LOCATION BASED USER MODELING IN ADAPTIVE MOBILE LEARNING FOR ENVIRONMENTAL AWARENESS

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Keywords: Mobile learning, Environmental informatics, User modelling, Adaptive learning.

Abstract: Recently it has been widely acknowledged that the incorporation of advanced information technologies in the areas of ecological informatics may provide significant assets towards social environmental awareness. In this paper we present a sophisticated mobile learning system which offers environmental educational information to users based on their current geographical location. The system adapts its content according to the user's personal characteristics and to the user's mobile device. The adaptation of the user's interface is accomplished through the incorporation of a well known decision making model, namely the Analytic Hierarchy Process (AHP). The resulting prototype system is called m-AWARE and is targeted to people of all ages, providing easily accessible information about our environment for environmental awareness purposes.

1 INTRODUCTION

Environmental informatics is the application of information technology to environmental science. In (Rickinson, Lundholm and Hopwood, 2010), it is stated that the last 4 decades have seen growing international recognition for the educational dimensions of environmental and sustainable development issues. Since the late 1960s, international statements from organizations such as the IUCN (International Union for the Conservation of Nature) (www.iucn.org) and UNESCO (United Nations Educational, Scientific and Cultural Organization) (www.unesco.org) have called by environmental problems to be tackled through environmental education for all age groups. The need for prompt and valid information is even greater nowadays, since we are all witnesses of daily environmental disasters and of the irreversible damages to our ecosystem. Environmental disasters can have an effect on agriculture, biodiversity, economy and human health. The causes include pollution, depletion of natural resources, industrial activity or agriculture.

A remedy against the rapid destruction of our natural environment due to human activities may lie at providing easily accessible and comprehensive environmental data to all the people through the use of recent technological and scientific achievements. As it is stated in (Pillmann, Geiger and Voigt, 2006), in the science sector, a rapidly growing community conceived new computer applications for decision making and information exchange in the field of environmental protection, since environmental problems in the last decades have resulted in an increased ecological awareness in Europe.

Ecological informatics (ecoinformatics) is an interdisciplinary framework for the processing, archival, analysis and synthesis of ecological data by advanced computational technology (Recknagel, 2006). According to (Recknagel, 2006), computational technologies currently considered being crucial for data archival, retrieval and visualization in Environmental Informatics include:

- Object-oriented data representation to facilitate data standardization and data integration by the embodiment of metadata and data operations into data structures;
- Internet and world wide web to facilitate interactive and online simulation as well as software and model sharing;
- Remote sensing and GIS to facilitate spatial data visualization and acquisition;

Alepis E., Virvou M. and Kabassi K..
LOCATION BASED USER MODELING IN ADAPTIVE MOBILE LEARNING FOR ENVIRONMENTAL AWARENESS.
DOI: 10.5220/0003505302140217
In *Proceedings of the 6th International Conference on Software and Database Technologies* (ICSOFT-2011), pages 214-217
ISBN: 978-989-8425-76-8

• Adaptive agents to facilitate adaptive simulation and prediction of ecosystem composition and evolution.

In view of the above, in this paper we present a novel adaptive mobile learning system that incorporates all the four fore mentioned computation technologies. The system's main objective is to use location based and user modeling information for environmental awareness purposes. The resulting system is called m-AWARE, which is the acronym for "mobile-Adaptive Warnings and Advice for Resources of the Environment". More specifically, in this paper we focus on the application of recent advances in Information Technology, such as mobile software engineering, multi-criteria decision making, adaptive hypermedia and geographic information systems (GIS) to environmental science.

The proposed theory for the construction of the multi criteria decision making model is the Analytic Hierarchy Process (AHP) method. The AHP method is used as a reasoning mechanism for the specification of the information that is delivered to the users through their mobile devices. Each user's profile includes information about the specific user (such as user's age, user's educational background, interests, gender, etc.), as well as information about the users' current geographic location. Finally, information about each user's personal mobile device will be also retrieved in order to adapt the application to the user's device needs and limitations. The proposed system will also use stereotypic information derived from each user's given personal information.

