Relating Error Diagnosis and Performance Characteristics for Affect Perception and Empathy in an Educational Software Application

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Abstract

While the benefits of computer-assisted learning are acknowledged within the educational community, numerous new educational software applications are being developed. Educational software can become very effective if it is adaptive and individualised to the student. However, one important aspect of students that has been overlooked so far in such software applications is affect. This paper describes how system observations of students' behaviour while they interact with an educational application may provide important evidence about students' emotions while they learn. Observations mainly concern the way students respond to assessment questions in terms of the quality and correctness of their answers. The system's inferences about students' emotions are used by the system to adapt interaction to each individual student's needs taking into account their character and mood.

1 Introduction

There is a growing interest for educational software from educational institutions and educational strategic planners as a result of the general acknowledgment of the potential benefits of computer assisted learning. However, to a large extent educational software aims at being used by students without the physical presence of a human instructor. Therefore educational applications have to incorporate as many reasoning abilities as possible. One aspect of students that plays an important role in students' learning and has been overlooked so far is affect (De Vincente & Pain 2002; Kort & Reilly 2002). Indeed, affect has been overlooked by the HCI community in general (Picard & Klein 2002). However, how people feel may play an important role on their cognitive processes as well (Goleman 1995).

In this paper, we present and discuss the student modelling aspects of an educational application that combines evidence from students' errors and detectable performance characteristics in order to recognise important students' emotions and provide appropriate feedback. The educational application that has been used as a test bed for our research is a Virtual Reality game for teaching English. Previous versions of Virtual Reality games did not incorporate such features (e.g. Virvou et al. 2002).

2 Students' emotions in the educational application

The educational game for English has features that are quite common in virtual reality adventure games. Such features include dungeons, dragons, castles, keys etc. In this game the student-player tries to reach the "land of knowledge" and find the treasure, which is hidden there. The difference of the educational game is that one must fight one's way through by using one's knowledge. However, to achieve this, the player has to obtain a good score, which is accumulated while the player navigates through the virtual world and answers questions concerning English spelling. In the game worlds there are animated agents that communicate with the players. There are three types of animated agent, the advisor, the guard of a passage and the student's companion. Animated agents, who act as advisors, lead the student to lessons that s/he has to read. An example of an animated agent who acts as an advisor is the angel, which is illustrated in Fig. 1. On the other hand, guards of passages ask questions to players in order to let them continue their way into the passage and receive more points for their total score. Finally, companions are responsible for showing empathy to the students and help them in managing their emotions while playing and answering questions.

Figure 1: A screenshot of the game.

It is very important that the animated agents may be able to speak to the students. In most of the commercial games there are sound effects that a player hears during the game. However, the effect that makes games more human-like is that of the agents of the game speaking to the player. This feature gives the player a feeling of interplay with the agents, something like the player having a companion in his/her journey. This feature helps the educational game, because the students do not become bored easily.

The game itself may motivate students but it may also cause disappointment and frustration each time a student does not perform so well as s/he would like. Moreover, the testing process where students have to answer questions may cause them anxiety (as exams always do) and thus they may perform worse than they could, if they let their anxiety take over them. On the other hand there are students that may be quite confident and efficient in which case they may only need affective help when they face exceptionally disappointing situations for them (e.g. when they do not remember something correctly and they are not allowed to continue the game).

3 Evidence and inferences

For the purposes of finding out which aspects of the students' emotional state in relation to their performance in the educational game could be modelled, we conducted an empirical study. In this study, computer logging was used to record students' actions while they interacted with the application in a similar way as in (Virvou & Kabassi, 2000) and (De Vincente & Pain 2002). Through computer logging the system may continuously collect objective data for further analysis and interpretation without interfering with users during their interactions with the system (Chou 1999). The collected user protocols were passed on to 5 human experts who were asked to observe students' actions while they played the game and to note down what the students were likely to have felt. As a result, the experts had distinguished between different characters of students and assessed their emotions in relation to the students' characters and correctness of their knowledge.

Taking into account the results of the empirical study, the educational game uses as evidence on students' characters and emotions several actions that relate to typing and mouse movements. Time has played a very important role in our measurements. There are many inferences that can be drawn for the students' feelings and reactions depending on the time they spend before and after making some actions. Some examples of inferences based on observations on time spent for various activities are the following:

- *The time that it takes to the student to answer a question.* This measures the *degree of speed* of the student.
- *Pausing time after a system's response.* The time the computer is left idle after a response to the student is used to measure the *degree of surprise* that the response may have caused to the student.

In addition, certain patterns of actions are used to show aspects of the students' cognitive and emotional state. Some examples of students' actions that are used as evidence are the following:

- *The number of times that a student presses the "backspace" and "delete" button while forming an answer*. This evidence is used to measure the *degree of certainty* of the student concerning a particular answer; the more times the student presses "backspace" and "delete" the less certain s/he is about the answer.
- *Mouse movements without any obvious intent in the Virtual Reality space of the game*. This evidence is mainly connected to the *degree of concentration* or *frustration or intimidation* of the student; the more mouse movements without any obvious intent, the less concentrated or the more frustrated or intimidated the student is. The exact interpretation depends on the context. For example if the mouse movement without any obvious intent occurs some time after the student has been asked a question then it shows frustration since the student does not probably know how to answer.
- *The number of times the student drops out.* This is considered as evidence of *disappointment* or *boredom* depending on the context.

In some cases, inferences are drawn from the combination of two different categories of evidence. For example, the *degree of confidence* is calculated as the means of the degree of speed and the degree of certainty of a student.

