Adaptable and Adaptive Web-Based Educational Systems

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INTRODUCTION

Nowadays, the use of computers and Internet in education is on the increase. Web-based educational systems (WES) are now widely used to both provide support to distance learning and to complement the traditional teaching process in the classroom.

To be very useful in the classroom, one of the characteristics expected in a WES is the ability to be aware of students' behaviors so that it can take into account the level of knowledge and preferences of the students in order to make reasonable recommendations (Hong, Kinshuk, He, Patel, & Jesshope, 2001).

The main goal of adaptation in educational systems is to guide the students through the course material in order to improve the effectiveness of the learning process.

Usually, when speaking of adaptive Web-based educational systems, we refer also to adaptable systems. Nevertheless, these terms are not really synonyms. Adaptable systems are abundant (Kobsa, 2004). In these systems, any adaptation is predefined and can be modified by the users before the execution of the system. In contrast, adaptive systems are still quite rare. In adaptive systems, any adaptation is dynamic which changes while the user is interacting with the system, depending on users' behaviors.

Nowadays, adaptable and adaptive systems recently gained strong popularity on the Web under the notion of *personalized systems*. A system can be adaptable and adaptive at the same time.

In educational context, adaptable systems include also those systems that allow the teacher to modify certain parameters and change the response that the system gives to the students.

In this situation, we claim that, in educational context, it is important to provide both types of personalization. On one hand, it is necessary to let teachers control the adaptation to students. On the other hand, due to a great diversity of interactions that take place in a WES, it is necessary to help teachers in the assessment of the students' actions by providing certain dynamic adaptation automatically performed by the system. In this article, we will present how we can obtain adaptable and adaptive systems. Next, we will briefly present how we combine both types of personalization in PDINAMET, a WES for Physics. Finally we will describe some future trends and conclusions.

BACKGROUND

To provide personalization, systems store the information needed in the so-called *models for adaptation.* These models contain information about users' characteristics and preferences (the so-called *user model*). Educational systems also need information about the domain that is being taught (the so-called *domain model*) and the pedagogical strategies that will be followed when guiding students (the so-called *pedagogical model*). The first systems in incorporating these models were the Intelligent Tutoring systems (Wenger, 1987).

These models usually make use of an attribute-value representation. The value of each attribute can be obtained directly from the users by means of initial questionnaires (for example, to acquire personal data). Other attributes can be directly obtained from the data that the system logs from the users' interaction (for example, number of course pages visited) (Gaudioso & Boticario, 2002). Neverthe-

less, certain attributes can neither be directly obtained from the user nor from the data logged, and they must be automatically inferred by the system.

Various methods can be used to infer these attributes (Kobsa, 2004). These methods include simple rules that predict user's characteristics or assign users to predetermined user groups with known characteristics when certain user actions are being observed (the so-called *profiles* or *stereotypes*).

The main disadvantage of the rule-based approach is that the rules (and the profiles) have to be pre-defined, and so all the process is very static. To make the process more dynamic, there exist other methods to obtain the value of those attributes (Kobsa, 2004). Probabilistic reasoning methods take uncertainty and evidences from users' characteristics and interaction data into account (Gertner, Conati, & VanLehn, 1998). Plan recognition methods aim at linking individual actions of users to presumable underlying plans and goals (Darío, Méndez, Jiménez, & Guzmán, 2004). Machine learning methods try to detect regularities in users' actions (and to use the learned patterns as a basis for predicting future actions) (Soller & Lesgold, 2003).

These systems can be considered adaptive since the adaptation is dynamic and it is not controlled by users. For example, once a rule is defined, it usually cannot be modified. Another review (Brusilovsky & Peylo, 2003) differentiates between adaptive and intelligent WES; authors consider adaptive systems as those that attempt to be different for different students and groups of students by taking into account information accumulated in the individual's or group's student models. On the other hand, they consider intelligent systems as those that apply techniques from the field of artificial intelligence to provide broader and better support for the users of WES. In many cases, Web-based adaptive educational systems fall into the two categories. According to our classification, both adaptive and intelligent systems can be considered as adaptive. We think that our classification is more appropriate from a user's point of view. A user does not usually first care about how the adaptation is being done but if she or he can modify this adaptation. A complete description of the personalization process (distinguishing between adaptive and adaptable systems) can be found at Kobsa, Koenemann, and Pohl (2001) and Oppermann, Rashev, and Kinshuk (1997).

As mentioned earlier, in the educational domain, it is necessary to let teachers control the personalization process. Thus it seems necessary to combine capabilities of both adaptive and adaptable systems.

A HYBRID APPROACH TO WEB-BASED EDUCATIONAL SYSTEMS

In this section, we present PDINAMET, a system that provides both types of personalization.

PDINAMET is a Web-based adaptive and adaptable educational system directed to the teaching of dynamics within the area of the physics. In PDINAMET, we maintain three types of models: student model, domain model, and pedagogical model.

Besides personal data, the student model contains information about the students' understanding of the domain. The domain model includes information about the contents that should be taught. Finally, pedagogical model includes information about instructional strategies.

In PDINAMET, we consider an *adaptation task* as any support provided by the system to learners and teachers taking into account learners' personal characteristics and knowledge level. In PDINAMET, two types of adaptation tasks are considered: *static* (that makes PDINAMET adaptable) and *dynamic* (that makes PDINAMET adaptive). Static adaptation tasks are those based on predefined rules. These include assigning students to pre-defined profiles (that can be modified by teachers) in which PDINAMET based certain recommendations (e.g., recommend a suitable exercise). To come up from the lack of coverage of pre-defined rules for every situation that could arise during the course, some dynamic tasks are performed in PDINAMET. These tasks include: diagnosis of student models, intelligent analysis of students' interactions, and recommend instructional strategies (Montero & Gaudioso, 2005).

FUTURE TRENDS

We have seen that teachers should have access to the models in order to inspect or modify them. From this point of view, an open question is how and when we should present the models to a teacher in a