Adaptivity In E-learning Systems

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Abstract

This paper aims to give a short review of adaptivity in e-learning systems and the work done in this field. The review is mainly focused on the different parameters we can use to make an e-learning system adaptive. Some adaptive e-learning systems are shortly described, highlighting the student characteristics the system adapts to. Deciding the parameter or parameters the system will adapt to, is the first step in designing an adaptive e-learning system, which is the final goal of the future work that can be done, discussed in the conclusions section. The final system will be used in education, as a helpful system to come to student needs, and increase their learning performance and motivation.

1 Introduction

Nowadays, e-learning is a widely discussed topic, and many e-learning systems have been developed so far. However, traditional e-learning systems tend to neglect the diversity of learners, their abilities, their knowledge and skills, and the learning context [J14]. The lack of adaptive learning environments or an environment with adaptive features is partly due to the concept one-size-fits-all.Very often, e-learning courses have a problem of universal size as the same static content is presented to all students. Adaptive e-learning systems are the new trend in e-learning systems.Their ultimate goal is to personalize learning material and their sequences to match the needs of an individual learner as closely as possible. These systems integrate learner characteristics such as learning style, affective state and knowledge level to provide personalized services and recommend relevant instructional material [Bru01]. Jameson describes an adaptive system as an interactive system that adapts its behaviour to individual users on the basis of processes of user model acquisition and application that involve some form of learning, inference, or decision making [Jameson 2009].

Research has shown that the application of adaptation or personalization can provide a better learning environment since learners perceive and process information in very different ways. So, the adaptive educational systems are an alternative to the traditional teaching; they can be considered to be the next generation of e-learning [Per08].

Before designing an adaptive e-learning system, one of the main challenges is to identify which learner needs or characteristics should be made adaptive. Researchers have suggested different approaches, and some adaptive e-learning systems are designed. In this paper, a short review of adaptivity parameters is described, and then some adaptive systems are mentioned, highlighting the adaptivity parameter they use. Adaptive models are analyzed further, being a central part of designing an adaptive system. The paper closes with a conclusion and future work.

2 Adaptivity parameters

A system that automatically adapts to the student, based on its assumption about the student, is referred to as an adaptive system [itk15]. In other words, the system cannot be called adaptive if it is not flexible to specific students needs. This leads to the fact, that deciding which student feature or characteristic to make adaptive, in order to come more closely to students needs, while building this adaptive e-learning system, is one of the key decisions, and one of the main factors to indicate its success. In the past decade, various adaptive learning systems have been developed based on different parameters that represent the characteristics or preferences of students as well as the attributes of learning content [Wan11]. Based on a review done with various systems built, we are going to overview

some of the main parameters used.

2.1 Adaptation To Student Knowledge

One common example of adaptation in an e-learning system is the adaptation of the learning materials, content presentation according the knowledge of the student in the subject area. The main idea is that for an advanced student, the system can provide a brief summary of the material and hyperlinks to the more detailed description of it. In the case of a learner who has little knowledge on the field, the system can provide more detailed information in a smooth logical flow [Puu05]. One system that uses this method is ELM-ART. It is an adaptive e-learning system used to learn Lisp programming. It was one of the first and most influential adaptive e-learning systems [P01], so much so that its last version, of 2001, remains in use until today to learn Lisp programming. It adapts learning material according to each learners knowledge level. [Bru15]. SQL-Tutor, another example, is an intelligent tutoring system that personalizes SQL learning concepts according to the individuals knowledge level. It selects some questions in basis of learners model, then it adapts the model based on the answers validity [Hau04].

2.2 Adaptation To Learning Styles

This method of adaptation is based on the idea that a student can learn more efficiently given the material according to his learning style. Different people have different learning styles. Researchers have proposed different learning style theories or models. Some of them are: The Felder-SilverMan model, the Dunn and Dunn Model, the Kolb Model, the Witkin Model etc. The model which has been recognized from many researchers as highly suitable for adaptive e-learning systems is the Felder-Silverman model. This model categorizes ways students process information based on these groups: sensory and intuitive, visual and auditory, inductive and deductive, reflective and active, generally and sequential. Based on each group, the appropriate teaching method is used for each particular student. There have been a number of adaptive e-learning systems built, using this approach, as described in the figure 1

It has been argued that if a learner has a strong affinity for a particular learning style, the learning material and strategies should match this style to enhance learning [K02].