The above kind of evidence based on a student's actions is combined with evidence on the student's degree and quality of knowledge of the parts of the lessons that are examined during the game. Therefore for each question asked, the system examines the correctness of the student's answer and if the answer is incorrect it performs error diagnosis. The system also tries to estimate the severity of an error (i.e. whether it was an accidental slip or whether it was due to a persistent misconception).

Examples of some rules that show such kind of combination are the following:

- If a student repeatedly answers questions with a high degree of speed and s/he produces a high degree of incorrectness then this may show *anxiety*.
- If a student repeatedly shows a high degree of confidence irrespective of correctness of his/her answers then this may show *determination* (the student does not give up).
- If a student has given an incorrect answer and then drops out this shows *disappointment*.
- If a student has answered correctly in most questions and drops out before the end of the game then this shows *boredom.*

There are also some more general inferences that can be drawn by using many of the above measurements.

- Degree of efficiency: Depending on the degree of confidence of the student when s/he gives correct answers and his/her degree of concentration, the degree of his/her efficiency is calculated.
- Consolidation: Depending on the percentage of the correct answers and the certainty of the student the system may calculate a degree of consolidation of his/her knowledge.

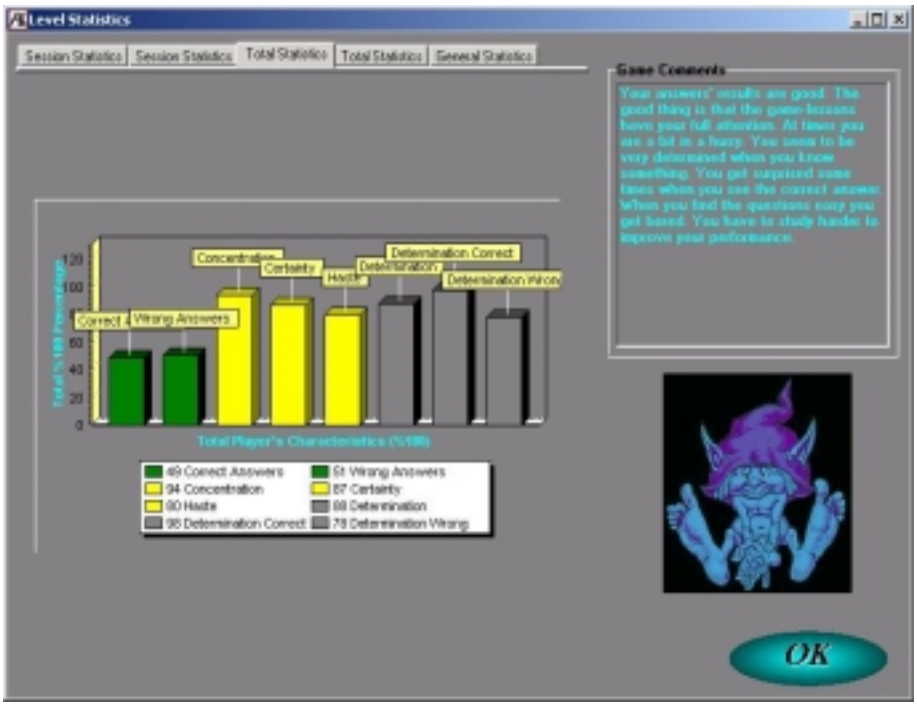

Figure 2: A report of inferences drawn by the system

All kinds of evidence are used by the system to adapt its interaction with the user. Moreover a user may see a report of the inferences drawn by the system. This report is used to show the user a more personal interaction since the system tries to know him/her better. An example of such a report is illustrated in Fig. 2.

4 Conclusions

In this paper we have described how evidence from the students' actions using the keyboard and the mouse may be combined with evidence on the student's knowledge of the domain being taught for drawing inferences for the student's emotional state while interacting with the educational application. Such inferences may be very helpful for adapting the system's advice on the needs of each individual taking into account both his/her knowledge state and character and mood.

References

Chou, C. (1999). Developing CLUE: A Formative Evaluation System for Computer Network Learning Courseware, Journal of Interactive Learning Research, 10(2)

De Vincente A. & Pain H. (2002). "Informing the Detection of the Students' Motivational State: An Empirical Study". In S.A. Cerri, G. Gouarderes and F. Paraguacu (Eds.): Intelligent Tutoring Systems 2002, LNCS 2363, pp. 933-943, Springer-Verlag 2002.

Goleman D. (1995). "Emotional Intelligence". Bantam Books: New York

Kort, B. & Reilly, R. (2002) "An affective module for an intelligent tutoring system". In S.A. Cerri, G. Gouarderes and F. Paraguacu (Eds.): Intelligent Tutoring Systems 2002, LNCS 2363, pp. 955-962, Springer-Verlag 2002.

Picard R. W. & Klein J. (2002) "Computers that recognise and respond to user emotion: theoretical and practical implications" Interacting with Computers 14, pp. 141-169.

Virvou M. & Kabassi K., "An Empirical Study Concerning Graphical User Interfaces that Manipulate Files", Proceedings of ED-MEDIA 2000. World Conference on Educational Multimedia, Hypermedia & Telecommunications, AACE, Charlottesville VA, 2000a. pp. 1724-1726.

Virvou, M., Manos, C., Katsionis, G. & Tourtoglou, K. (2002) "Incorporating the Culture of Virtual Reality Games into Educational Software via an Authoring Tool" In IEEE International Conference on Systems, Man and Cybernetics (SMC 2002).