Towards Empathic Virtual and Robotic Tutors

Ginevra Castellano[1], Ana Paiva[2], Arvid Kappas[3], Fernando Nabais[4], Ruth Aylett[5], Wolmet Barendregt[6], Helen Hastie[5] and Susan Bull[1]

[1] University of Birmingham, UK
[2] Inst de Engenharia de Sistemas e Computadores Investigação e Desenvolvimento, Portugal
[3] Jacobs University Bremen GmbH, Germany
[4] YDreams-Informatica S.A., Portugal
[5] Heriot-Watt University, UK
[6] Goeteborgs Universitet, Sweden
g.castellano@bham.ac.uk

Abstract. Building on existing work on the design of artificial tutors with human-like capabilities, this paper describes the EMOTE project approach to harnessing the benefits of an artificial embodied tutor in a shared physical space. Embodied in robotic platforms or through virtual agents, the EMOTE project aims to capture some of the empathic and human elements that characterise a traditional teacher. As such, empathy and engagement, abilities that are key to influence students' learning, are at the core of the EMOTE approach. We here present the non-verbal and adaptive dialogue challenges for such embodied tutors as a foundation for researchers investigating the potential for empathic tutors that will be accepted by students and teachers.

Keywords: Virtual and robotic tutor, affect recognition, adaptive behaviour

1 Introduction

Artificial tutors are being developed with the ability to perceive emotions experienced by learners, and to incorporate these into pedagogical strategies [1]. For example, determining the appropriateness of affective interventions by means of empathic strategies as a response to a learner's emotional state [2]; and strategies for keeping students in an affective state that promotes learning [3]. The presence of a tutor, embodied as a 2D or 3D character, has shown some positive learning effects, in particular in student engagement [4]. Recent research on artificial companions has demonstrated the key role that embodiment plays in user perception of an artificial entity: experiments comparing robots with their virtual representations demonstrated that the robotic embodiment was preferred by users in terms of social presence [5], enjoyment [6] and performance [7]. Possible reasons were identified with reference to size, realism, shared physical space, physical presence and perceived social presence [8], which may facilitate the establishment of a social bonding with the artificial entity.

Okita et al. have explored which features in robots affected children's learning and behaviour [9]; Saerbeck et al. explored the effects of supportive behaviour of a robotic tutor on children's learning performance and motivation [10]; and Han et al.

found that home robots are more effective for children's learning concentration, learning interest and academic achievement than other types of instructional media [11]. Studies on robotic companions in real world classroom environments [12] indicate that robotic platforms are promising tools for experimental learning.

The automatic recognition of a user's affective state is of primary importance for a virtual agent or a robot to establish an affective loop with the user, through the generation of an appropriate response [13]. Non-verbal behaviours play an important role in Human-Agent and Human-Robot Interaction, as they are considered to help the user maintain a social relationship with the robot or agent [14]. While there have been advances in expressive behaviour of virtual agents have been witnessed in recent years [15], expressive mechanisms for social robots are still, in general, quite limited.

The above opens up opportunities for novel contributions in artificial tutors. This paper introduces some of the key issues to be considered in the design of embodied virtual and robotic agents that take an empathic approach. We present the EMOTE project's approach to addressing the unique challenges, setting out areas underpinning future directions for research into empathic adaptive virtual and robotic tutors.

2 Embodied Empathic Virtual and Robotic Tutors with EMOTE

Two students are learning about ecology models. They want to create a model of how acid rain impacts the level of fish in a local stream both in winter, when it contains a lot of cold water, and in summer, when its water level is low and much warmer. They find grasping how the processes affect each other quite difficult and, when completing structured learning activities at their own computers, they get tired and frustrated.

Another option is to work on the activity together at the multi-touch table with the robot tutor Emys. Emys calls up a graphical representation of the processes on the table and asks the children to link them together to create their model. During this activity, Emys tracks their choices and asks questions that set them on the right track while physically pointing at items on the table that scaffold their learning. The students ask Emys questions using buttons on the table and related gestures. Emys encourages the children when they seem uncertain and praises when they succeed. Through their non-verbal responses and progress in the task, Emys confirms that they now understand how to construct this model much more clearly, and suggests a follow-up activity that involves collecting field data to input into the model and offers to come with them on a visit to the stream. They agree and Emys migrates to their phones for the trip.

Following from the above, the EMOTE project's aim is to (1) facilitate the building of tutors that enrich learning experiences by:

(a) monitoring the learner's abilities and difficulties throughout learning;
(b) modelling affect-related states experienced by the learner during the learning task and the interaction with the tutor;
(c) providing appropriate feedback to the learner by means of contextualised empathic reactions, adaptive dialogue and personalised learning strategies

and (2) demonstrate the practical (technical and learning) possibilities of achieving this, realised across virtual and robotic embodiments. Figure 1 gives examples of tabletop learning situations with students interacting with the Emys robotic tutor and;

and gesture/pointing interaction by the Nao robot. Future researchers will then be able to build on the findings as applicable to their own contexts.

