

Socially Intelligent Tutor Agents

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Abstract. Emotions and personality have received quite a lot of attention the last few years in research on embodied conversational agents. Attention is also increasingly being paid to matters of social psychology and interpersonal aspects (see [3], for example, and [11], for work of our group). Given the nature of an embodied conversational agent's main activity: "conversation", we feel that interpersonal issues should be central in their design. We consider the case of tutoring systems in more depth and examine some of the interpersonal factors that need to be accounted for when building emotionally intelligent tutors.

1. Introduction

We view embodied conversational agents much as we view real people, as social actors playing interaction games; deliberately choosing a tactic of what to say and show (including, for instance, emotions felt or faked). The way we (real people) act and what we feel is heavily influenced by what we believe about the beliefs, intentions and emotions of our partners in interaction and how we want to influence these. This determines how we present ourselves; what we reveal, hide and fake. Also facial expressions and other forms of nonverbal communication, depend mostly on social factors [10]. In short, the theories we have about the other are crucial to the way we operate in interactions. We would therefore like to see agents with modules that are specifically concerned with reading the minds of others as a form of "social intelligence" [2].

Social interaction requires that every interactant has a good sense of what the other believes and feels. This concerns both attitudes in general, about the topic of conversation, and attitudes towards the interactant in particular. In modelling conversational characters, we are primarily dealing with social interaction and interpersonal relations. In many cases this means that we should pay special attention not just to what the characters themselves should be feeling but more importantly about how they think the other feels, part of which is reasoning about such things as "how will the other feel if I would show (or hide) what I'm thinking and feeling and what would I feel about this effect". Rather than dealing with raw affect, emotional intelligence involves knowing how to play an interpersonal, social game. Emotional intelligence mainly means being sensitive to feelings of others [7].

One of the research topics of the Human Media Interaction group is concerned with studying and computationally modeling natural ways of interaction and incorporating the results into intelligent interactive systems. The work described in this paper is an extension of previous work on tutoring systems, particularly the INES

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system [12] and the work on emotion modelling as described in [4], [5] and [16]. In the generic INES system, the “mind” of the tutor was set up as a society of agents representing different cognitive functions or specialised “expert” knowledge. This system is being extended as part of the current work with new components that will take care of the tutor’s social and emotional intelligence skills. Actions of tutors do not merely concern the specific skill or subject that has to be taught. Taking into account a model of the student’s mental state is of prime importance for tutor agents.

2. Socially Intelligent Tutors

A tutor engages in interaction with a student to teach certain knowledge or skills. Typical acts of the tutor include setting objectives for the student, motivating her, giving instructions, setting a specific task, asking questions, answering questions, explaining, illustrating, providing support, hinting, pumping for more information, summarizing, giving examples, providing positive or negative feedback, and evaluating the student. An important part of an intelligent tutoring system consists in determining which type of action is to be carried out and the precise form this takes. In the current work we are looking at ways to have the tutor agent make informed decisions based, in part, on what the agent can assume about the mental state of the student. Several other factors are important in this choice. First, there is the general goal of the specific lesson. The tutor may also have decided on a specific strategy to get there. By choosing the Socratic method, for instance, asking questions will be selected rather than explanations. Of course, the choice of action is also determined by the kind and quality of the student’s actions.

As we said, in choosing actions and deciding on the way to execute them, an experienced tutor will take the mental state of the student into account. Elements of this state can be classified as relating to mood in general, feelings about motivation and achievements (task related) and attitudes towards others (the tutor, parents and peers) and their attitudes and actions. The emotionally intelligent tutor agent that we are developing is trying to construct a model of the mental state of the student and is knowledgeable of the potential effects of tutoring acts on the mental state. These insights are used to determine the appropriate action sequence and the manner of executing the actions. We are therefore specifying conversational actions of tutors such that pre-conditions and effects of the actions take the mental state of the student into account.

To make it possible that the tutor agent makes decisions informed by the mental state of the student, the system has to construct a student model. We will now consider the kinds of things we want to put in this model.

Variables

There are four kinds of variables that we wish to consider in more depth in our project. We have first listed some psychological variables that influence the way a student would carry out the task: how well is she doing, is she paying attention, what about her motivation and self-esteem, is she attributing mistakes and successes to

herself, others or circumstances. Next, we have listed some aspects that relate more directly to the emotional state of the student. The values for the emotion axis have been taken from [13] and describe the cyclical dynamics of the emotions a student could or should go through during a session. We have also listed the social emotions (emotions about others or in which others play some role) that we want to look at. The latter are closely connected with some typical interpersonal dimensions like dominance and affiliation, antagonism and trust: how the student and the tutor relate to each other on an interpersonal level.

