Chapter 9
An Emotional Student Model for Game-Based Learning

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ABSTRACT

Students’ performance and motivation are influenced by their emotions. Game-based learning (GBL) environments comprise elements that facilitate learning and the creation of an emotional connection with students. GBL environments include Intelligent Tutoring Systems (ITSs) to ensure personalized learning. ITSs reason about students’ needs and characteristics (student modeling) to provide suitable instruction (tutor modeling). The authors’ research is focused on the design and implementation of an emotional student model for GBL environments based on the Control-Value Theory of achievement emotions by Pekrun et al. (2007). The model reasons about answers to questions in game dialogues and contextual variables related to student behavior acquired through students’ interaction with PlayPhysics. The authors’ model is implemented using Dynamic Bayesian Networks (DBNs), which are derived using Probabilistic Relational Models (PRMs), machine learning techniques, and statistical methods. This work compares an earlier approach that uses Multinomial Logistic Regression (MLR) and cross-tabulation for learning the structure and conditional probability tables with an approach that employs Necessary Path Condition and Expectation Maximization algorithms. Results showed that the latter approach is more effective at classifying the control of outcome-prospective emotions. Future work will focus on applying this approach to classification of activity and outcome-retrospective emotions.

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INTRODUCTION

Information technologies for supporting education have evolved into increasingly sophisticated environments. Virtual environments, tele-presence, video games, intelligent tutoring, haptic devices and social environments are only some of the technologies that have been applied successfully. However, challenges are still present in the area of personalized emotional learning. Emotion is considered an essential component of human experience and from a Human-Computer Interaction (HCI) viewpoint, Graphical-User Interfaces (GUIs) that do not address emotion appropriately are perceived as socially-impaired and can limit users’ performance (Brave & Nass, 2008). As a result, two research areas, Edutainment and Computer Tutoring, i.e. Intelligent Tutoring Systems (ITSs), have concentrated efforts on recognizing or showing emotion (Picard et al., 2004). Incorporation of affective modeling promises enhanced student motivation, learning and understanding. The topic of “emotion in education” is also gaining popularity in the field of Cognitive Psychology. Theories that aim to provide an enhanced explanation of the origin of emotion in an educational context are important (Schutz & Pekrun, 2007).

Whilst attempting to reason about or understand emotion, common questions appear, such as how emotion arises and the emotions most relevant for the teaching-learning experience. As part of the endeavor in finding the most suitable answers to these questions, this chapter reviews related work in the areas of ITSs and Edutainment, which aims to identify emotion. In addition, approaches, such as recognizing the physical effects of emotion (D’Mello et al., 2008), which have been derived and used to recognize and reason about emotion are examined and discussed by outlining their advantages and disadvantages. This chapter also focuses on examining cognitive psychology theories, such as the Ortony, Clore and Collins (OCC) model (Ortony, Clore & Collins, 1990), which have previously been used as a basis to implement emotional student models and other theories that have not been previously employed, such as the Control-Value theory of achievement emotions by Pekrun, Frenzel, Goetz and Perry (2007).

We have developed PlayPhysics, an emotional game-based learning environment for teaching Physics at undergraduate level. It was designed to derive and evaluate our emotional student model and facilitate students’ self-reporting of their emotions. PlayPhysics is a space adventure, where the student, an astronaut, has to overcome challenges using his/her Physics knowledge of vectors, circular and linear kinematics and Newton’s laws for particles and rigid bodies. The first challenge involves piloting the Alpha Centauri spaceship in order to arrive at the Athena space station before the ship’s fuel is exhausted. PlayPhysics is implemented with the Unity Game Engine, Hugin Lite, MySQL and Java. The design and implementation of PlayPhysics are also discussed in this chapter.

This chapter focuses mainly on the analysis, design and implementation of an emotional student model using contextual and feasible variables related to students’ observable behavior for game-based learning. The approach employed is Cognitive-Based Affective User Modeling (CB-AUM), which involves employing the Control-Value Theory (Pekrun et al., 2007) as a basis. Control-Value Theory has not been employed previously for implementing an emotional and computational student model. As part of our research methodology, we employ Probabilistic Relational Models (PRMs) to facilitate the derivation of Dynamic Bayesian Networks (DBNs) (Sucar & Noguez, 2008).

DBNs enable us to handle uncertainty and incorporate previous domain knowledge (Jensen & Nielsen, 2007). Multinomial Logistic Regression (MLR) was employed to select the most significant regressors (Kinnear & Gray, 2010) and cross-tabulation was employed for setting the probabilities in the Conditional Probability Tables (CPTs) in previous work, where we ob-