SOFTWARE LIFE-CYCLE FOR AN ADAPTIVE GEOGRAPHICAL INFORMATION SYSTEM

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Abstract: This paper presents the software life-cycle for the development of a knowledge-based GIS. The life-cycle framework used is called MBIUI and provides the experimental studies that are required for designing, implementing and testing a decision making theory in a graphical user interface. The decision making theory has been adapted in the user interface for is used for the evaluation of different environmental data in terms of some criteria that concern the user needs and skills and select the one that seems most suitable for a user.

1 INTRODUCTION

The Geographical Information (GI) industry is a specialized component of the broader information technology sector and has scientific and technical links to many other disciplines such as environmental science, engineering, computer science, health delivery, planning and resource management. However, Geographical Information Systems (GISs) are usually targeted to scientists for the environment and other users who are not specialists find them confusing. A remedy to this problem is the development of systems with an ability to adapt their behaviour to the interests and other features of individual users and groups of users (Virvou 2001).

Given the popularity of geographical data and the variety of users groups dealing with this data it is desirable to develop Geographical Information Systems adaptable to the users' needs and skills. Indeed, lately there is an increasing interest for personalized GIS for making recommendations and for this purpose several techniques have been proposed (Malpica et al. 2007, Choi 2007). In view of the above we have developed ADAPTIGIS (Kabassi et al. 2006), a knowledge-based GIS that can adapt its interaction to each individual user.

2 MULTIMEDIA GIS IMPLEMENTATION

The latest advantages in computer industry have led to the development of multimedia and GIS. In constrast to traditional GIS, multimedia GIS (mmGIS) is not only able to collect, analyze and store data in traditional formats i.e. text, images and graphs but also audio, animations and video.

The focus of this study is to design a mmGIS to promote the ecotourism in the island of Zakynthos, Greece. The data available for the study area consists of an heterogeneous data-set that contains three major categories of data types: Raster Data, including aerial photos, Landsat and ASTER satellite images, scanned topographic maps and scanned geological maps. Vector Data describing administrative boundaries, road and hydrographical network, the coast line, urban limits, soil data, Corine land cover data archaeological sites etc. as well as various footpaths and mountain bike tours that have been recorded using GPS. Finally 3D representations and Multimedia data such as texts, digital photos, audio and video files were included.
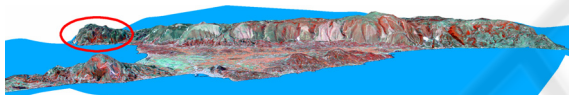

Figure 1: 3D representation of the study area.

The GIS was implemented using TNT mips integrated GIS and Image Processing software package and it is available to be distributed in CD, info kiosks as well as through internet as WEBGIS.

In order to evaluate different geographical information, the system uses a simple decision making model. The information that is rated highest by the decision making model are selected to be presented by the system.

For this purpose a life-cycle framework have been used for the incorporation of a multi-criteria theory in ADAPTIGIS. This framework is called MBIUI (Multi-criteria Based Intelligent User Interface) life-cycle framework (Kabassi & Virvou 2006) and involves the description of a software life-cycle that gives detailed information and guidelines about the experiments that need to be conducted, the design of the software, the selection of the right decision making theory and the evaluation of the IUI that incorporates a decision making theory.

During requirements capture, a prototype is developed and the main requirements of the user interface are specified. At this point the multi-

criteria decision making theory that seems most promising for the particular application has to be selected. This decision may be revised in the procedural step of requirements capture in the phase of construction.

During analysis, two different experiments are conducted in order to select the criteria that are used in the reasoning process of the human advisors as well as their weights of importance. The experiments should be carefully designed, since the kind of participants as well as the methods selected could eventually affect the whole design of the IUI. Both experiments involve human experts in the domain being reviewed.

The information collected during the two experiments of the empirical study is further used during the design phase of the system, where the decision making theory that has been selected is applied to the user interface. Further, the user modelling component of the system as well as the basic decision making mechanisms are developed. As a result a new version of the IUI is developed which incorporates fully the multi criteria decision making theory.

3 REQUIREMENTS CAPTURE

During requirements capture the basic requirements of the system are specified. For this purpose we conducted an empirical study. For the purposes of the empirical study a questionnaire was designed and distributed to 299 users. The users were randomly selected from different places in Zakynthos as well as other parts of Greece.

6 human experts analysed the questionnaires collected. Such an analysis provided information about the possible categories of the users interacting with the GIS, the interests and the knowledge of the users belonging to each category for environmental matters as well as for the Information and Communication Technologies (ICT).

The analysis of the questionnaires revealed that the potential users of the Web GIS could be divided to five main categories. More specifically, 29% of the users answering the questionnaires were residents of the island (this category contained pupils as well as people of different occupation but not the residents working in a public authority). The residents working in a public authority of the island that answered the questionnaire corresponded to the 10% of all users participating the empirical study. However, most of the users that answered the questionnaire were tourists (42.5%). This was due to

the great touristic interest of the island. Additionally, the environmentalists or researchers that participated the study were just 2%. Finally, the empirical study participated many students of the department of ecology and the environment in the Technological Educational Institution of the Ionian Islands, which is located in Zakynthos (16.5%).

