An Adaptive Mobile System Based on the Felder-Silverman Learning Styles Model

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Abstract—Mobile technologies are invading everyday life. Their use has extended to areas and aspects of life that we did not necessarily imagine before. That being said, all efforts have been pooled recently in order to extend its use to educational applications and above all to exploit its potential in order to guarantee the most optimal learning process possible. Learners tend to consult teaching content in their mobile devices even if the learning objects are not necessarily designed for this specific environment. So it has become essential to adapt to this rapid technological evolution and to design learning systems that take into consideration this new dimension, hence the need to add this new pole in adaptive learning systems. This paper introduces an adaptive learning system designed for mobile devices. The system which is an extension of some previous works in the adaptive learning systems area is based on the learning styles as defined by Felder and Silverman and an adaptive model that provides the learning objects based on the recommendations of a specific instructional model, using mainly a Bayesian Network. The developed architecture takes into consideration the context constraint related to the technical part of the mobile device, which leads ultimately to a novel adaptive learning system designed exclusively to run in mobile environments.

Keywords—adaptive learning system, context awareness learning, mobile learning, learning styles, Bayesian network

1 Introduction

The last few years have seen a very pronounced enthusiasm on the part of researchers around adaptive learning systems (ALS) [1],[2]. These systems are intended to personalize the learning process according to specific needs, previously expressed in the adaptive model. Most ALS focus on the learning profile which is designed according to a specific learning styles model and sometimes also the prerequisites, in order to provide an adequate learning path for any learning profile.

Meanwhile, mobile technology is experiencing an unprecedented booming and is being used in several areas. We are thus witnessing a new way of using technology which is also part of the paradigm "A society on the move". People with their devices

are constantly on the move; Applications must necessarily meet this need for mobility, and therefore the services covered by mobile applications reach all areas including online education.

Thus e-learning is not always taking place using only computers; it has even extended to tablets, cell phones and smartphones. These devices have battery and connectivity requirements, which raises the question of how far can we utilize its assets when it comes to managing and transferring knowledge? Therefore, pooling efforts and leveraging the strengths of ALS and mobile environments was inevitable in this era and it was only a matter of time before we started to see the emergence of this new class of e-learning systems [3],[4],[5],[6],[7].

Thus in this work we present a novel architecture of an ALS that runs exclusively in mobile environment. This architecture is an extension of some previous works [8], [9], [10], [11], [12] and [13]. The main objective is to develop an adaptive mobile system, able to provide learning objects based on the learning styles of Felder and Silverman and a prerequisites test. It should be noted that working on ALS that operate with the Felder-Silverman learning styles in a mobile environment will lead to some conflicts regarding the recommendation of learning objects, and this will be fully discussed in this paper. Having said that, this paper is structured into 6 sections:

In section 2 we will discuss the relevance of the ALS in general, and putting the focus mainly on the developed system called ALS_CORR [LP] [11]. Section 3 will be dedicated to the introduction of the context awareness learning and focusing primarily on the mobile dimension. Section 4 will present the architecture of the new system operating in a mobile environment and also discussing any conflicts that may arise due to the nature of learning objects. Then in Section 5 we will discuss the result of the study conducted in this paper. In the final section we will draw some conclusions.

2 Adaptive learning systems

Adaptive hypermedia systems (AHS) are able to adapt content based on user profiles. ALS remains the most popular ones among the (AHS). Also known as adaptive teaching, tutoring, training systems or e-learning. These systems are essentially based on data collection about the learners profile in order to offer appropriate teaching content. The logic of these systems is based on the fact that the learning system will necessarily be used by learners with heterogeneous profiles, and therefore the personalization is ensured in order to guarantee an optimal learning experience. This is possible by watching and detecting the behavior of students during the whole process, in order to generate the most relevant learning path. ELM-ART system which teaches the LISP programming language [7] remains one of the most successful systems. When it comes to personalization of the learning path, the research work carried out in [9], [10], [11], [12], [13] and [14] had shown that the ALS function according to one of the next operating methods:

There are systems that use so-called implicit methods to collect learner profile information in order to guarantee the content adaptation [15], [16].

There is also a second category of systems that provide adaptation through the use of information-gathering methods. These systems use some explicit methods [17], [18] and [19] by offering the learner some forms in which he must express his preferences in terms of the most suitable learning object.

