effect, requiring further adaptive responses from the tutor. Or, an interaction exchange may be a mixture of utterances and task steps. For example, when the tutor guides a student through the process of running the factory simulation the tutor guides the student through the sequence of steps involved in running the simulation, commenting and answering questions along the way.

Characteristics of Tutor Interaction Tactics

Unsurprisingly, many tutor-initiated interactions are offers of hints. What was surprising, though, was that these hints were expressed in a variety of different ways, and relatively few were explicit instructions to perform an action. Some were expressed as questions, e.g.:

> **Tutor:** Want to look at your capacity?

> **Tutor:** Do you want to move that over so that way you'll be able to see this while you're doing it at the same time?

Some hints were phrased as suggestions, expressed conditionally so that the student could decide whether or not to follow the tutor's suggestions, e.g:

> **Tutor:** So you could move down and do the basic parameters.

Consistent with the view of the tutor's comments as interaction tactics, nearly all tutor comments elicited a verbal response or acknowledgment from the learner or a nonverbal action to follow the tutor's suggestion. The only observed exceptions to this were as follows:

- The tutor was articulating a general principle that applied to the current situation but not specifically to it, e.g., "You want to save the factory every time you change it."
- The tutor's question was a rhetorical lead-in to a subsequent comment, e.g., "Can I give you a hint? On where…"
- The tutor's comment provided context or motivation for suggestion that followed immediately after, e.g., "And you can get individual statistics on products… click on here and get it."

Some hints were comments about what the tutor would do, rather than explicit suggestions of student actions:

> **Tutor:** I'd go to the very top.

In other cases the hint was a suggestion of what the student and tutor might do together, e.g.:

> **Tutor:** So why don't we go back to the tutorial factory and work on the planning there.

In yet other cases, the hint stated a goal to be achieved, as if the learner already had that goal, e.g.:

> **Tutor:** You wanna do one at a time, go back and change it, …

These tactics involve the learner in the decision making process, and make the activity a joint activity. In multi-turn interactions the tutor would typically switch agent stances between turns, as in the following examples:

> **Tutor:** … you can tweak it as you go.
> **Student:** Yeah.
> **Tutor:** That's what I'd do.

Tutor: You want to also read the tutorial. It gives you some—
Student: The what?
Tutor: The tutorial. Let's see what they say.

TOWARDS A SOCIALLY INTELLIGENT INTERFACE

We are now drawing from these lessons to build a social intelligence (SI) model and incorporate it into a guidebot-enhanced interface. As the learner interacts with the learning environment (i.e., simulations and Web pages), learner actions are recorded and will be passed to an analysis module that assesses the correctness of learner actions and the cognitive demands of the task. The SI model will use this information to assess whether pedagogical interventions are appropriate in the current context. The SI model also receives input in the form of visual information and conversational inputs. Visual information is processed using a module developed by USC's Laboratory for Computational and Biological Vision that tracks the user's face and infers focus of attention on the screen based on eye gaze.

A new guidebot interface has been developed, that incorporates the Digital Puppets guidebot persona architecture [7], and extends it with a conversational interface built around interaction tactics. Each guidebot-to-student dialog move is classified using the DISCOUNT scheme for marking up tutorial dialogs [5], extended with additional features to capture the distinctions in utterance form described above. Each dialog move consists of a move pattern, consisting of move category, features, and variables to be filled by verbs and noun phrases of the topic domain, and a corresponding text pattern, that expresses the move in natural language. A database of dialog moves has been created drawn from the interaction transcripts. The dialog move synthesizer searches the database for the closest match to the desired move pattern, instantiates the text pattern, and sends it to the student's computer to be uttered by the guidebot using text-to-speech synthesis. Our initial implementation provides user interface that human tutors may use to direct the choice of dialog move, and edit the generated text if necessary. This makes possible Wizard-of-Oz simulations of the completed SI system, and at the same time allows us to test the repertoire of dialog moves for coverage. A similar natural language input interface has been developed, built using eDrama Front Desk [3], that takes user inputs and classifies them against a library of student dialog moves.

Tests of the adequacy and coverage of conversational system are currently underway, and Wizard-of-Oz tests with students are planned to commence shortly. This will help us to compare the style of interaction as well as the learners' subjective experience against face-to-face interaction. We need to determine whether the interface supports interactive tutorial dialog, or whether the limited use of text in the interface alters the style of interaction in a significant way. Another question is whether visual input is essential, either to determine when to initiate a tutorial exchange or to monitor the learner's responses to those exchanges. Furthermore we wish to determine to what extent the learners perceive the tutor as being responsive to the learner. Based upon the results of these studies we can then proceed to automate the selection of interaction tactics by the guidebot.

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