Mental state	Learning success, Attention, Collaboration, Motivation, Self-Presentation, Self-Esteem, Attribution
Emotion axis	Anxiety - Confidence, Boredom - Fascination, Frustration - Euphoria, Dispirited - Encouraged, Terror – Enchanted
Social Emotions	Embarrassment, Pride, Dislike, Joy for other, Gratitude
Interpersonal aspects	Dominance, Affiliation, Trust

The elements of the mental state that have been mentioned in the table refer to the attitude towards the learning activity (achievements, attention paid to the task, motivation), the interaction with the tutoring system (collaboration, presentation) and general aspects of the student's personality that have an impact on the task (such as self-esteem). Attribution, for instance, is one of the central topics in social psychology and it plays a crucial part in the tutoring situation. It concerns the way we explain our own behaviour and that of others. In this case, attributions typically concern the success or failure of the actions of the student. Typically, tutors and students will disagree about certain attributions. Perceivers tend to overestimate personal or dispositional factors and underestimate situational factors. Actors, on the other hand might attribute their actions more to situational factors. Such different biases (also related to personality traits, not mentioned in the table) have been investigated in quite some depth. Such tendencies are incorporated in our models of affect.

Attributions will affect other parameters of the mental state, like motivation and emotion. Relevant in this respect is, for instance, the work by Weiner [18] who made a distinction between two kinds of achievement-related affects: 'outcome-dependent' (did we achieve our goals or not) and 'attribution-linked' affects (was it because of what we did or not). This means that events influence the emotional state in two-stages, relating different elements of the table above: failure leads to outcome-dependent affect (misery, embarrassment), and causal attribution of the failure (self/other/circumstances) leads to future expectancies (hope/no hope) and associated affect (depressed/optimism). These kinds of effects will have to be considered by the emotionally intelligent tutor.

If we want to build tutor agents that choose their actions and the way they perform them considering the emotional state of the student, then it is important to ask ourselves what emotional states a tutor should want to achieve. In [13], the learning cycle that learners experience is matched with a model of emotions. The emotions that students go through are described in a cyclic movement. In emotional terms, motivation to solve a problem may arise out of curiosity (a positive incentive) or puzzlement and confusion. This means that negative emotions may have positive

effects for the learning process. The paper emphasises the changes and their function in the learning process. In the choice of action (the kind, manner, sequence), tutors will have to take such values into account and through their actions try to change them in the direction desired.

In general, the affective state of the student is important during the learning process. In the table we have listed social emotions separately (emotions that somehow relate to “others”). The values for the emotions in the Emotion Axis cell, on the other hand, refer specifically to how the student feels about the problem he is facing in the learning process and how he can cope with that. But given the fact that there are others, like the tutor, his peers and parents, the student will be concerned with, social emotions should be taken into account as well. The whole teaching process consists in negotiating about obligations to do certain tasks and evaluations of the result. Almost every action carried out by the tutor has to take such variables into account. Note that the social emotions, again depend to a large extent on attribution of the cause of an action on oneself or others.

Intricately connected with the social emotions are the attitudes towards others. Two important factors that are often discussed are: dominance and affiliation. Also in the case of a student-tutor relation these factors play an important role. The type of relationship that a tutor wants to establish with the student, or the style of tutor chosen by the designer of the tutor will be set to a great extent by these parameters. The degree of dominance and affiliation can be varied and this will clearly have an impact on the kinds of actions that are chosen or the teaching style in general. To see the relevance of these variables to the tutoring situation one can look at the following table taken from [1]. Here, Argyle lists some typical actions or techniques that are often used in these different strategies. These acts are not limited to the tutoring case, but it is immediately obvious that they will be relevant there as well.

DOMINANCE		
AFFILIATION LOW	Analyses	Advises
	Criticises	Coordinates
	Disapproves	Directs
	Judges	Leads
	Resists	Initiates
	Evades	Acquiesces
	Concedes	Agrees
	Relinquishes	Assists
	Retreats	Cooperates
	Withdraws	Obliges
	DEPENDENCY	
		AFFILIATION HIGH

What this table reveals is how social actions can be classified along two interpersonal dimensions. Our current work involves specifying and classifying tutor actions, as conversational moves along such lines. Insights from social psychology related to these variables will have to be incorporated in this specification. We will now indicate the way we want to proceed with this.