In this paper, we will be based on the architecture developed in the ALS_CORR [LP] system [12], [13]. This system uses both an implicit and explicit methods to generate learning path, with an architecture that is articulated around 4 essential components namely: A learning model designed according to the FSLSM as well as a test of prerequisites. The second model is the domain model which is containing the SCORM standard [20] of learning object (LO) designed according the recommendations of the instruction model [22]. Finally there is the adaptation model responsible for ensuring adaptation based on a Bayesian network, that compute the adequacy of a (LO) to the characteristics expressed in the learner profile.

3 Context awareness learning

Taking context parameters into account in interactive computer applications is the new trend, especially for applications whose context is constantly changing. To comprehend the ins and outs of the context and to better facilitate the creation of applications, it is essential to understand the components of an application as well as the requirements of the context.

Several definitions circulate around the notion of context, the most relevant is the one adopted by [23], which emphasizes the fact that a context represents all the information that characterizes a situation, it could be an object (person or even place) and it has to be pertinent for the communication between an application and its user.
According to the work of Albrecht Schmidt, the following model, which concerns the perception of the context, describes the perception process from the user and the application perspective. If they are not alike, then we are creating systems with lack of cohesion regarding the awareness dimension, and therefore the behavior of the system becomes disappointing to users' expectations.

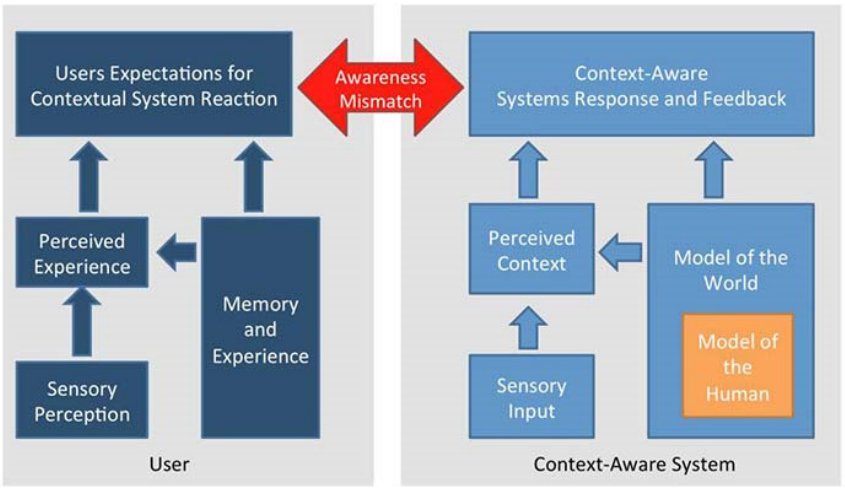

Fig. 1. The user-context perception model (UCPM)

When it comes to learning systems, the context highlights 4 important elements described in the following figure:

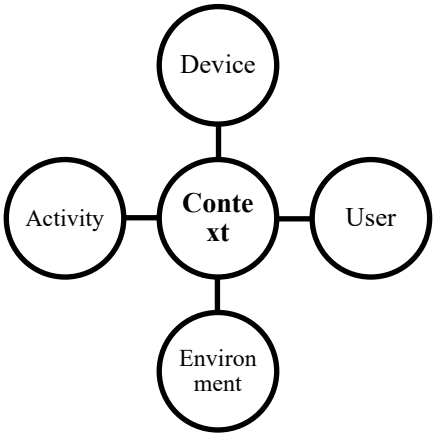

Fig. 2. Elements involved in the context process

As described in the figure above, the context is based around 4 key elements: User, device, Environment and Activity. The following table elucidates the main attributes of each element.

Table 1. The main attributes of each context element

Context element	User	Device	Environment	Activity
Attributes	-Personal info (name, age, etc.) -FSLS Profile -Prerequites	-Battery -Connectivity	-Localization -Mobility	-LO -LO versions -Objective

4 Building the adaptive mobile system

The developed architecture of the ALS that takes into consideration the context-related parameters is based around 5 key elements: The domain model (DM), the learner model (LM), the pedagogical model (PM), the context model (CM) and finally the adaptive model (AM).

