Designing a Game Companion for Long-Term Social Interaction

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ABSTRACT

The ability to understand the user's affective states and expressions is an important requirement for a robot companion. In this paper we focus on an interaction scenario where an iCat robot plays chess with children. We discuss the challenges to address in the design of an affect recognition system for a game companion and we present the initial steps carried out to build a framework for the dynamic modeling of the user's affect. We conclude by providing examples of how we intend to exploit information about the user's affect to generate an empathic behavior in our game companion.

Categories and Subject Descriptors

J.4 [**Computer Applications**]: Social and Behavioral Sciences

General Terms

Algorithms, Human Factors, Design, Theory

Keywords

Affect recognition, human-robot interaction, non-verbal behavior, contextual information

1. INTRODUCTION

In the human-robot interaction community there is an increasing interest towards new applications where robots are likely to play an important role as companions. One important prerequisite of companionship is the ability to sustain long-term interactions, which requires a robot companion to be able to display a social, affective behavior [1], [6].

The ability to understand the user's affective states and expressions is of the utmost importance for a robot companion to display socially intelligent behavior. Robot companions should be sensitive to verbal and non-verbal cues displayed by the user and the context in which the interaction with the user takes place in order to infer useful information regarding the ongoing situation.

While some efforts in affect recognition research have been reported in the literature [13], the design of an affect recognition module for use in a human-robot interaction framework has not been extensively addressed yet.

Designing an affect recognition framework for robot companions presents several challenges. A robot companion's affect recognition system must go beyond the detection of prototypical emotions and be sensitive to application-dependent affective states and cues. It must be trained using naturalistic, spontaneous expressions and integrate contextual information [2]. These challenges become a design issue: the first important step of the design of an affect recognition system for a robot companion, in fact, consists of the identification and the modeling of the affective states and cues displayed by the user and the context in which the user and the companion are involved when the interaction takes place.

In this paper we focus on a specific interaction scenario where children play chess with an iCat robot [12] and we propose our plans for the design of an affect recognition framework for a game companion.

2. SCENARIO

In our interaction scenario, the user plays chess while interacting with an iCat robot. The robot acts as a peer tutor, helping children to improve their chess skills [8]. 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.

An overview of the interaction cycle is depicted in Figure 1. After each user's move, the contextual information
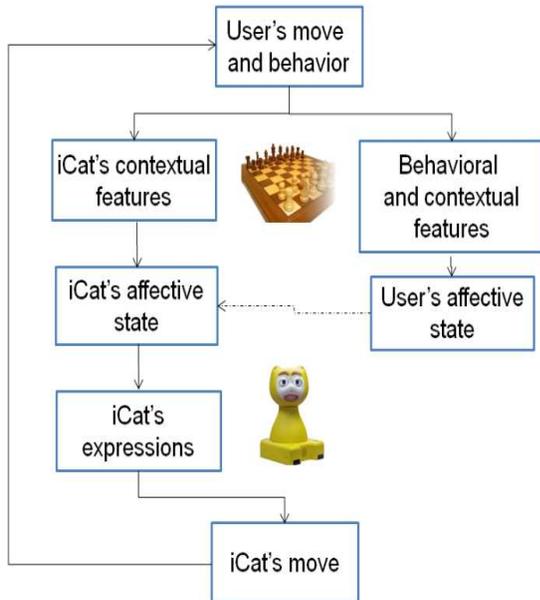
Figure 1: Overview.

related to the game changes. This includes, for example, information about captured pieces on the chessboard and an evaluation value that indicates the advantage of the user or the iCat in the game. The iCat uses this information to update its affective state and to display an affective expression to the user. Then, it asks the user to play its move. When the user plays the move asked by the iCat, the robot thanks the user and the game continues until one of the opponents wins the match.

In our previous work, the iCat's affective state was only influenced by its own contextual features, i.e., only using its evaluation of the game (for more details on how the iCat's affective state and consequent facial expressions are generated see [9]). However, one of the main prerequisites for companionship is sensitivity to the user's affect. Therefore, we propose a multimodal framework for affect recognition, based on both contextual information and user's behavioural features. Our aim is to endow the iCat with affect recognition abilities, in a way that the iCat's affective state will also depend on the user's affective state. By doing so, we believe that the iCat will behave in a more emphatic manner, which will help in sustaining long-term interactions with the users.

3. A FRAMEWORK FOR THE MODELING OF THE USER'S AFFECT

Our framework for the modeling of the user's affective states includes both causes and effects of affect. In our scenario it is expected that the user's affective states are both influenced by the task that the user and the companion are involved in (i.e., playing chess) and by the social interaction with the iCat. Hence our decision to focus on the valence of the user's feeling (i.e., positive vs. negative) and the interest shown by the user towards the iCat.

As the primary objective of our research consists of designing a game companion capable of establishing and maintaining long-term interactions with human users, we believe that the detection of the user's level of engagement with the iCat is of the utmost importance, as it provides information regarding the acceptance of the companion over time. Engagement can be detected by taking into account the context in which the interaction takes place. For example, similarly to what Peters et al. proposed in [10], if the user does not show interest when the iCat generates some form of behavior, e.g., when it displays an affective facial expression, then we may conclude that the user is probably not engaged. Therefore, while the valence of the feeling and the level of interest displayed by the user are continuously computed, the level of engagement with the iCat may be evaluated only at specific times. An assessment of the level of engagement throughout the interaction is important for the iCat to decide whether to plan an intervention (e.g., non-verbal behavior, small talk, etc.) to maintain the interaction with the user.