The architecture that is used for the representation of the available data is based on the Object Oriented model. Object oriented approaches have been already widely used in software development environments (Chiu, Lo and Chao, 2009), (Pastor, Gomez, Insfran and Pelechano, 2001). The resulting system is able to process ecological data and present the appropriate information to users who own mobile devices based on their personal profile, where they are (geographic location in a specified range), and what mobile device they are using. Accordingly, the representation of the available ecological educational information is dynamically adapted to each user. Finally, the interaction between users and the application is friendly to a high extent through the use of pedagogical animated agents.

2 DECISION MAKING MODEL THROUGH THE ANALYTIC HIERARCHY PROCESS

AHP is one of the most popular Multi Criteria Decision Making (MCDM) methods. It has solid theoretical foundation and objectivity to some degree. AHP is based on three principles: decomposition, comparative judgments, and the synthesis of priorities, and can help decision makers to develop systematic approaches for a variety of problems.

The Analytic Hierarchy Process (AHP) (Saaty, 1980) is composed of several previously existing but unassociated concepts and techniques, such as hierarchical structuring of complexity, pair wise comparisons, an eigenvector method for deriving weights etc. (Jandric and Srdjevic, 2000), (Selly and Forman, 2001). Based on mathematics and psychology, the AHP has been extensively studied and refined over the last decades. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

The method consists of the following steps (Zhu and Buchman, 2000):

• **Developing a goal hierarchy.**

• **Setting up a pair wise comparison matrix of criteria.**

• **Ranking the relative importance between alternatives.**

• **Checking consistency of the comparisons. Calculating AHP values.**

The AHP value is computed using the following formula:

$$AHP_i = \sum_{j=1}^{N} a_{ij} w_j \text{ , for } i = 1,2,3,..., M$$

where M is the number of alternatives and N is the number of criteria; a_{ij} denotes the score of the i^th alternative related to the j^{th} criterion; W_j denotes the weight of the J^{th} criterion.

Figure 1, illustrates the AHP hierarchy that results by the application of the AHP's model to our system.

The exact weights for the criteria that are used in our implementation of the AHP model have been initially specified by the authors. However, a future empirical study may reveal more accurate values for the determination of each criterion's importance.

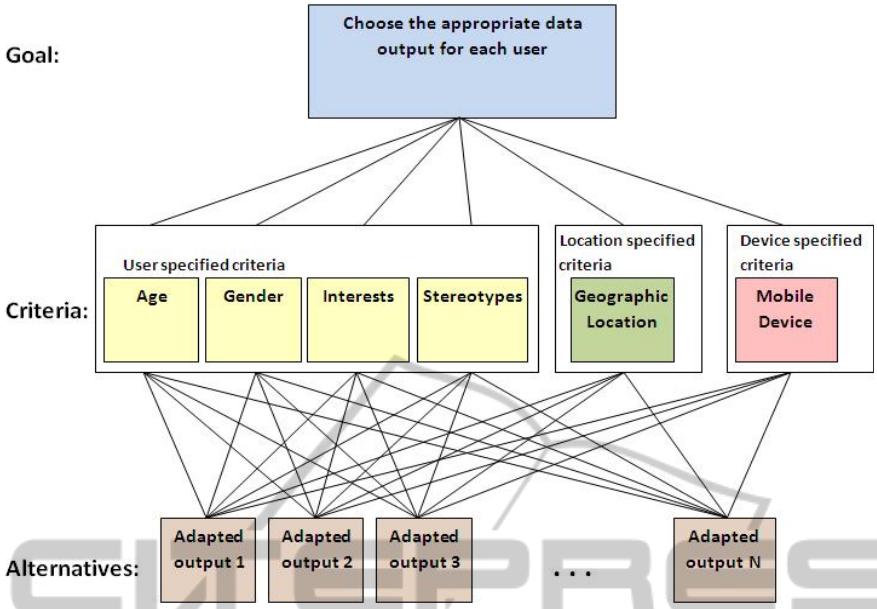

Figure 1: AHP hierarchy in m-AWARE.