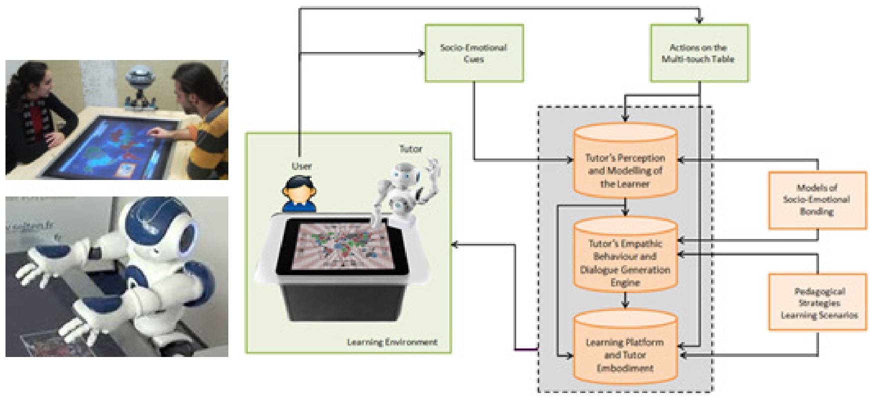

Fig. 1. Tabletop interaction examples and functional architecture

The following have been identified crucial to the success of embodied empathic virtual and robotic tutors, that may not necessarily apply in other tutor contexts:

- an empathy model allowing tutor understanding of learners' affective states in interaction with both a virtual and robotic embodied tutor.
- Robotic tutors that have perceptive capabilities to engage in empathic interactions with learners in a shared physical space.
- Modelling learner affective states that may emerge during the learning process and related to the interaction with a robotic tutor.
- Development of a set of cues that should create social bonding despite the fact that not all features will be anthropomorphic (for example: emblematic highly synthetic sounds as used in toys and sci-fi movies ("R2-D2").
- Establishing a new paradigm for optimisation of dyadic bonding (by systematically evaluating the role of features such as shared gaze, synchronisation of gestures and sensitivity to certain movements on the side of the human).

Figure 1 also shows the EMOTE functional architecture for addressing the unique challenges of an empathic virtual and robotic tutor: the learning interaction (shown here with user, robotic tutor and tabletop), providing information through actions on the multi-touch table, and socio-emotional cues. Along with models of socio-emotional bonding, these contribute to the tutor's perception of learners and learner modelling, allowing, in turn, empathic tutor behaviour based on a dialogue generation engine, also informed by pedagogical strategies. Actions of the embodied tutor will feed back to the learning environment and further influence the tutor's guidance.

Summary

The challenges for building successful empathic virtual and robotic tutors are substantial. The EMOTE project's aims include defining and creating a new generation of artificial tutors that are embodied (through a robotic platform and a virtual character) and engage in empathic interactions with learners. This paper presented initial steps in identifying unique challenges for embodied empathic virtual and robotic tutors.

Acknowledgement

This project is supported by the European Community under the 7th Framework Programme (EMOTE). This document does not represent the opinion of the European Community and the European Community is not responsible for any use that might be made of its content.

References

1. Burleson, W. Affective Learning Companions: Strategies for Empathetic Agents with Real-Time Multimodal Affective Sensing to Foster Meta-Cognitive and Meta-Affective Approaches to Learning, Motivation, and Perseverance, PhD Thesis, MIT (2006)
2. Robison, J. McQuiggan, S. & Lester, J. Evaluating the Consequences of Affective Feedback in Intelligent Tutoring Systems, Proceedings of ACII, Amsterdam, 37-42 (2009)
3. Robison, J. McQuiggan, S. & Lester, J. Modeling Task-Based vs. Affect-Based Feedback Behavior in Pedagogical Agents: An Inductive Approach, AIED09, IOS Press 25-32 (2009)
4. McQuiggan, S.W. & Lester, J.C. Modeling and evaluating empathy in embodied companion agents, International Journal of Human-Computer Studie, 65, 348–360 (2007)
5. Kidd, C. Sociable Robots: The Role of Presence and Task in Human-Robot Interaction (2003)
6. Pereira, A., Martinho, Leite, C.I. & Paiva, A. iCat the chess player: the influence of embodiment in the enjoyment of a game, in Proceedings of the 7th International Joint Conference on AAMAS , Estoril, Portugal, 1253-1256 (2008)
7. Bartneck, C. eMuu-an embodied emotional character for the ambient intelligent home (2002).
8. Hoffmann, L. & Krämer, N.C. How Should an Artificial Entity be Embodied? Comparing the Effects of a Physically Present Robot and its Virtual Representation, Proceedings of Workshop on Social Robotic Telepresence, HRI (2011)
9. Okita, S.Y. Ng-Thow-Hing, V. & Sarvadevabhatla, R.K. Learning together: ASIMO developing an interactive learning partnership with children, Proceedings IEEE Int. Symposium on Robot and Human Interactive Communication, 1125–1130 (2009)
10. Saerbeck, M., Schut, T., Bartneck, C. & Janse, M.D. Expressive robots in education: varying the degree of social supportive behavior of a robotic tutor, Proceedings of the International Conference on Human Factors in Computing Systems, 1613-1622 (2010)
11. Han, J., Jo, M., Jones, V. & Jo, J.H. Comparative Study on the Educational Use of Home Robots for Children, Journal of Information Processing Systems 4(4) (2008)
12. Leite, L., Castellano, G. Martinho, A., Pereira, C. & Paiva, A. Modelling Empathic Behaviour in a Robotic Game Companion for Children: an Ethnographic Study in Real-World Settings, Proc. ACM/IEEE Int. Conference on Human-Robot Interaction (2012)
13. Castellano, G. et al., Affect recognition for interactive companions: Challenges and design in real-world scenarios, Journal on Multimodal User Interfaces, 3(1–2), 89-98 (2010)
14. Breazeal, C. Emotion and sociable humanoid robots, International Journal of Human-Computer Studies 59, 119-155 (2003)
15. Pelachaud, C. Multimodal expressive embodied conversational agents, Proceedings of ACM International Conference on Multimedia, 683–689 (1995)