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Affective Tutoring System for Better Learning

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ABSTRACT

Intelligent tutoring systems (ITS) are still not as effective as one-on-one human tutoring. The next generation of intelligent tutors are expected to be able to take into account the emotional state of students. This paper presents research on the development of an Affective Tutoring System (ATS). The system called "Easy with Eve" adapts to students via a lifelike animated agent who is able to detect student emotion through facial expression analysis, and can display emotion herself. Eve's adaptations are guided by a case-based method for adapting to student states; this method uses data that was generated by an observational study of human tutors. This paper presents an analysis of facial expressions of students engaged in learning with human tutors and how a facial expression recognition system, a life like agent and a case based system based on this analysis have been integrated to develop an ATS for mathematics.

Keywords: *Affective Tutoring Systems; Case Based Systems; Facial Expressions; Human Tutors; Lifelike Agents*

INTRODUCTION

It is believed that Intelligent Tutoring Systems (ITSs) would be significantly enhanced if computers could adapt according to the emotions of students (Picard, 1997; Kort, Reilly and Picard, 2001; Alexander and Sarrafzadeh, 2004). This is idea behind the developing field of Affective Tutoring Systems (ATSs): ATSs are ITSs that are able to adapt to the affective state of students in the same ways that effective human tutors do (Sarrafzadeh, Fan, Dadgostar, Alexander and Messom, 2004; de Vicente, 2003). It seems that the term "Affective Tutoring System" is a relatively recent term (Alexander, Sarrafzadeh and Fan, 2003; de Vicente, 2003), although the popular concept of an ITS adapting to perceived emotion can be traced back at least as far as Rosalind Picard's book *Affective Computing* (1997). However, so far as the authors are aware, no ATSs other than Eve have yet been implemented, although several groups are working towards this goal (Kort, Reilly and Picard, 2001; Alexander, 2004; Litman and

Forbes-Riley, 2006; D'Mello, Craig, Gholson, Franklin, Picard and Graesser, 2005).

During its brief history, the field of ATSs has faced two main barriers: reliably detecting the affective state of students; and knowing how best to adapt to this information once a student's emotions have been detected. The first of these issues seems to have generated by far the most attention, with growing numbers of researchers investigating various forms of facial expression analysis and gesture analysis, voice analysis, wearable computers, and predictive emotion models. In contrast, the second of these issues seems to have suffered serious neglect. However, as the technical obstacles to detecting emotions are being gradually overcome, the pressing relevance of *how* to adapt to student emotion is becoming increasingly obvious.

Therefore, the aim of this research has been to investigate *how* to adapt the affective state of students; to develop a method for adapting to the affective state of students; and then to implement this method in an ATS. The first of these aims has been addressed by an observational study of how human tutors adapt their tutoring based on the affective state of students. This has led to the development of a case-based reasoning method for adapting to student affect, where recommended tutoring actions are generated based upon the ways in which human tutors adapt their tutoring to a student's state. This in turn has been applied to what is perhaps the first ever ATS, *Easy with Eve*; *Eve* is an animated lifelike agent that is able to both express and react to a range of affective states. Eve appears on the screen which is currently a computer screen and is able to show emotions, gestures and speech. The agent could easily be used on a mobile phone or PDA screen.

This paper will present the results of the observational study of human tutors, the case-based method that was developed based on this study, the implementation of *Easy with Eve*, and avenues for future work. The next section provides a background to ATSs, and a brief summary of the observational study of human tutors.

BACKGROUND

The overall aim of this research is to develop an ATS that is capable of recognising both the cognitive and affective state of students, and of usefully adapting to this information. The aim of the ATS is summarised in Figure 1 in a model adapted from Conati (2002): the left hand side of the diagram at time t_i represents the cognitive and affective state of the student immediately following a student action, where the affective state is identified by detecting the student's facial expression. At time t_{i+1} the system's animated agent then responds to the cognitive and affective state of the student by adapting both its tutoring and its own facial expression, with the intention of mapping the student's cognitive and affective states to a particular desired state.

Animated Pedagogical Agents

Though few if any existing ITSs can recognise emotions, many ITSs have been developed that can show emotions through an animated pedagogical agent (Johnson, Rickel and Lester, 2000; Prendinger and Ishizuka, 2004). Animated pedagogical agents are "lifelike autonomous characters that cohabit learning environments with students to create rich, face-to-face learning interactions" (Johnson, Rickel and Lester, 2000). Animated agents carry a persona effect, which is that the presence of a lifelike character can strongly influence students to perceive their learning experiences positively (van Mulken, André and Muller, 1998). The persona effect has been shown to increase learner motivation, especially in technical domains, although its overall benefits remain unclear (van Mulken, André and Muller, 1998).

How Student Emotions Affect Learning

The emotions of a student can be shown to have a significant influence on his/her ability to learn new information or to solve problems. Although