3 OVERVIEW OF THE SYSTEM

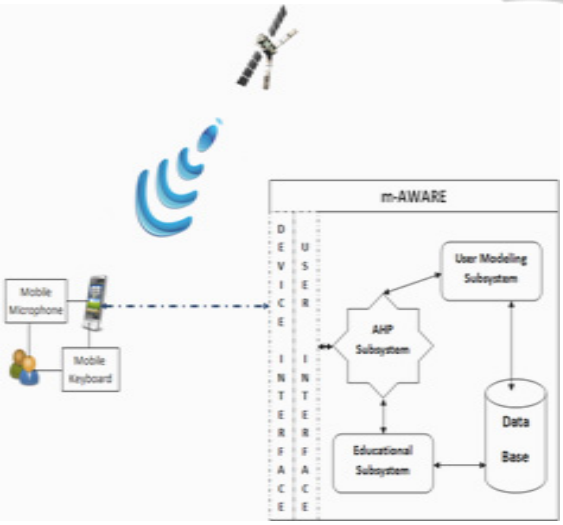

Figure 2: Architecture of m-AWARE.

In this section, we describe the overall functionality and features of m-AWARE.

The architecture of m-AWARE consists of the main educational application, a user modeling component, a decision making inference mechanism and a database. Part of the database is used to store educational data and another part is used to store data related to user modeling. Accordingly, the database is also used to store user models and user personal profiles for each individual user that uses and interacts with the system, as well as stereotypic information about user profiles. The system's architecture is illustrated in figure 2.

As we can see in figure 2, the students' interaction can be accomplished either orally through the mobile device's microphone, or through the mobile device's keyboard. The educational system consists of three subsystems, namely the user modeling subsystem, the educating application subsystem and the subsystem that incorporates the decision making mechanism. Both the user modelling subsystem's data and the educational subsystem's data are stored in the main system's database, while the decision making subsystem is responsible for the resulting interface created for each user during his/her interaction with m-AWARE. m-AWARE has been developed to operate on the Android mobile operating system, while as for future work the authors are planning to provide implementations for other existing mobile phone platforms as well. Correspondingly, the system is programmed using JAVA as a programming language. This specific programming language is also compatible with the system's Object Oriented structure. Figure 3 illustrates a snapshot of the operating educational application, where a user is retrieving environmental information about a specific geographic location.

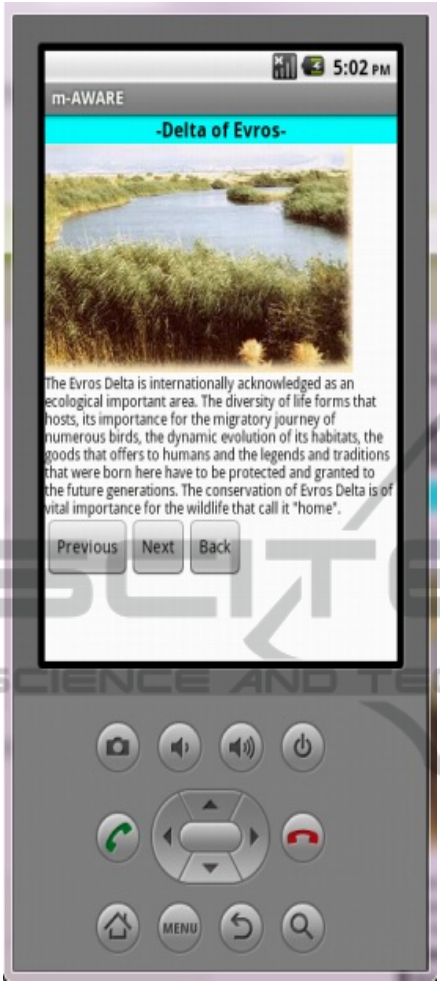

Figure 3: A user is viewing the available information adapted to his/her profile.

4 CONCLUSIONS AND FUTURE WORK

Greece, has the tenth longest coastline in the world at 14,880 km in length, featuring a vast number of islands (approximately 1400, of which 227 are inhabited). Eighty percent of Greece consists of mountains or hills, making the country one of the most mountainous in Europe. However, continuous environmental disasters have negative effects on our country's agriculture, environment and tourism and as a result to our economy and human health. A remedy to such environmental problems may lie in providing environmental education for all age groups. In our research, we have aimed in creating a novel Adaptive Mobile Learning system for Environmental Awareness. It is in our future plans to evaluate m-AWARE in order to examine the degree of its usefulness as an educational tool, as well as the degree of usefulness and user-friendliness for the people who are going to use the educational system.

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