2.3 Adaptation To Cognitive Abilities

According to [Riding and Rayner, 1998] Cognitive Style (CS) refers to an individuals method of processing information. Cognitive abilities are mecha-

Name	Description
CS383	Based on the Felder-Silverman learning style model, computer systems course
TANGOW	Combines sensory-intuitive and sequential-global learning style dimensions of Felder-Silverman model
eTeacher	Uses an intelligent human agent and dynamic learner modeling of learning style
iWeaver	Adapts learning concepts related to Java programming according to a learning style
LearnFit	Adapts learning material for PHP programming based on learning style

Figure 1: Learning styles adaptive systems [P99] [P04] [Sch08] [iWe03] [Bac11] [K02]

nisms that allow humans to acquire and recognize pieces of information, to convert them into representations, then into knowledge, and finally to use them for the generation of simple to complex behaviors [Sot08]. There are four cognitive abilities: working memory capacity, inductive reasoning ability, associative learning ability, and speed of information processing. Research has suggested that cognitive abilities along with learning styles are very important factors for learning efficiency, so it should be considered in designing adaptive systems. AES-CS system is an intelligent system that recommends relevant learning material based on the Witkin model of cognitive style: field dependence and field independence.

2.4 Adaptation To Learning Behavior And Motivation

Tracing learners behavior in real time is a quite challenging task. In her work, [Conati, 2002] address the problem of how an interactive system can monitor the users emotional state using multiple direct indicators of emotional arousal. Detection of users body expressions requires special sensors. The system was applied on computer-based educational games instead of more traditional computer-based tutors, as the former tend to generate a much higher level of students emotional engagement.

Another approach used is real time eye tracking. In [Gutl et al., 2005] the authors introduced the Adaptive e-Learning with Eye-Tracking System, a system that utilizes a monitor mounted camera that records the eye of the participant and trace the gaze in a scene through imaging algorithms. Real- time information of the precise position of gaze and of pupil diameter can be used for assessing users interest, attention, tiredness etc [Geo10].

3 Adapting To Multiple Methods

There is also a number of adaptive e-learning systems that integrate both learning style and knowledge level as learner characteristics that drive adaptation:For example, MASPLANG is one of the pioneers, combining both learning style based on the Felder-Silverman model and knowledge level to adapt learning material related to a computer networking course. One recent example of a successful system is Protus, an adaptive e-learning system based on learning style and knowledge level that recommends relevant learning material for teaching the Java programming language [Mil11].

Although there are different adaptation techniques for e-learning systems, the common idea for them all is that each student must learn the way he prefers, the adaptation must be done frequently, no one should continue to learn something that is completely learned successfully, and each student must be presented with different information of a certain subject until he has learned it successfully.

4 Adaptive Models

Adaptive models represent an important research area. They can be used to form the design and development of adaptive e-learning systems, taking into account their main components. Mainly adaptive models answer these three questions: what can we adapt (domain model), to what we can adapt (student model), and how can we adapt (adaptation model). One popular approach is the Dexter Hypertext Reference Model, which can be used as a logical foundation for designing and comparing different adaptive systems. The model consists of three layers including a run-time layer, a storage layer and a within-components layer.The storage layer refers to how contents are connected and stored in a database. The run-time layer deals with the representation of user interaction and hypertext. The within components layer deals with the content and structure of components within a hypertext network. The Dexter model has influenced the design of many interactive web-based systems [Hal94]. An extension of the Dexter model was developed to support adaptively, called the Adaptive Hypermedia Application Model (AHAM) [Bra99]. AHAM enhanced the storage layer of the Dexter model by adding three submodels including a domain model, a user model and an adaptation model.

4.1 Domain model

A domain model is an abstract representation of part of the real world. It is composed of a set of domain knowledge elements and is the result of capturing and structuring knowledge related to a specific domain. The content of domain models are those that are adapted to the different needs of learners in adaptive e-learning systems. Learning objects are usually organized and annotated using metadata in order to describe, sequence, store and manipulate them. For example, Sun, Joy and Griffiths have proposed a novel mechanism to categorize learning objects according to the Felder-Silverman learning style model in order to dynamically provide relevant learning objects to each learner according to their learning style preferences [Gri07]. They proposed a multi-agent system which stores each students current learning style and the style attributes of each learning object. Initially, the student style is set based on Felder-Silverman questionnaire to determine students style. Each learning object is also categorized based on the learning styles. The system searches the repository of learning objects, and fetches the appropriate learning object based on the student learning style. The Learning Object Agent is responsible to provides relevant learning objects for students with different learning styles.

