Emulating Empathy For Educational Robots

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Effective human teachers are able to engage, motivate and empathise with learners. They are able to interpret the aims and intentions of humans based on ability and accumulated background knowledge to help identify contexts and cues from the student behaviour. Part of this effective teaching strategy is building up a long term relationship between teacher and learner, knowing the learner's strengths and weaknesses and adapting interactions and exercises accordingly. If robots and tutoring systems are to be accepted and play a long-term role in an educational environment, we need to develop human-like intelligence that models these socially intelligent, empathic behaviours.

Whilst the field of affective computing has grown in popularity, there has been little work specifically on computationally modelling empathy. Empathy is defined by the Oxford English Dictionary as 'the ability to understand and share the feelings of another'. The educational domain is ideal for studying a number of questions related to empathy such as 1) how to model such behaviours using various machine learning techniques; 2) what effects do these social behaviours have on the interaction and learning of the user; and 3) how do we measure and evaluate these effects.

In the multidisciplinary Emote EC FP7 project [1][1], a robotic tutor was developed that was able to perceive the user's emotional state using vision along the arousal/valence dimensions [2] and adapt its behaviour accordingly with the aim of being empathic (Fig. 1). A hybrid statistical/rule-based interaction manager was developed [3] and in addition, exploratory work investigated using deep reinforcement learning to learn certain behaviours. A hybrid approach was adopted so that effective, well-established teaching strategies gathered from interviews with learning and teaching experts could be combined with learned aspects of tutor-learner interaction.

With regards evaluation, a key question is whether empathic behaviour is being exhibited by the robot/agent and whether this contributes to student learning. Evaluations of spoken dialogue systems have typically consisted of a combination of subjective and objective measures using a mixed-methods approach; or in terms of intrinsic and extrinsic measures; or a weighted combination to give a single measure of quality such as user satisfaction as in the PARADISE framework [4]. Task based system evaluations are reasonably straightforward,

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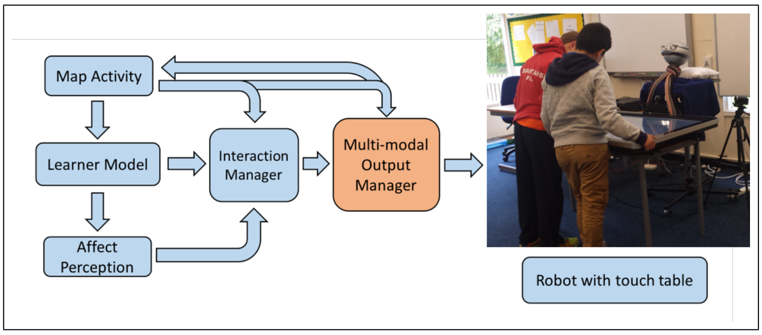

Fig. 1. Emote system architecture with two young learners interacting with the Emys robot whilst performing a map-based task on a touchtable

such as finding a flight or a restaurant where one can measure, for example, time-on-task and task success. On the other hand, evaluation for affective based systems, in particular for educational tasks is not so clearly defined.

One could evaluate the system in terms of its ability to use empathy to engage users. Engagement is important as it fosters learning and maintains learner motivation. User engagement has been used in real-time interactions to mitigate against disengagement as with the Emote system and that reported in [5]. User proximity, linguistic and visual cues can provide some approximation of user engagement but as yet there is no clear domain-independent measure other than manual video annotation, which is very time-consuming and in itself highly subjective.

One measure that has been used in tutoring systems for some time is learning gain collected along with some kind of user experience or student satisfaction score. In some recent work, [6] found that, whilst the presence of a robot can improve learning gain for children aged 7 or 8, this improvement is lost when the robot is 'social', using affective responses, gestures and personalisation (though not explicitly empathy). The authors speculate that the affective robot may be a distraction and is viewed more as a teacher in the non-social case, and warn that applying social behaviour to a robot in a tutoring context may have negative effects. [7] on the other hand did show a significant improvement in learning gain through adding the social skill of personalisation in the form of including 'memory' of previous interactions. However, interestingly the artificial tutor with memory was perceived as less likeable, perhaps as the agent with memory is seen as a harder task master. These two studies show that there is a complex relationship between likeability and robot effectiveness in terms of improving learning gain when a robot exhibits social behaviours.

The above-mentioned studies show that there may be unintended negative effects of robot social behaviour, and this has ethical consequences when it comes to running experiments with social robots, in particular where vulnerable users such as children are concerned. In general, when performing an evaluation, one wants the subjects to have an enjoyable experience and not opt-out. Also for consideration is the ethics of running experiments in which the user is placed in a situation that maximises the use of empathic and social behaviours. If the student is continually doing well and therefore has neutral or happy affect then we may not even observe the very phenomena for which the robot has been trained, that is to be empathic when the child is struggling with the lesson. In addition, the emotional state of boredom is unlikely to occur due to the novelty factor of interacting with a robot. The duration of studies also has ethical considerations. For short term studies, exposure may not be long enough to show a difference in learning gain, whereas for long term studies the users could form an attachment to and anthropomorphise the robot, which may result in potential distress at the end of the trial when the robot goes away [8].

A further dimension of the evaluation to consider is the user group. Much work has been done for younger children [6] but less so for teenagers. As [9] states, older children are less likely to view robots and virtual agents as social actors and, therefore, would require the robot to have more complex interactions and social behaviours. With this higher level of sophistication would come a greater expectation of capability and if the agent falls short of this then negative feelings may result towards the agent.

To conclude, further interdisciplinary work is needed to explore how human teachers are able to create socio-emotional bonds, whilst finding a balance between empathic interaction and effective teaching strategies and how we can use machine learning techniques to model such behaviours and evaluate them accordingly.

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