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Detecting students' perception style by using games

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ABSTRACT

Knowing students' learning styles allows us to improve their experience in an educational environment. Particularly, the perception style is one of the most important dimensions of the learning styles since it describes the way students perceive the world as well as the kind of learning content they prefer. Several approaches to detect students' perception style according to Felder's model have been proposed. However, these approaches exhibit several limitations that make their implementation difficult. Thus, we propose a novel approach to detect the perception style of a student by analyzing his/her interaction with games, namely puzzle games. To carry out this detection, we track how students play a puzzle game and extract information about this interaction. Then, we train a Naive Bayes Classifier to infer the students' perception style by using the information extracted. We have evaluated our proposed approach with 47 Computer Engineering students. Experimental results showed that the perception style was successfully predicted through the use of games, with an accuracy of 85%. Finally, we conclude that games are a promising environment where the students' perception style can be detected.

1. Introduction

Students learn in many ways (Felder & Silverman, 1988); they acquire and process information on the basis of their learning styles. A learning style model classifies students according to where they fit into a number of scales related to the ways in which they receive and process information.

Identification of students' learning styles makes it possible to (a) personalize the way the information is presented to them (Alkhuraiji, Cheetham, & Bamasak, 2011; Li, Lau, & Dharmendran, 2010), (b) improve group performance (Alfonseca, Carro, Martín, Ortigosa, & Paredes, 2006), or (c) assist them during Web-based courses (Schiaffino, Garcia, & Amandi, 2008). A number of learning style models and frameworks have been proposed (Jung, 1971; Kolb, 1984; Myers & McCaulley, 1985). One of them is Felder's model, proposed by Felder and Silverman (Felder & Brent, 2005; Felder & Silverman, 1988). This model has been widely studied and applied, especially in engineering education. It is also most appropriate for Web-based courses and in research related to learning styles in advanced learning technologies (Carver, Howard, & Lane, 1999).

Felder's model comprises four dimensions: perception, input, processing and understanding, each defining two opposite learning styles. In this work, we focus on the detection of the students' perception learning style (perception style for short) from Felder's model (Felder & Silverman, 1988). The dimension of perception distinguishes between sensitive and intuitive students. Sensitive students like facts, data and experimentation and are patient with detail. In contrast, intuitive students prefer principles and theories and welcome complications. In summary, this dimension responds to the question: what type of information does the student preferably perceive: sensory (external) sights, sounds, physical sensations, or intuitive (internal) possibilities, insights, hunches?

We focus on the perception style for being the most important learning style dimension according to the literature (Felder, Felder, & Dietz, 2002; McCaulley, 1990). Particularly, this style is important because it is correlated with career preferences and aptitudes, management styles, learning styles, and various behavioral tendencies (Felder & Silverman, 1988). Thus, identification of students' perception style (a) allows professors to improve their teaching style, for instance, they can strike a balance between concrete information (facts, data, real or hypothetical experiments and their results) and abstract concepts (principles, theories, mathematical models) (Coffield, Moseley,

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Hall, & Ecclestone, 2004; Felder, 2010); (b) allows students to understand how their learning process works, thus, they may become more comfortable with this process, less critical of themselves for having it, and more positive about education in general (Felder & Silverman, 1988); and (c) allows educational environments to personalize the reading material and adapt course content to students' perception style (Alkhuraiji et al., 2011; Carver et al., 1999; Cha, Kim, Lee, & Yoon, 2006, pp. 513–524; Kolekar, Sanjeevi, & Bormane, 2010; Popescu, Badica, & Moraret, 2010).

Several approaches to detect the students' learning styles and, in particular, the perception style of the Felder's model, have been proposed. In general, these approaches track how the student interacts in an educational environment (Web-based courses, online courses, etc.) and extract some information about this interaction (Crockett, Latham, Mclean, Bandar, & O'Shea, 2011; García, Amandi, Schiaffino, & Campo, 2007; Graf & Kinshuk, 2010; Graf, Kinshuk, & Liu, 2009; Hj Ahmad & Shamsuddin, 2010; Özpolat & Akar, 2009; Villaverde, Godoy, & Amandi, 2006) such as type of reading material preferred (abstract or concrete), exam results, kind of participation in chats and forums, and time devoted to exam revision. Thus, these approaches categorize students on the basis of their perception style by considering the information extracted mentioned above. The automatic detection of learning styles has several advantages over traditional approaches (questionnaires). Since information is gathered from the students' interaction with the educational system, no supplementary amount of work - such as answering a questionnaire or providing explicit feedback about learning preferences – is required from the students. In addition, an automatic approach gathers information from a time span rather than from a specific point in time. Therefore, changes in the students' learning characteristics can be followed over time.

