Using Adaptive Empathic Responses to Improve Long-term Interaction with Social Robots

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Abstract. The goal of this research is to investigate the effects of empathy and adaptive behaviour in long-term interaction between social robots and users. To address this issue, we propose an action selection mechanism that will allow a social robot to chose adaptive empathic responses, in the attempt to keep users engaged over several interactions.

Keywords: social robots, affective user modeling, empathy, adaptive feedback.

1 Introduction and Research Questions

For robots to become part of our lives, they should be able to communicate with people in similar ways people interact with each other [2]. This requires not only the ability to convey verbal and non-verbal behaviours, but to do so at the appropriate timing and in response to an action or expression perceived from the user. There are still many open challenges when developing robots and virtual agents for long-term social interaction, in particular the role that affect plays is still not clear. The ability to understand and respond appropriately to the affective states of others is commonly designated as empathy [6]. Empathic virtual agents have been widely studied in a variety of contexts, and the results suggest that the presence of empathic behaviours positively affects users' opinion of those agents [1]. Pedagogical agents that model and respond to user's affect have also been employed successfully in intelligent learning environments [11]. In the field of social robotics, the first empathy studies also are starting to appear [5]. However, these findings were obtained in studies where subjects interacted with these agents for a short period of time. Further research is needed to ensure that these results still apply in long-term interaction, as users' opinion is likely to change.

The goal of this research is to study the role of empathy in social robot companions. In particular, our aim is to investigate the effects of adaptive empathic behaviour in the relationship established between the robot and the user. Most of the existing pedagogical agents that model and respond to user's affect are based either in stereotypes (derived from cognitive or psychological theories) or on machine learning techniques that determine the "optimal" intervention for

each case [3]. This means that the agent displays the same behaviour whenever the user is experiencing an affective state, without knowing if such response is actually effective for that user, or if it is just making the user feel more frustrated. However, as suggested by Rich [10], "often individual users vary so much that a model of a canonical user is insufficient", especially if the user will spend a lot of time interacting with the system. As our goal is to build an artificial robot companion for long-term interaction, the robot should be capable of adapting its affective behaviour to the behaviour of a particular user. We aim to achieve this goal by addressing the following research questions: *What is the role of empathy and adaptive behaviour when developing social robots for long-term interaction? How the robot's empathic behaviour influences the relationship established between the user and the robot?* We defend the hypothesis that if the robot adapts its behaviour by selecting the most effective empathic responses for a particular user, users will be more willing to interact with the robot and, consequently, their relationship may improve.

2 Progress to Date

Our application scenario consists of a Philips' iCat robot that plays chess with children using an electronic chessboard. The iCat provides feedback on the moves that children play by conveying facial expressions determined by its affective state. A previous study showed that the affective behaviour expressed by the iCat increased children's perception of the game [7]. With the approach proposed in this paper, we aim to improve this scenario by endowing the robot with adaptive empathic capabilities. Most of the efforts so far have been dedicated to preliminary experiments that will serve as basis for the research challenges that we aim to address. To date, two studies in different directions have been completed.

The first experiment investigated the changes in children's perception of a social robot after several interactions. In this study [8], we analysed the same group of children playing an entire chess game with the iCat over five sessions (once a week). Children filled in a social presence questionnaire both in the first and last week of interaction. The results suggest that social presence decreased over time, especially in terms of perceived affective and behavioural interdependence (the extent to which users believe that the behaviour and affective state of the robot is influenced by their own behaviour and affective state). The outcomes of this experiment strengthen our hypothesis that the ability to understand and respond to user's affect is crucial for long-term interaction.

In the second experiment [9], we evaluated the influence of empathic behaviours on user's perception of a social robot. For this study, a slight variation of our application scenario was implemented, where the iCat observes and comments a chess match between two human players. The robot exhibits empathic behaviours towards one of the players and neutral comments to the other player, through facial expressions and verbal comments. The results of this study sug-

gest that players towards whom the iCat displayed empathic behaviour perceived the robot as friendlier.

3 Proposed Solution

To address the questions presented above, we need to create a model of the user that contains: (1) a prediction of the current user's affective state and (2) a dynamic representation of the user's preferences in terms of empathic strategies employed by the robot. The first step, a multimodal system for predicting some of the user's affective states, is currently being developed in the context a research project[1]. The affective states that this system is able to predict in real time are user's *engagement* and user's *valence of feeling* (positive or negative). The focus of this proposal is on the second part, which deals with selecting the empathic responses that are most effective to keep the user in a positive affective state.

We intend to adapt the robot's empathic behaviour as follows. During the game, after every user's move, the robot updates its affective state and the user model component updates the user's affective state. Then, taking into account its affective state, the user's affective state and the previous user reactions to certain empathic behaviours, the robot selects an empathic response. A while after the robot's action, the affect detection system updates the user model about the new affective state of the user. This new affective state serves as feedback to update the user's preferences in terms of empathic responses. As an example, consider a situation where the user is experiencing a negative feeling for loosing an importance piece in the game and the iCat responds with an encouraging utterance. If the user's valence changes from negative to positive, then utterances containing encouraging behaviours will become part of the user's preferences in that particular situation. As the same users are expected to interact with the robot for several games, the preferences for a particular user are updated even over different interaction sessions. To dynamically learn patterns associated to a particular user, we are considering to use Reinforcement Learning, as it was successfully employed before to induce pedagogical strategies without requiring a large training corpus [3]. Several empathic and pro-social strategies existing in the literature are being considered for implementation in the robot's behaviour [4], for example: facial expressions (e.g., mimicking the user's affective state or suppressing strong positive emotions that might offend the user), empathic utterances to encourage and motivate the player, and game related strategies (for example, propose a new game or suggest a good move for the user to play).

4 Future Work

We are currently implementing the action selection mechanism that will allow the iCat to provide empathic feedback on the children's moves. Among the list of possible empathic strategies for a particular situation, at this stage the robot is

[1] http://lirec.eu/

randomly choosing one. We will perform a long-term experiment with this model to evaluate if the presence of empathic behaviour influences participants' perception of the robot after several interactions. After that, we intend to improve the user model by implementing the adaptive feedback mechanism described earlier, so that the robot is able to choose the most effective strategy for a particular user rather than a random one. With this new model, we plan to conduct another long-term experiment and compare the results obtained from the two experiments. Measures such as social presence and perceived friendship are being considered for this study.

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