Adaptivity and Personalization in Mobile Learning

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Mobile educational systems have started to emerge as potential educational environments supporting life-long learning. However, these environments still suffer from various technological and access related problems in many parts of the world. For example, the access to course materials is slow; courseware does not adapt to individual students; the real time interaction between student and the environment is hard to achieve because of the connection unreliability and bandwidth limitations. There is also a lack of pedagogical infrastructure for mobile learning. This paper focuses on the adaptive approaches for individual learners through the use of mobile technology. Various aspects of the research are discussed that aim to exploit the benefits of location, device and learner modelling, and combine them with mobile technology to achieve personalized delivery of multimedia-rich learning objects: anywhere and anytime.

Introduction

In the mobile learning environment, the learners could receive the learning materials provided by system according to where they are when learning in the mobile learning environment (Chang & Chang, 2006; Chen, Kao, Yu, & Sheu, 2004). Mobile learning strategy can actually achieve the goal, that is, learning at anytime and anywhere. Ubiquitous learning is becoming an interesting and important issue in informal learning field recently (Syvanen, Beale, Sharples, Ahonen, & Lonsdale, 2005), focusing on enabling learners learn with their topics of interest transparently and immediately using various devices whenever and wherever they want.

Generally speaking, the personalization can be achieved via two adaptive approaches: (1) the learning service can adapt to learners' characteristics such as learning styles, requirements, status, performances, preferences, and profiles; and (2) the learning service can adapt to the context surrounding the learners. The first approach is easy to understand, for example, the learning service can deliver multimedia materials to learners with a visual learning style or provide step-by-step instructions to the learner who has difficulty in solving specific problems. The second approach applies context-awareness ability to the learning service, for example, it will probably be useless for a learning service to deliver botanical materials to the learner who is inside an art gallery.

This paper discusses two solutions based on the abovementioned adaptive approaches for realizing personalization in mobile learning. One solution uses learners' characteristics such as their learning styles to provide learners with personalized learning experiences. The other solution uses context-awareness knowledge structure to generate personalized learning activities for learners according to the learning objects and relevant domain knowledge that exist in the surroundings of the learners.

Section 2 introduces the past research works related to the two solutions and identifies the gap in the research that our solutions attempt to fill. Section 3 describes the personalized mobile learning solution which adapts to the learners, viz. learning style. In Section 4, we discuss how to use context-awareness knowledge structure to generate different learning activities for learners in different environment, for example, in a museum. Section 5 provides a conclusion and discusses the possible future visions.

Research Background

In traditional learning environment, the education process take place in classroom, where teachers and learners meet face to face at the same time and in the same place. The learners typically only get the learning materials prepared in advance by the teacher. As a result, the learning activities are limited in what teacher arranged and consequently it is rather difficult to adapt the learning materials to individual learner's learning requirements and demands.

E-learning, on the other hand applies computer technologies and Internet to assist teachers' teaching and learners' learning (Brodersen, Christensen, Dindler, Grønbæk, & Sundararajah, 2005). A mix of e-mail, learning management system, web-camera and other online tools are used in e-learning in order to facilitate learning without requiring the teacher and learners to be present at one location (Martin, 1994). However, both traditional classroom based learning and e-learning do not cater for those courses where authentic learning demands observation in real environment, for examples, butterfly watching and plant observation in a biology course (Chang & Chang, 2006; Chen, Kao, Yu, & Sheu, 2004; Thornton, & Houser, 2004).

Mobile learning extends the learning from indoors to outdoors by giving learners opportunities to understand the learning materials through touch, observation and feel of the learning objects in real environment (Kuo, Wu, Chang, Chang, & Heh, 2007; Yatani, Sugimoto, & Kusunoki, 2004). Furthermore, mobile learning can also enable learners to apply what they have learned in real environment (Darmarin, 1993). Mobile learning therefore adds a new learning strategy to the e-learning; however, the issue of flexible learning still remains. Without the consideration of adaptivity towards individual learners and their surrounding environment, and implementation of such adaptivity in real-time, the learning activities remain limited to specific learning environment where the specific domain knowledge has been arranged (generally by the teacher) in advance.