In our scenario the user's affective states are modeled using a number of task and social interaction-based features that proved successful in helping to discriminate among the selected affective states [3] [4]:

- **User's non-verbal behavior**:

  User looking at the iCat: it indicates whether the user is looking at the iCat rather than at the chessboard or elsewhere.

  User smiling: it indicates whether the user is likely to be smiling or not.

- **Contextual features**:

  Game state: is a value that represents the condition of advantage/disadvantage of the user in the game.

  Game evolution: is given by the difference between the current and the previous value of the game state and measures whether the user is improving in the game or not.

  Captured pieces: indicates if, in the last move played by the user and the iCat, a piece was captured either by the user or the iCat.

  User sensations: are calculated with the same mechanism used by the iCat to generate its affective reactions, but from the user's perspective, i.e., taking into account the user's game state. This feature attempts to predict the user's sensations resulting from the mismatch between expectations and factual events.

  iCat displaying an affective reaction: indicates whether the iCat is displaying an affective facial expression.

As far as the user's non-verbal behavior is concerned, a smile and an eye gaze detector are currently being developed. The contextual features are automatically extracted in real-time during the interaction. The fusion of automatically extracted contextual features and annotated non-verbal behavior (i.e., eye gaze and smiles) has already proved successful in the descrimination of the user's affect using a bayesian framework [5].

4. FUTURE WORK

Future work includes the selection of a corpus of affective expressions suitable for the design of a real-time affect recognition system. An experiment with human coders will

be performed to label the samples that will be used for training the system.

We plan to explore the use of more features, for example the user's level of activity, as well as lateral postural changes. Fusion of multiple modalities of expression and contextual features will be designed in an affect recognition framework that takes into consideration the dynamics of causes and effects of affect. We plan to explore the use of Dynamic Bayesian Networks. The modeling over time of the user's affect will allow the companion to be able to plan appropriate actions to maintain the social interaction with the user.

We intend to use the detected user's affective state as an additional input to the iCat's affective state. We plan to improve the iCat's affective state with more empathic behavior, grounded on theoretical empathic models that exist in the literature such as the Perception-Action Model (PAM) [11] or the work of de Vignemont and Singer [7]. For example, if the iCat is going to win the game in the next few moves, it might want to display happy and enthusiastic expressions. However, if at the same time the user is experiencing a negative feeling, the robot may inhibit some of its happy expressions, in the attempt to empathize with the user's feelings. Our main challenge is thus to create an empathic game companion that is capable of helping children to improve their chess skills, while at the same time behaving in a way that the user would expect from a companion.

5. ACKNOWLEDGEMENTS

6. REFERENCES

[1] C. Breazeal. Emotion and sociable humanoid robots. *International Journal of Human-Computer Studies*, 59(1-2):119–155, July 2003.

[2] G. Castellano, R. Aylett, A. Paiva, and P. W. McOwan. Affect recognition for interactive companions. In *Workshop on Affective Interaction in Natural Environments (AFFINE), ACM International Conference on Multimodal Interfaces (ICMI'08)*, Chania, Crete, Greece, 2008.

[3] G. Castellano, I. Leite, A. Pereira, C. Martinho, A. Paiva, and P. W. McOwan. It's all in the game: Towards an affect sensitive and context aware game companion. In *International Conference on Affective Computing and Intelligent Interaction*, Amsterdam, 2009. IEEE Press.

[4] G. Castellano, I. Leite, A. Pereira, A. Paiva, and P. W. McOwan. Affect recognition for interactive companions: Challenges and design in real-world scenarios. *Manuscript submitted for publication*, 2009.

[5] G. Castellano, A. Pereira, I. Leite, A. Paiva, and P. W. McOwan. Detecting user engagement with a robot companion using task and social interaction-based features. In *International Conference on Multimodal Interfaces*, Cambridge, MA, 2009. ACM.

[6] K. Dautenhahn. Socially intelligent robots: Dimensions of human-robot interaction. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 362(1480):679–704, 2007.

[7] F. de Vignemont and T. Singer. The empathic brain: how, when and why? *Trends in Cognitive Sciences*, 10(10):435–441, October 2006.

[8] I. Leite, C. Martinho, A. Pereira, and A. Paiva. iCat: An affective game buddy based on anticipatory mechanisms. In *AAMAS '08: Proceedings of the 7th International joint Conference on Autonomous Agents and Multiagent Systems*, pages 1229–1232, Richland, SC, 2008. International Foundation for Autonomous Agents and Multiagent Systems.

[9] I. Leite, A. Pereira, C. Martinho, and A. Paiva. Are emotional robots more fun to play with? In *17th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2008)*, pages 77–82, August 2008.

[10] C. Peters, S. Asteriadis, K. Karpouzis, and E. de Sevin. Towards a real-time gaze-based shared attention for a virtual agent. In *Workshop on Affective Interaction in Natural Environments (AFFINE), ACM International Conference on Multimodal Interfaces (ICMI'08)*, Chania, Crete, Greece, 2008.

[11] S. D. Preston and F. B. M. de Waal. Empathy: Its ultimate and proximate bases. *Behavioral and Brain Sciences*, (25):1–72, 2002.

[12] A. van Breemen, X. Yan, and B. Meerbeek. iCat: An animated user-interface robot with personality. In *AAMAS '05: Proceedings of the Fourth International Joint Conference on Autonomous Agents and Multiagent Systems*, pages 143–144, New York, NY, USA, 2005. ACM.

[13] Z. Zeng, M. Pantic, G. I. Roisman, and T. S. Huang. A survey of affect recognition methods: Audio, visual, and spontaneous expressions. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 31(1):39–58, January 2009.