Current Work

In a typical sequence the tutor presents a problem to the student, the learner starts to solve the problem, the tutor assesses the answer and provides feedback. Such sequences often loop and have alternative branches: in cases of misunderstanding, right or wrong answers, etcetera. Given a specific choice for a teaching strategy, certain actions will be preferred. The major question to be answered in the current project is which action and strategy is to be chosen and how are these to be performed taking the variables presented above into account.

A major part of the ongoing work takes the form of a formal specification of the different dialogue moves of a tutor. We are working at refining these actions by subtyping and parameterising them further. Pre- and postconditions in these specifications will relate to the variables discussed. For instance, whether or not and how a tutor sets a task, and the kind of task (difficult, easy) for a student can depend on the strategy chosen, on the motivational state of the student or her achievements so far. The acts can be further distinguished along the manner in which they are executed, where manner depends, amongst others on the interpersonal relationship. The specification of the different tutoring acts, are similar to the definitions of speech acts as provided by Searle [17]; indicating the different preparatory conditions and the intended effects. It is interesting to recall some of the dimensions of variation (12 in total) that Searle uses to distinguish illocutionary acts from one another.

- Differences in the point (or purpose) of the (type of) act.
- Differences in the expressed psychological states.
- Differences in the force or strength with which the illocutionary point is presented.
- Differences in the status or position of the speaker and hearer as they bear on the illocutionary force.
- Differences in the way the utterance relates to the interests of the speaker and the hearer.
- Differences in the style of performance of the illocutionary act.

It is immediately obvious that these dimensions that Searle refers to directly relate to the variables we are interested in.

The following is a generic definition for a general `set_task` act that does not refer to any of the variables discussed above.

`set_task_act(T,Task,S)`

Constraints: `tutor(T) & task(Task) & student(S) & knowledge(K) & example(E)`

Precondition: `know(T,Task) & want(T,set_task_act(T,Task,S) & (know(S,related(Task,E)) or know(S,related(Task,K)))`

Effect: `do(S,Task)`

In our socially intelligent variation on this definition, this is further refined. The conditions referring to the social variables are similar to Searle's *sincerity conditions*. Setting a task for a student is a kind of "directive." It can be put forward as a suggestion, a puzzle, or an assignment. Depending on the past achievements, the difficulty of the task can be adjusted. The task can be provided to set a challenge for the student and so it can change the emotional state of the student. If the student is set a task, then the intended effect is that the student will perform the task. Whether or not the student will perform the task, will of course depend on the motivational state.

Several aspects of how the student is engaged in the learning session are thus of importance for determining the appropriate reactions of the tutor. An important issue involves determining the mental state of the student. Obviously, not all of the parameters are easily to monitor. There are different ways to get information. Estimates of what the student is thinking or feeling with respect to the situation can partly be made on the basis of general models and patterns; i.e. on typical expectations of how people behave. The way the student actually responds can be taken into account to adjust this information to the particular situation. Some of the things that can be measured are the time the student takes to answer (hesitation/distraction), the correctness of the answers, etcetera. Certain information can also be obtained by explicitly asking the student questions related to the mental state. Information from previous interactions can also be taken into account. Finally, one could also consider taking physiological measurements. We are currently looking at several of these methods.

3. To Conclude

In [9], Gratch and his co-authors make a distinction between communication-driven approaches and simulation-based approaches to modelling emotion and personality for building believable virtual humans. “In communication-driven approaches, a virtual human chooses its emotional expression on the basis of its desired impact on the user. [...] Tutoring applications usually also follow a communication-driven approach, intentionally expressing emotions with the goal of motivating the students and thus increasing the learning effect. [...] The second category of approaches aims at simulation of ‘true’ emotion (as opposed to deliberately conveyed information).” Cosmo [14] is cited as an example of the first approach, whereas in the work by Gratch and Marsella [15] the second approach is taken. On the one hand, our approach focuses on the communication between the tutor agent and the student, but only in this sense can we consider it a communication-driven approach. Our specific goal in creating a socially or emotionally intelligent agent however is not to build an “emotional agent” that can *express* its emotions but rather an agent that chooses its actions (kind and manner) appropriately, in accordance with the mental state of the student. Of course, this could have as a side-effect that the tutor is considered to show great empathy with the student. In this way the tutor can also be said to show emotions.

In our current work on embodied conversational agents, we want to emphasise their social and interpersonal functioning. In this paper about work in progress we have provided some background motivation for this approach and looked at ongoing work in specifying emotionally intelligent tutors. We have reviewed (in part) the parameters that we are considering in defining felicity conditions for conversational acts and the kinds of insights from social cognitive psychology that will be modelled.

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