It is important to recognize that the learners are not just passive receivers of the learning materials from teachers during learning. They have the abilities to learn the concepts, knowledge and skills by interacting with real-life objects in their surrounding environment (Vygotsky, 1978). Brown, Colins, & DuGuid (1989) argue that the concepts and knowledge are situation-based, and the learning is influenced by a combination of teaching activity, situation and interactions, called situated learning. The research in ubiquitous/pervasive learning aims to exploit this dimension (Thomas, 2005).

Adaptive Learning considering Students' Characteristics

In this section, we introduce an adaptive mobile learning environment, which offers many services for students to learn anytime and anywhere, using the advantages of mobile learning. Figure 1 illustrates the architecture of the environment.

A fundamental design consideration is to use the multi-agent system (MAS) paradigm to seamlessly integrate and deploy software components, devices, learners, educational services, and situations to form mobile learning communities and facilitate collaborative problem solving. Another important design consideration is to have a global student model and several student modelling agents which capture specific information about the learners, such as learning styles, location, context, behaviors, actions, and performance. The student modelling agents are responsible for gathering the required data from the respective services and making the information accessible for all services. The services themselves are responsible for providing learners with an adaptive and mobile learning environment. The location-awareness service is used to help mobile students forming face-to-face learning groups. Moreover, social networking issues are considered and integrated in the infrastructure. An adaptive mechanism is included, which is responsible for providing learners with learning materials that fit to their individual learning styles. The context-awareness service identifies the personalized context-aware knowledge structure and directs individual students to learn and move in the real world using automatically generated guidance messages. Furthermore, students are supported by an intelligent and multimodal asynchronous Q&A knowledge sharing platform. Another service deals with providing effective integration of problem based learning in the adaptive and mobile learning environment. Moreover, different multimedia inputs are considered for providing a richer source of interaction in mobile learning.

