Towards an Empathic Chess Companion

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ABSTRACT
In this paper, we propose an empathic model for a social robot that acts as a chess companion for children. The model will attempt to recognize some of the user's affective states (interest, boredom and frustration), by combining information retrieved from facial and body expression recognition systems with contextual features of the game (e.g., who is winning, for how long...). We further present a set of possible empathic behaviours that the agent can perform when the user is experiencing such affective states.

Keywords
Empathy, affect, long-term interaction, companions.

1. INTRODUCTION
The interaction paradigm in synthetic characters is changing. Seminal work in this field has considered agents that interacted with users for short periods of time, but we are now moving towards a new paradigm in which characters are able to relate to us, assist us and engage us in a long-term basis [1]. The LIREC Project (Living with Robots and Interactive Companions) aims to create a new generation of interactive and emotionally intelligent companions that are capable of establishing long-term relationships with different users. Research focuses on both virtual agents and physically embodied agents such as robots.

To build agents that are successful in establishing and maintaining long term meaningful interactions with users, some social and cognitive abilities are needed. One of such abilities is empathy, which involves role taking, the understanding of nonverbal cues, sensitivity to the other's affective state and communication of a feeling of caring, or at least sincere attempts to understand in a non judgemental manner [2]. Research shows that empathic agents are perceived as more caring, likeable, and trustworthy than agents without empathic capabilities, and that people feel more supported in the presence of such agents [3]. Therefore, we believe that if a character is endowed with empathic behaviours, the interaction with the user will be more natural, believable and engaging, which can be of extreme relevance for our long-term goal.

Our application scenario includes a social robot, the iCat [4], which plays chess with children using an electronic chessboard. The iCat acts as a peer tutor, helping children to improve their chess skills [5]. While playing with the iCat, children receive feedback from their moves on the chessboard through the iCat's facial expressions, which are generated by an affective system influenced by the state of the game. The affective system is self-oriented or competitive, i.e., when the user plays a good move the iCat displays a sad facial expression and when the user plays a bad move the iCat displays positive reactions (for more details in the affective system please see [6]). We have adopted this approach instead of a more cooperative behaviour because, from our observations of children playing against each other in a chess club, such reactions are more consistent with what they might expect about their opponents. Nevertheless, after performing experiments with the iCat in a chess club for several weeks [7], we realized that sometimes children felt uncomfortable with the iCat displaying intense happy expressions when they were losing, especially in front of their other colleagues. If the iCat could understand their affective state and react in a more empathic manner, situations like this one could be avoided. Our main challenge is thus to create an empathic chess playing companion that is able of helping children to improve their chess skills, while at the same time behaves in a way that the users will want to continue interacting with it without feeling embarrassed or stressed.

Another interesting finding from the experiment conducted at the chess club was that sometimes users reacted in an empathetic way towards the iCat. We have witnessed some moments in which users were imitating the iCat's sad expressions, as if they were sharing that same emotion. Likewise, some users also demonstrated empathetic behaviour through sentences such as "Oh, the iCat is sad...", with a sad intonation in their voice.

Although there is not a common agreement on the definition of empathy, in most of the proposed definitions the ability to understand another's affective state, either due to a pure cognitive or affective process, appears to be the foundation for the human's empathic behaviours. As such, empathy can be seen as "an observer reacting emotionally because he perceives that another is experiencing or about to experience an emotion" [8].

In this paper, we propose a model for recognizing the user's affective states in a turn-based game. The document is organized as follows. After a brief overview of existing work on empathic agents and recognizing the user's affective state, we present our model, which is composed of two main parts: visual and contextual features. We then present some of the empathic behaviours that the agent might perform in response to those user's affective states. Finally, we draw some conclusions and future work.

2. RELATED WORK
There are two main branches of research when studying empathic agents: agents that simulate empathic behaviour towards the users and agents that foster empathic feelings on the users. The work presented in this section is focused on the first topic.

One of the functions of human emotions is to elicit adaptive social responses from others. It was shown that when we detect personal distress in another person we tend to empathise and display the prosocial behaviour of sympathy [9]. This behaviour can often lead to a decrease or relief of the other person's distress. Reeves and Nass [10], in a series of empirical studies, reported that humans behave naturally and socially towards machines as they do with other humans. In this line of thought, we can hypothesise that a computer with an empathic behaviour can also simulate the prosocial behaviour of empathy, and therefore relieve users of personal distress.

This hypothesis began to be addressed by Klein et al. [11]. Their studies were designed to relieve user frustration caused by an intentional faulty computer application, through the use of a text based agent. This agent used active listening, empathy and sympathy with the intention of helping to relieve the user's negative state. However there were no significant results to prove the hypothesis that a computer program could really help users feel less frustrated only by the use of an empathic agent.

Meanwhile, a study presented years later by Hone [12] continued Klein et al.'s work and tested the same hypothesis. In this new study, the author suggested that the above referred possibility could be right. It was shown through a series of three experiments that a text based agent with empathetic behaviour could indeed help users to successful relieve their frustration. This study also showed that a virtually embodied character is even more successful at achieving the same purpose. The author reflects on this result explaining that "there is a good match between the characteristics of the feedback strategy (human–human) and the characteristics of the entity delivering that feedback". It remains unknown if a social robot could outperform a virtual agent in this task, even though in our previous work [13] there was evidence that a robotic agent does provide greater feedback than a virtual agent in human-machine interaction.