The LM contains the result of the FSLSM and the result of a requirement test. Meanwhile the PM provides the recommendation of the differentiated pedagogy which preconize designing numerous versions of the same LO. The DM covers the LO. The AM calculates the probability of adequacy between the LM, the DM and the CM, which by the way takes into consideration the requirement of the used device namely the Battery and the Connectivity. The figure below represents the elements involved in the new architecture:

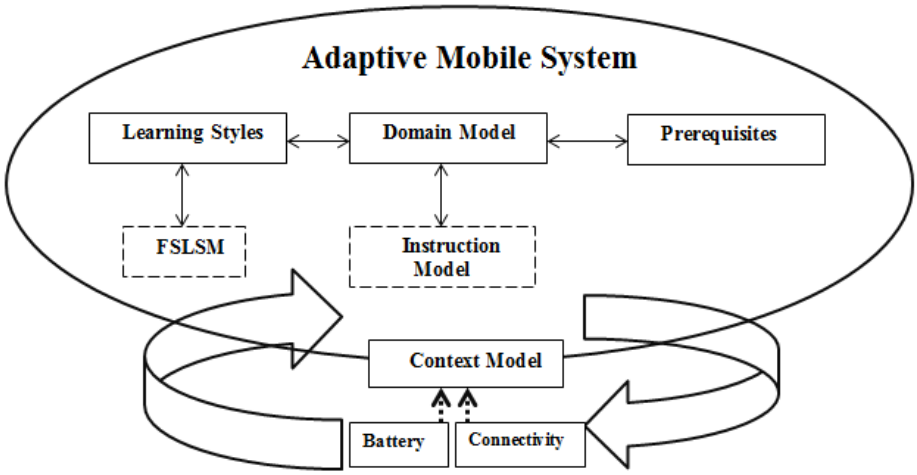

Fig. 3. Architecture of the system

4.1 The context model

The context model is responsible for data collection about the battery level and mainly the connectivity. The aim is to recommend learning object according to the state of the mobile device.

Since the learner model is expressing the preferences of the learning object according to the Felder-Silverman Learning style [20], there will be some major conflict regarding the use of the learning style in this specific context, therefore it is extremely important to highlight those conflicts. The following figure discusses the different conflict that might appear.

4.2 Conflicts study between the FSLSM and the constraint related to the Mobile context factor

The FSLSM is one of the best models that describe the appropriation of certain knowledge. Through the ILS index [24], it is possible to distinguish four dimensions related to learning. This model describes the learning process according to four dimensions regarding the input, the perception, the processing and finally the understanding of knowledge. Each dimension of the FSLSM favors a specific learning object. The following table summarizes the correspondence between the FSLSM and the learning object with the requirement of the mobile device.

Table 2. The correspondence between learning styles and the elements of the mobile context

FSLSM dimension	Corresponding LO	Device Requirement	
		Battery	*Connectivity*
Active	Assessment, Exercises	Low	Low
Reflective	Examples, outlines, summaries, result, pages	High	High
Sensing	Examples and factual explanations	High	Low
Intuitive	Algorithms	Low	High
Visual	Images and animations, diagrams and videos	High	High
Verbal	Audio and Text	High	High
Sequential	Exercises and link pages	High	Low
Global	Summaries and Outlines,	Low	High

The learning objects described in the previous table lead us ultimately to essential questions: how much can we stick to the recommendation according to the learning style in a mobile environment? Should we be limited to the recommendation even when the battery and the connectivity are very low?

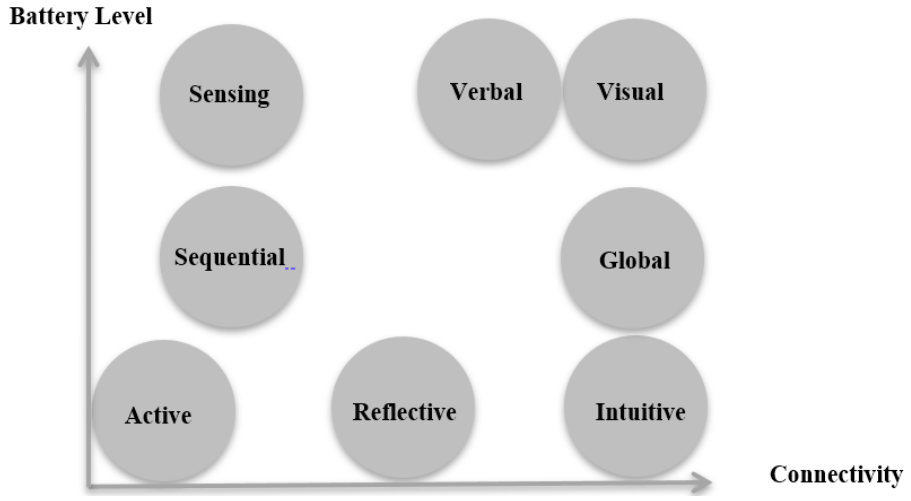

Fig. 4. Learning object recommendation according to the mobile device requirements

4.3 The adaptive model

The developed architecture is based on a BN. It is able to compute the probability that a LO corresponds to a particular learning style and level of prerequisites, without forgetting of course the requirements of the mobile environment.