Although these approaches exhibit a certain degree of precision for detecting students' perception style, we observe some limitations in their application. Firstly, in order to address the different characteristics of the perception style, educational environments need to present a large amount of information available in multiple formats. For example, the content presented should balance concrete information, such as facts and data, with abstract concepts and theory. Moreover, educational environments should provide a large number of exercises so that students' may perform repetitive tasks and at the same time promote innovative thinking. As we will explain in Section 3.1, puzzle games incorporate, from their inception, most aspects of the perception style by supporting students with different preferences.

Secondly, students are not usually motivated to use educational environments because the information presented disregards their learning styles from the beginning of the interaction. Since personalization of the educational environment is a key factor to motivate students and improve their learning experience (Ley & Young, 2001; Papanikolaou, Grigoriadou, Kornilakis, & Magoulas, 2003; Popescu et al., 2010; Schiaffino et al., 2008; Verpoorten, Glahn, Kravcik, Ternier, & Specht, 2009), we consider it essential to identify students' perception style before they start to interact with the educational environment. In this context, games can help to solve this problem, avoiding students' initial frustration.

Finally, previous works have demonstrated that students' inexperience at work with Web-based courses modifies their behavior and makes learning style detection difficult (García et al., 2007). In this respect, we think that students are less likely to exhibit changes in behavior while playing games since games do not require previous experience: students learn to play the game by playing it (Prensky, 2001).

For this reason, the objective of this work is to present a new environment where students' perception style can be detected. We propose a novel approach to detect a student's perception style by analyzing how he/she interacts with games, namely puzzle games. We claim that the educational environment-based approaches present a number of limitations, which can be solved by using a game-based approach.

In the last years, games have been more and more used in education (Shih, Squire, & Lau, 2010; Sung, 2009). From an educational standpoint, games are engaging and adaptable to almost any subject. They can be particularly useful for teaching cause-and-effect relationships, and the lessons learned from games often tend to stay with students because of the interactive nature of the learning experience (Consortium, 2005). Also, because playing is not perceived as *working*, students may spend more time playing a game than they would reading related material or solving problems at the end of the chapter (Annetta, Minogue, Holmes, & Cheng, 2009). Furthermore, games improve students' motivation, since games are very popular among students nowadays (Prensky, 2003).

To carry out the detection of the perception style from games, we track how students play a puzzle game and extract information about this interaction (results obtained, time elapsed, total times played, level reached). Then, we define and train a Naive Bayes Classifier, which models different aspects of the student–game interaction in order for us to infer students' perception style. Notice that both the game- and educational environment-based approaches can coexist. Our approach focuses on the early detection of the perception style, that is, we focus on the detection when the student's perception style is completely unknown. In fact, it is in this early stage where the existing approaches show some limitations. However, after detecting the perception style, the educational environment can be personalized immediately, and the student's behavior can be monitored for style updating in case some change is detected.

The experimental results show that a high precision in the detection of the students' perception style can be obtained from little information. The experiments were carried out with 47 Computer Engineering students who played a puzzle game called *Equilibrium*. We obtained a precision of 85.1% in the detection of the students' perception style, which is higher than several approaches for perception style detection that track students in an educational environment.

The rest of the article is organized as follows. Section 2 introduces the background topics in the area of learning styles detection and also in games and education. Section 3 presents the approach to detect students' perception style by using games. In Section 4, the results extracted from the experiments are presented. Finally, in Section 5, we state our conclusions and suggest future work.

2. Background

In this section, we review two streams of research related to the learning style detection approach proposed in this paper. First, we present some current directions and related works in the area of learning style detection. Then, we analyze the benefits of using games in education, and we present a number of related works that support this idea.

2.1. Learning styles detection

Students acquire and process information in different ways depending on their learning styles. There are many learning style definitions, but one widely accepted by leading theorists is the one given in Keefe (1979, pp. 1–17) which states that: "[a learning style is] the composite