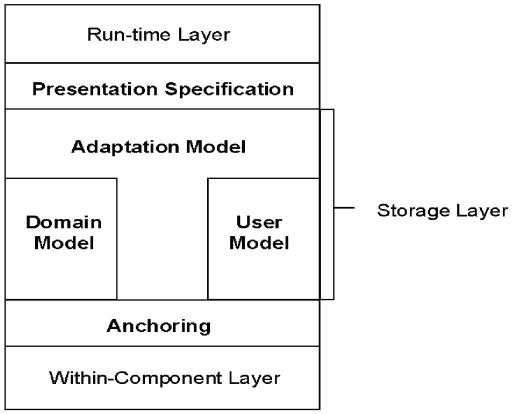

Figure 2: AHAM Model [Bra99]

4.2 Student model

In the area of the Web systems the user models have the task to manipulate information that refer to the knowledge of a user in a specific domain, to his/her personality, his/her preferences, or to any other information that can be useful in the customization of an application. The student model stores information that is specific to each individual learner: it concerns how and what the student learns or his/her errors, and the student model plays a main role in planning the training path, supplying information to the pedagogical module of the system. This component provides a pattern of the educational process, using the student model in order to decide the instruction method that reflects the different needs of each student [Lic04].

Figure 3 provides an abstract representation of the student model and its content.

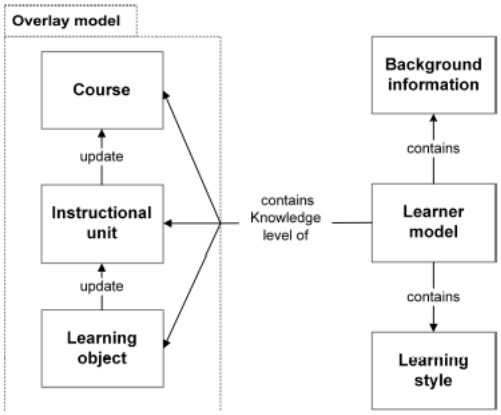

Figure 3: An abstract represantation of the student model [Alshamari 2016]

User (learner) modeling involves different stages such as data elicitation, model representation and maintenance. Data elicitation is usually based on explicit methods via user generated feedback (such as questionnaires, like/dislike and rating) or implicit methods, which consider system generated feedback (such as mouse movements, time spent and page visits). Although explicit methods are considered more reliable and more accurate, learners may be reluctant to provide explicit feedback. In contrast, implicit methods allow learners to focus entirely on their main task. A large amount of data can be captured through an implicit method [Lic04]. In many learning systems, learners are allowed to interact and update their own learning model. Students model is updated either on the basis of test performance or a student can himself update by marking concepts known to him. Learner modeling is done on two different time scales: long term and short term modeling . The long term modeling attempts to model those aspects of a learner that are not expected to change too dynamically. The short-term modeling is also being performed in two ways: indirectly and directly. Indirect short term modeling includes counting the number of times a learner reviews a learning object, measuring the total time taken to complete the topic. Direct short-term modeling is carried out by assessment on questionnaires that evaluates the learner performance as a skill level. More complicated techniques, such as Bayesian belief networks can be effectively used to construct student models. Several researchers have explored the use of Bayesian belief networks to represent student models [Gre04].

4.3 Adaptation model

An adaptation model bridges the gap between the learner model and the domain model by matching relevant learning material, or sequence of objects, to the needs and characteristics of an individual learner [Lic04]. The adaptation model is strongly related to the student model. According to student model, it adapts and recommends relevant learning material. Based on the design of the system, the adaptation model can adapt using short memory cycle, or long memory cycle. In the first case, the adaptation is done based on recent information about the user; for example after completing a test. In the second case, the system takes into account historical information in addition to recent one, to make the adaptation. The adaptation model can incorporate different adaptive methods and techniques to support adaptation. They can be included in these categories: adaptive navigation, adaptive content, adaptive presentation.

4.3.1 Adaptive Navigation

Adaptive navigation recommends selective learning paths or curriculum sequencing. Other examples include link generation, direct guidance and link hiding.

4.3.2 Adaptive Content

The idea behind this technique is that the system can choose from the learning material the most appropriate fragment of content based on the user model.

4.3.3 Adaptive presentation

Adaptive presentation is related to zooming, scaling and layout-changing techniques. Another classic adaptive navigation technique is personalized learning paths. This generates different learning paths for learners based on their preferences, learning style or knowledge level [J14].

5 Conclusions

Designing an adaptive e-learning system is still an up to date topic. Although researchers have proposed different models, they are mainly experimental, and very few have become commercial or really used. Another challenge is integrating these systems with our educational system, especially in universities. Students are faced with a large amount of material to study, and often they dont know how to filter it, and lack motivation for studying. An adaptive e-learning system can be a helpful, being in the role of the personal tutor for them. They can also be aware of their knowledge or expertise of a field, and have a clear idea about their personal level, every time. There are many challenges for this idea, the right methods and strategies

to meet student needs should be applied. This paper has given a shortly review of these adaptive systems, ways we can make it adaptive, and main components of an adaptive system. In the future, the aim is to design a convenient system to be applied at universities, which will facilitate students and pedagogues work.

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