The variables represented by nodes designating “concepts" while the relationships in the diagram represent the dependency between the concepts.

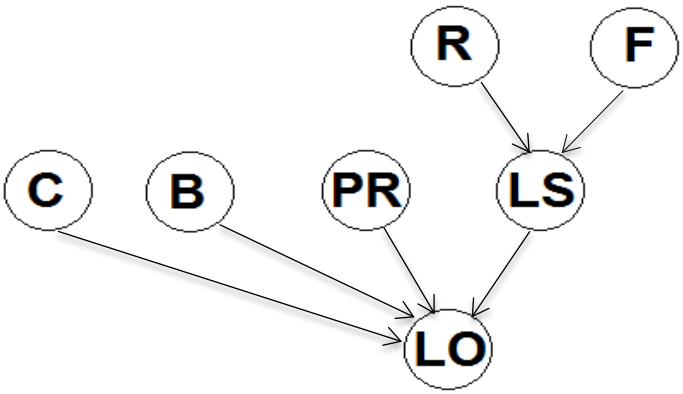

Fig. 5. The Bayesian network generating the learning object

The graphical model of the Bayesian network, which corresponds to the adaptation system running in the mobile environment, is defined as follows:

PB(C), PB(B), PB(PR) and PB(LS) represent the prior probabilities of the learning style and the prerequisites.

LO: Learning object

F: LO Format

R: LO resource = {Exercise, Example, Definition, Quiz}

PB: Prerequisite = {Low, Medium, High}

B: Battery= {High, Low}

C: Connectivity = {High, Low}

$$
\begin{aligned}
PB(LO,LS,PR,C,B,F,R) &= PB(LO|LS,PR,C,B,F,R).PB(LS,PR,C,B,F,R) \\
&= PB(LO|LS,PR,C,B,F,R).PB(LS|PR,C,B,F,R).PB(PR,C,B,F,R) \\
&= PB(LO|LS,PR,C,B,F,R).PB(LS|PR,C,B,F,R).PB(PR|C,B,F,R).PB(C,B,F,R) \\
&= PB(LO|LS,PR,C,B,F,R).PB(LS|PR,C,B,F,R).PB(PR|C,B,F,R).PB(C|B,F,R).PB(B,F,R) \\
&= PB(LO|LS,PR,C,B,F,R).PB(LS|PR,C,B,F,R).PB(PR|C,B,F,R).PB(C|B,F,R).PB(B|F,R).PB(F,R) \\
&= PB(LO|LS,PR,C,B,F,R).PB(LS|PR,C,B,F,R).PB(PR|C,B,F,R).PB(C|B,F,R).PB(B|F,R).PB(F|R).P(R) \\
&= PB(LO|LS,PR,C,B,F,R).PB(LS|F,R).PB(PR).PB(C).PB(B).PB(F).PB(R)
\end{aligned}
$$

Fig. 6. Matching probabilities using Bays law

5 Discussion

In the current work, we are ensuring the learning content adaptation according to the FSLSM and a prerequisite test. Adaptation of learning content is an essential and decisive element during the learning process, as many authors [1], [2] agreed that learners whose learning styles are not supported by the learning environment might face many challenges during the learning process if their preferred LS are not reinforced by the teaching environment. With the current technological change of using mobile technologies, it was necessary to migrate to this technology learning wise. The question we tried to answer was how well we can adapt the learning object according to FSLSM in a mobile environment.

Obviously, the learning object recommendation according to the Felder-Silverman learning styles in a mobile context has some limitations as it was shown in Table 2, because among the dimensions that Felder and Silverman insist on is the Visual / Verbal dimension. Both of them require a highly charged battery and a fast connectivity. Which allow us to deduce that the adaptation according to Felder-Silverman learning styles in those environments cannot always take place since we are jeopardizing the device operation.

6 Conclusion

Through this paper we presented architecture of an ALS operating with the FSLSM that runs in a mobile environment. The developed architecture has shown that some conflicts may appear while recommending the learning object, those conflicts are due to the requirement of the mobile device namely the battery and the connectivity, since FSLSM put the focus on the Learning Object format in the Visual / verbal dimension. The next step is to implement the new BN in the System ALS_CORR [LP] and test its behavior during a learning process which takes place in a mobile device.

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