Furthermore, the analysis of the answers of the subjects in the questions of the third part of the questionnaire revealed what is more likely to interest the users belonging in each one of the categories of potential users, namely Residents, Tourists, Environmentalists/Researchers, Public Authorities, Students.

Finally, the analysis of the results revealed that the computer skills of the tourists and the residents of the island varied depending on the educational level or the occupation of the person answering the questionnaire. In view of the above, users could be categorised into three categories taking into account their computer skills. These categories should correspond to high, medium and low level of expertise in ICT.

4 ANALYSIS

According to MBIUI, during analysis, two different experiments are conducted. The first experiment aims at determining the criteria that are used in the reasoning process of the human advisors and the second aims at calculating their weights of importance.

4.1 Specifying the Criteria

The six human experts that participated the empirical study during requirements capture were also asked about the criteria that human experts take into account while evaluating alternative information that would be appropriate and useful for a user. These criteria are presented below:

- Degree of Interest (i): The values of this criterion show how interesting information about Zakynthos is for the users belonging to one particular stereotype.
- Need for information (n): This criterion shows how important information about Zakynthos is.
- Comprehensibility of the information(c): This criterion shows how comprehensible each information about Zakynthos is to the users belonging to each stereotype.

- Level of computer skills (l): This criterion shows how comprehensible the way of presentation of each information about Zakynthos is to the users belonging to each stereotype.

4.2 Determining the Weights of Importance of the Criteria

The group of 6 human experts that selected the final group of criteria also participated the experiment for the estimation of the weights of importance of the criteria. For this purpose, a scale from 1 to 4 was proposed for rating the criteria. More specifically, every one of the human experts was asked to assign one score of the set of scores (1, 2, 3, 4) to each one of the four criteria and not the same one to two different criteria. The sum of scores of the elements of the set of scores was 10. The scores assigned to each criterion by each human expert were summed up and then divided by the sum of scores of all criteria (10*6 human experts = 60).

As a result, the weight for the degree of interest (i) is $w_i = \frac{22}{60} = 0.37$, the weight for the need for information (n) is $w_n = \frac{18}{60} = 0.30$, the weight for the criterion of comprehensibility of information (c) is $w_c = \frac{12}{60} = 0.20$ and the weight for the criterion that is related to the level of computer skills of the user (l) is $w_l = \frac{8}{60} = 0.13$.

5 DESIGN

During design, the user modelling component of the system is designed and the decision making model is adapted for the purposes of the particular domain. Furthermore, the information collected during the two experiments of the empirical study is further used during the design phase of the system, where the decision making theory that has been selected is applied to the user interface.

After the calculation of weights was made, the SAW method was used further for the calculation of the multi-criteria function. According to the SAW method the multi-criteria function is calculated as a linear combination of the values of the four criteria that had identified in the previous experiments:

$U(X_j) = \sum_{i=1}^{4} w_i c_{ij}$, where w_i are the weights of criteria and c_{ij} are the values of the criteria for the X_j theory topic.

In view of above the formula for the calculation of the multi-criteria function is:
$$U(X_j) = 0.37i + 0.30n + 0.20c + 0.13l \quad (1)$$

This function can be used for the evaluation of information about Zakynthos and select the one that seems to be the most appropriate for the particular user. For this purpose, the values of the multi-criteria function $U(X_j)$ should be calculated for each theory topic, taking into account the values of the criteria of the activated stereotypes. In this way, an interaction with the system could be adapted to each user by selecting different information for different users.

6 IMPLEMENTATION

In view of the above, a Geographical Information System was developed. The described GIS operates over the Web and contains data about the physical and anthropogenic environment of Zakynthos, an island of Greece. The information that is maintained in such a GIS would be of interest to a great variety of users.

However, different kinds of users may have different interests, needs and background knowledge. In view of the above, the main characteristic of ADAPTIGIS is that it can adapt its interaction with each individual user. In order to adapt the informatio4n provided to the interests and background knowledge of each user interacting with ADAPTIGIS, the system incorporates a user modelling component. This component maintains information about the interests, needs and background knowledge of all categories of potential users. The information that is collected for every category of users has been based on the analysis of the results of the empirical study.

7 CONCLUSIONS

In this paper we described the software life-cycle of a knowledge-based GIS. The main characteristic of the system is that it can adapt its interaction to each user. For this purpose the system uses a simple multi-criteria decision making model. However, for the application of this model, different experimental studies are required. Therefore, we used a general software life-cycle framework which describes the experimental studies that are required for the application of any decision making model.

The application of the MBIUI framework revealed that it seems rather effective for the design and implementation of a GIS. In the particular GIS the multi-criteria decision making is used for the evaluation of different environmental data in terms of some criteria that concern the user needs and skills and select the one that seems most suitable for a user.

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