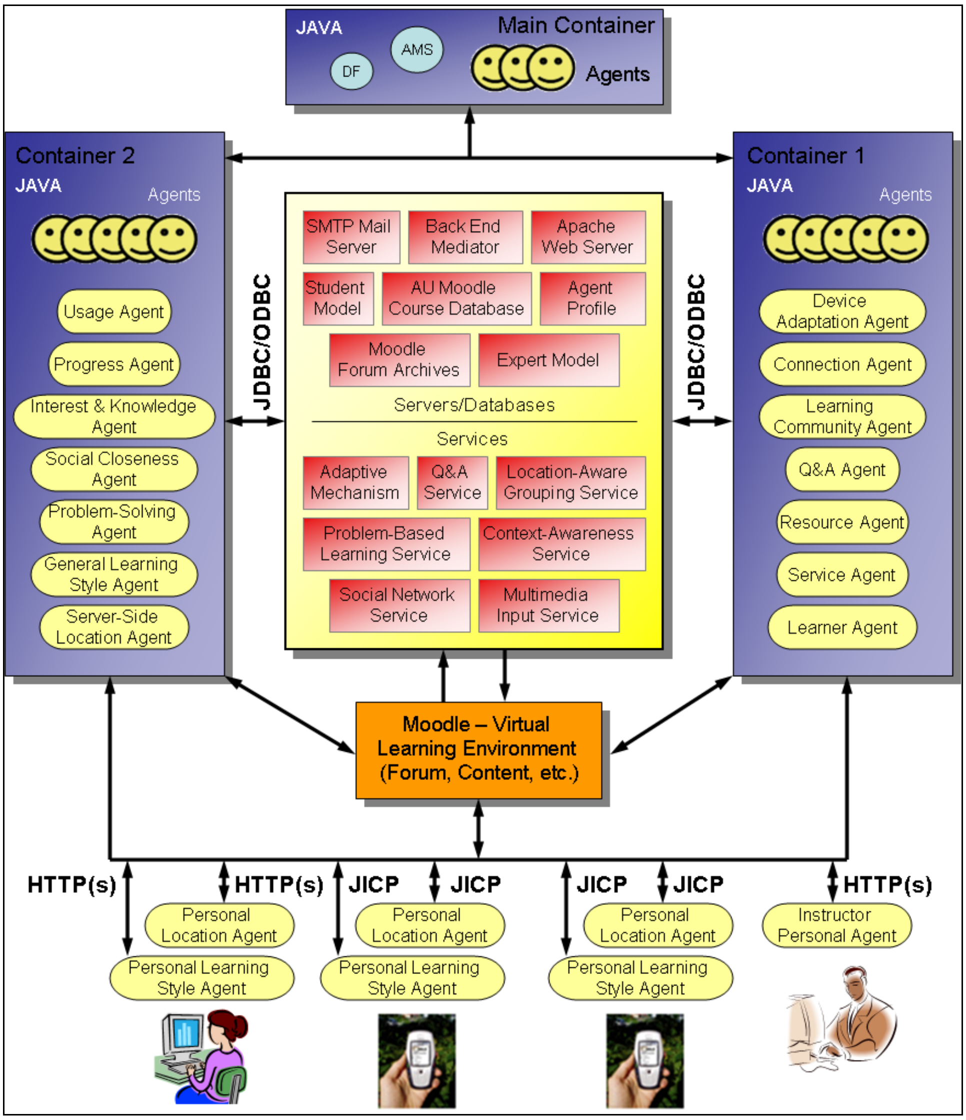

FIGURE 1. *Architecture of the adaptive mobile learning environment.*

This learning environment aims at providing learners with rich learning experience through different services, supporting learning at any time and any place. Furthermore, adaptivity and personalization is an important issue. Therefore, the environment gathers data about students' usage of the environment, learning progress, interests, knowledge level, social closeness, problem-solving abilities, location, and learning styles and uses this information for providing adaptivity.

As an example, we focus on one of these characteristics, namely learning styles, in the next paragraphs and describe how learning styles can be gathered and how adaptivity can be provided in the proposed mobile learning environment.

For considering learning styles, the Felder-Silverman learning style model (FSLSM) (Felder & Silverman, 1988) is used. Many learning style models exist in literature (e.g., Honey & Mumford, 1982; Kolb, 1984; Pask, 1976). However, most of them classify students into few groups, whereas Felder and Silverman describe the learning styles of a student in more detail, distinguishing between preferences on four dimensions: active/reflective, sensing/intuitive, visual/verbal, and sequential/global. Therefore, each leaner has a preference on each of these four dimensions. By using dimensions and scales, the degree of preference can be expressed to describe a balanced learning style. Another main difference is that FSLSM is based on tendencies, indicating that students with a high preference for certain behaviour can also act sometimes differently. In addition, FSLSM is suggested and used very often for technology enhanced systems (e.g., Carver et al., 1999; Kuljis & Liu, 2005).

The student model uses the students' behaviour, actions, and preferences in several services as well as an advanced student modelling approach for identifying learning styles in an automatic, dynamic, and global way. With respect to automatic student modelling, the students' behaviour and actions are used in order to infer their learning styles. The dynamic part of the student modelling approach is responsible for using the information about student's behaviour and actions for updating the student model immediately while students are using the system for learning. Therefore, the student modelling approach is able to improve and revise the information in the student model frequently, leading to a higher accuracy of adaptivity. Furthermore, the global aspect of student modelling focuses on considering all services integrated in the mobile learning environment for gathering data about the students' behaviour and actions. In addition, the student modelling approach can optionally incorporate information from a learning style questionnaire for initialising the student model, while data about students' behaviour and actions are then used for revising and improving the information from the questionnaire.