Ochs et al. [14] showed that a virtual agent is perceived more positively when it expresses empathic emotions than when it expresses no emotions. This work also raised a preeminent challenge in the creation of empathic agents, as it showed that if the same agent expresses the empathic emotions in an inconsistent way, the opposite effects occurs (i.e., the agent is perceived more negatively than another agent without empathic behaviour). These results suggest that recognizing the right affective state of the user (to be able to display the appropriate empathic behaviour) is of extreme relevance.

Therefore, research on empathic companions needs to take into account the design of an affect recognition framework. It is important to stress that a companion's affect recognition abilities must go beyond the detection of prototypical emotions and be sensitive to application-dependent affective states, such as, for example, interest, boredom, frustration, willingness to interact, etc. [15].

Some efforts in this direction have been reported in the literature. Kapoor and Picard [16], for example, proposed an approach for the detection of interest in a learning environment by combining non-verbal cues and information about the learner's task (level of difficulty and state of the game) Kapoor et al. [17] designed a system that can automatically predict frustration of students interacting with a learning companion by using multimodal non-verbal cues including facial expressions, head movement, posture, skin conductance and mouse pressure data. El Kaliouby and Robinson [18] proposed a computational model for the detection of complex mental states such as *agreeing, concentrating, disagreeing, interested, thinking and unsure* from head movement and facial expressions.

3. RECOGNIZING THE USER'S AFFECTIVE STATE

As discussed in the related work section, understanding the user's affective state is the ground for empathic behaviour. Initially, we intend to endow our agent with the ability to recognize a limited set of the user's affective states. Taking into account the domain in which the agent is immersed as well as its role, we have chosen to start focusing on interest and boredom. In the future, we will attempt to model the recognition of frustration.

To identify the affective states mentioned above, we propose a model divided in two main parts: (1) recognition of user's facial and body expressions and (2) contextual features of the game. The affective states recognized by the model will work as the basis for the iCat's empathic behaviours. The remaining of this section describes in more detail the approach that we intend to follow.

3.1 Visual Features

During the whole interaction, the user sits in front of the iCat (see Figure 1), separated only by the chessboard. Since both the iCat and the user are in a fixed position, it is possible to use a camera to capture some expressions displayed by the user.

Figure 1. User playing with the iCat at the chess club.

We intend to employ new and existing vision libraries to analyze a set of non-verbal cues, including:

- Head gestures (e.g., head nods, shakes)
- Facial expressions (e.g. smiles)
- Eye gaze (e.g., fixed at the iCat, fixed at the chessboard or looking away)
- Lateral Posture (e.g., approach versus avoidance)

To validate which non-verbal cues are relevant to the affective states that we aim to recognize, as well as to our specific scenario of interaction, we are going to use both results from studies regarding body and facial expression of emotion (such as [19]) and video observation and annotation of interaction sessions conducted at the chess club. We plan to have two different groups of annotators: a first group to annotate the user's affective states (interest, boredom or neither), and a second group to annotate the user's expressions. With this approach, we intend to come up with a set of visual cues that are statistically significant in the discrimination of the defined set of affective states for our specific scenario. Our final aim is to build an affective recognition system that can work in real-time, in a real game scenario.

3.2 Contextual Features

Even though facial and body expressions are very important means of non-verbal communication, sometimes they can be misleading. People may want to dissimulate their facial expressions [20], particularly in a situation of a turn-based game in which two players play against each other. Moreover, affect recognition through visual cues may return the same patterns for different affective states, or people may express the same affective states in slightly different manners. These are some of the reasons for which we believe that situational context is very important when recognizing the user's affective state. As such, we will use contextual features either to disambiguate or to strengthen the confidence of the affective states identified by the vision system.

We start assuming that, when the user is playing with the iCat, many of the experienced affective states may be related to the events happening in the game, or with the behaviour and expressions displayed by the robot. The following list contains the contextual features that may influence the user's affective state:

- *Who has advantage/disadvantage in the game:* this information is obtained by the chess evaluation function, which also works as the main input for the iCat's affective model. Information such as which pieces were captured both in the user's side and in the iCat's side can also be retrieved.

- *Robot's facial expressions:* there may be a correlation between the user's affective state and the iCat's expressions, especially the ones displayed after each user's move.

- *Time the user takes to play a move:* this feature may vary among different users, and therefore it will only be helpful after some interactions. For instance, if the user usually takes about two minutes to play each move, and at some moment of the game he/she starts looking away more often and taking much more time to play, that might be a signal of boredom. But boredom might not be always associated to taking too much time to play. Another different user might feel bored if the exercises proposed by the iCat are very easy for him/her, and in that case the user does not need much time to play.

In addition to these features, we can also use the mechanism that the iCat uses to generate its affective reactions, but with the information from the user's perspective, i.e., taking into account the user's position in the game. The *emotivector* (Figure 2) is an anticipatory system that generates an affective signal resulting from the mismatch between the expected and the sensed values of the sensor to which it is coupled to [21].