Each service is provided with access to the student model. Therefore, the information about students' learning styles calculated by the student modelling approach can be used by the services to provide students with a learning experience which incorporates and fits their preferred ways of learning. The learning styles are used as the basis for the adaptive mechanism which aims at providing students with learning objects and activities that fit their individual learning styles. Furthermore, the problem-based learning service uses the information about learning styles in order to assign suitable problems to students and the location-aware grouping service considers learning styles for building learning groups. Furthermore, the question and answer service incorporates learning styles in order to provide answers which fit the preferred ways of perceiving and acquiring information, such as considering the preferred media type.

Context-aware Learning Activities in Museum

Museum is a place with plentiful knowledge in different domains. Museum learning is a kind of informal learning, which means that the learning occurs outside of school (Nikolaos, Loannna, Dimitrios, Nikoletta, Vassilis, & Nikolaos, 2008). The mobile applications have already been used in the museums to deliver information to the visitors, to provide tools to support the learning process, and to present educational multimedia contents (Tsung, Tan, & Yu, 2006).

However, these mobile learning applications in museum do not incorporate context-awareness techniques and therefore do not provide the learners personalized learning experiences based on where the learners are inside the museum. In this section, we introduce a learning activity generator for the learners taking adventures in the museum. Since the generator is context-awareness, only the learning activity which involves the artifacts around the learners is generated. Different learners consequently receive different activities based on their location in different exhibition halls and/or floors.

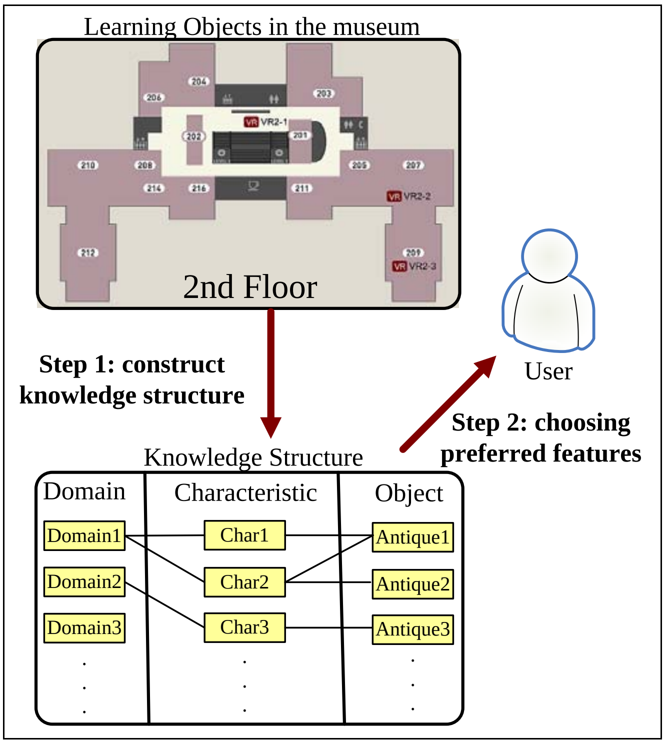

FIGURE 2. *First Phase - Information Preprocess.*

The context-awareness activity generation process is composed of two phases, as shown in figures 2 and 3. The first phase of information preprocessing has two steps: the knowledge structure construction step (step 1) and the preferred feature selection step (step 2). Step 1 adapts the learning service to the context of the learner's surroundings. Step 2 adapts the learning service to the learner's preferences. The second phase of personalized learning experience has three steps: the personalized learning activity generation step (step 3), the activity realization step (step 4), and, the personalized experience update step (step 5).

First of all, it is common for museums to have a lot of artifacts and the artifacts in different areas/floors may belong to various topics and knowledge domains. When a learner visits a museum, the learning service must have some idea about what artifacts are in the learner's surroundings, and what characteristics do the artifacts have that are suitable to be used by learning activities. This is part of phase 1 - the information preprocessing. Figure 2 shows two steps in phase 1. The system first discovers the characteristics of the artifacts by using context-awareness knowledge structure and rough set. The context-awareness knowledge structure is typically analyzed and designed by the pedagogical experts for storing and retrieving multidisciplinary knowledge and relevant learning objects (Wu, Chang, Chang, Liu, & Heh, 2008). After the system has constructed the knowledge structure about the artifacts that are available in the vicinity of the learner, the system then offers the learner some relevant features that the artifacts may have and let the learner select his/her preferred ones.