In the iCat's affective system, the emotivector is coupled to values received from the chess evaluation function (for more details see [6]). When the user plays a new move, the chess evaluation function returns a new value, updated according to the new state of the game. The emotivector system captures this value and, by using the history of evaluation values, an expected value is computed (applying the moving averages prediction algorithm [22]). Based on the mismatch between the expected and the actual sensed value (i.e., the new value received from the evaluation function), the emotivector generates one of the nine different affective signals for that percept (see Figure 2). Each one of these nine sensations will result in a different affective reaction in the iCat's facial expression.

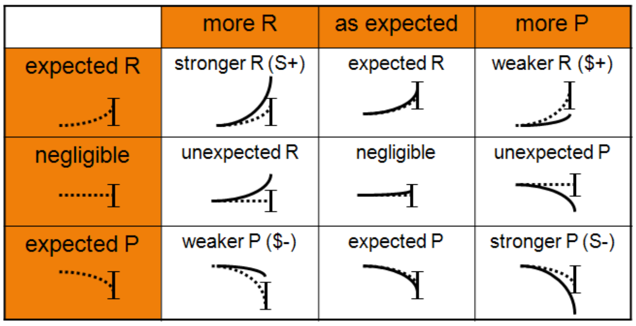

Figure 2. Emotivector mechanism. "R" means reward and "P" stands for punishment.

For instance, after three moves in the chess game, if the iCat has already captured an opponent's piece, it might be expecting to remain in advantage in the game (i.e., expecting a "reward") after the next user's move. So if the user plays an even worse move than the one that iCat was expecting (e.g., by putting her queen in a very dangerous position), the elicited sensation will be a "stronger reward", which means "this state of the game is better than I was expecting". In the presence of a "stronger reward", the iCat displays a facial expression of happiness.

Now we will present the same example, but from the user's perspective. After three moves in the game, the user has lost one piece, so he/she might be expecting the iCat to keep the advantage (i.e., expecting another "punishment"). If the user plays a terrible move, and acknowledges that by looking at the iCat's expression of happiness, he/she might be experiencing something closer to a "stronger punishment" sensation. At this time, and taking into account the game history, the iCat may assume that the user is experiencing frustration.

This example attempts to show the kind of reasoning that the iCat can perform about the user, to infer his/her affective experiences. Of course such results need to be verified, either by other contextual features or by information from the vision system.

4. EMPATHIC BEHAVIOUR

After recognizing the user's affective states, the agent should use that information to behave in a more empathic manner. Some of the empathic behaviours that might be employed are the following:

- *Boredom*: when the agent detects that the user is bored, it can ask him/her to start over the game, propose a new exercise or, at extreme conditions, suggest the ending of the interaction. If the game is balanced, the iCat can propose a stalemate, which may increase the user's interest to continue the interaction. Small talk about the game, or about previous games the iCat and the user played together, is another technique that could be used to prevent or remediate boredom. Finally, if the user is bored for being constantly in an advantageous position in the game, one can increase the chess engine's difficulty, and the iCat will become a stronger opponent. The opposite may also occur (the user getting bored because the game is too difficult), and it can be amended as well.

- *Interest*: if the user is currently on this state, the agent can assume that it is on the right track and so it should continue with the same behaviours and playing with the same difficulty level.
- *Frustration*: when the user is frustrated for being in disadvantage in the game, he/she might become even more frustrated with the iCat expressing very happy emotions. Therefore, one of the empathic behaviours that we suggest to deal with user's frustration is for the iCat to inhibit some of its happy facial expressions, or display them with a lower intensity. Another alternative to reduce frustration might be to reduce the difficulty of the chess game engine.

Most of these empathic behaviors are context dependent. Even so, the same strategies, if proved to be successful, could be applied in other contexts of interaction. This can be particularly true for the behaviors related to the expression/inhibition of emotions.

5. CONCLUSIONS AND FUTURE WORK

In long-term interactions, social robots need to be capable of more than just displaying emotions and social cues towards the user. They need to be socially aware, interactive and empathic, by taking into account the user's intentions and affective states. In fact, previous research on virtual agents has shown that one of the main aspects that breaks the user's suspension of disbelief in such interactions is the restricted way in which agents are receptive to the social cues displayed by the user [1]. This also happened in our scenario, as the iCat only perceived the game events, and was unable to "understand" the affective cues displayed by its opponent.

In this paper, we presented a model for detecting the user's affective state with the purpose of endowing a social robot with more empathic capabilities. In the near future, we intend to validate the proposed model by performing another field trial to collect new data, so we can validate the results obtained with the existing data. After completing this step, we plan to implement the empathic behaviour mentioned in Section 4, and evaluate if such behaviour has impact on the user's long-term interaction with the agent. As a ground for comparison, we will use the results obtained from our previous long-term experience with the iCat [7].

6. ACKNOWLEDGMENTS

The research leading to these results has received funding from European Community's Seventh Framework Program (FP7/2007-2013) under grant agreement nº 215554.

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