As Figure 3 shows, the second phase enables personalized learning experience. In this phase, there are three steps. Step 3 follows step 2 where the learner has selected preferred artifact features. Different learning topics involve different artifacts in the museum and these artifacts may have the feature(s) the learner is interest in, hence, the learning service can take the learner's preferred feature as the learner's preferred topic to generate personalized learning activity. The system picks suitable artifacts from the context-awareness knowledge structure and puts these artifacts into the activity generation engine in order to get different activity series, as shown in the "Topic" box in Figure 3.

In step 4, the learner can choose and undertake one of the learning activities that are generated by the activity generation engine in step 3. Each activity has one or more missions which the learner needs to complete, and every mission has descriptions to indicate the mission goal. The learner has to find out the artifacts required by the mission by observing or touching them on the device interface. When the learner accomplishes a mission, he/she gets permit to take the next mission in specific activity. The difficulty levels of missions get increasingly harder; the next mission will be more difficult than the former one. Finally, the learning service records and updates the learner's progress into personal experience database in step 5.

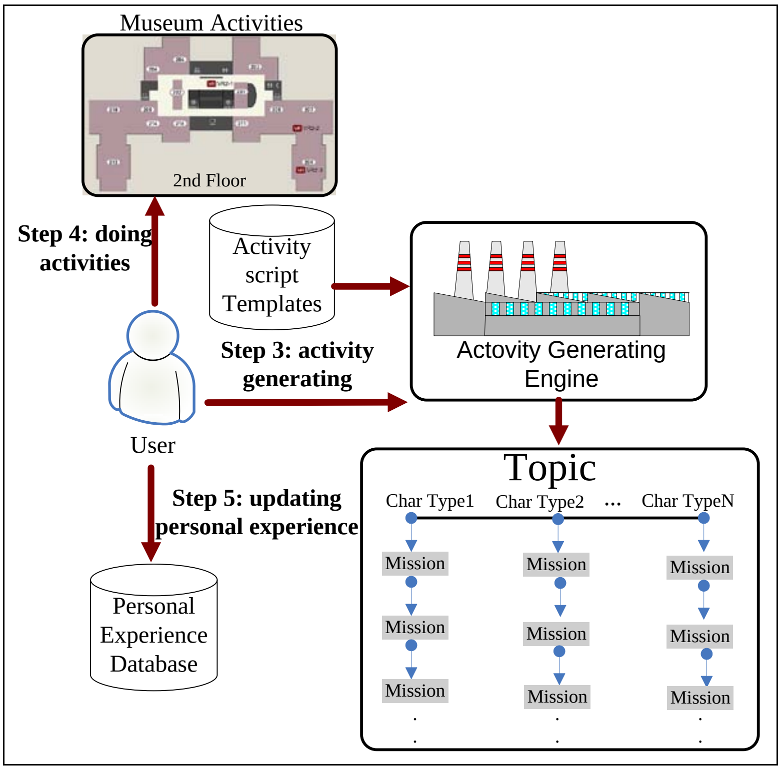

FIGURE 3. *Second Phase - Personalized Learning Experience.*

Conclusions

This paper described personalization in mobile learning via two adaptive approaches, one by adapting to the learner and the other by adapting to the context of the learner's surroundings. In this paper, we discussed each adaptive approach and demonstrated how the different methods/systems achieve the personalization. By incorporating students' characteristics such as learning styles, learners can be provided with learning materials, activities, and experiences that fit their individual needs and requirements. With context-aware knowledge structure and the learning activity generator, the system can provide not only the learning activities relevant to the learning objects in the learners' surroundings, but can also enable learners select their preferred topics and activities.

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