Implementation Issues of a Knowledge-based Geographical Information System

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Abstract. The research presented in this paper introduces a user context approach for the implementation of an adaptive Geographical Information System (GIS). The main focus of the paper is on presenting some implementation issues about the data used and their evaluation with respect to their suitability for the user interacting with the system. For the evaluation of the geographical information, the system uses a simple decision making model and selects the one that seems more appropriate for a user. In this way, the GIS has the ability of adapting its interaction to each user and make interaction more user friendly.

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. Geographical information is fundamental to our everyday lives. Satellite images bring daily weather reports; global positioning systems monitor the location of thousands of trucks and taxis; real estate sales use geographic information systems; and maps of all kinds are produced, displayed and analyzed using the Geographical Information technology. 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. 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 is selected to be presented by the system.

1. Data used and GIS implementation

A Geographical Information system has been developed for the Zakynthos island in Greece. A number of topographic features were digitized from Topographic Maps of the Geographic Service of the Army (scale 1:50,000). Topographical data include the coastline, the main and secondary road network, meteorological stations and village polygons (outline of village limits). A similar procedure was followed in the digitization of the geological maps of the Institute of Geological & Mineral Exploration IGME (scale 1: 50,000) and soil maps (land use and land capability for forestry) of the Ministry of Agriculture (scale 1: 20,000).

Table 1: Pre-Processing/Image Enhancement/Classification

<table>
<thead>
<tr>
<th>Technique</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georeferencing</td>
<td>Image map output in Hellenic Projection System of 1987</td>
</tr>
<tr>
<td>Color Composites</td>
<td>Best combinations for Landsat data are achieved using bands TM 1,3 (or 4) and 5 (or 7 ) as well as real color composites.</td>
</tr>
<tr>
<td>Intensity Hue Saturation HIS Images</td>
<td>Images are enhanced while shadow is suppressed.</td>
</tr>
<tr>
<td>Unsupervised classification using Self Organizing Maps.</td>
<td>Interpretation of spectral characteristics of images. Easy discrimination of land cover classes.</td>
</tr>
<tr>
<td>Automatic conversion of raster to vector data.</td>
<td>Map output. Inform the GIS database with the output vector data</td>
</tr>
<tr>
<td>Collection / input / coding, Storage/ Management, Retrieval, Processing / analysis, Presentation / Display, &amp; Map making</td>
<td>Creation of a relational database of the collected data, map making. Evaluation of temporal changes, map updating.</td>
</tr>
</tbody>
</table>

Geologic layers (vector) containing the hydrological network, lithological unit boundaries, tectonics (faulting and bedding system) were created. Following the digitization of the maps, georeferencing of them was performed, by choosing specific Ground Control Points (GCPs) in the corresponding maps and the digitized coastline. Accurate mapping of the most important sites of cultural and/or natural heritage, as well as mountainous footpaths of Zakynthos was carried out using a GPS Thales. For each path a description of the type of the path, the terrain involved, experience needed,
estimated time required and a classification of the paths according to the difficulty was attempted.

Two Landsat 7 Enhanced Thematic Mapper Plus (ETM+) scenes have been used, with acquisition dates 28/07/1999 and 15/08/2000, respectively. Various image processing and vector GIS techniques have been applied for the analysis of the satellite imagery (Table 1). Some results are presented in Figure 1.

Figure 1: A combination of raster (pseudocolor composite RGB -543 of a Landsat-7 ETM) and vector data (administrative boundaries and water basin boundary) in the GIS environment

2. Adaptation of environmental Information

The main feature of ADAPTIGIS is that it can adapt its interaction with each user. The system uses a simple decision making model. The suitability of each map for the particular user interacting with the system is estimated taking into account some criteria.

- Degree of interest (i): The values of this criterion show how interesting each information about Zakynthos is for the particular user.
- Need for information (n): This criterion shows how important each information about Zakynthos is for the particular user.
- Comprehensibility of the information(c): This criterion also shows how comprehensible each information about Zakynthos is to the particular user.
- Level of computer skills (l): This criterion shows how comprehensible the way of presentation of each information about Zakynthos is to the particular user.
The values of these criteria are estimated taking into account the information that is stored in the user modeling component of the system. This component stores information about each individual user interacting with the GIS.

For the evaluation of the geographical information, the reasoning mechanism of the system uses the SAW method (Fishburn, 1967, Hwang & Yoon, 1981). 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 \( X_j \) geographical information (map).

The criteria used for the evaluation of the geographical information are considered equally important and, therefore, the formula for the calculation of the multi-criteria function is formed:

\[ U(X_j) = 0.25i + 0.25n + 0.25c + 0.25l \]  \hspace{1cm} (1)

In view of the values of the multi-criteria function for the different geographical information, the maps are ranked and the one with the highest value is considered to be the most suitable for the user that interacts with the system.

3. Conclusions and future developments

We presented in this paper some implementation issues for the adaptation of geographical information in a GIS, called ADAPTGIS. The ADAPTGIS is dedicated to the study and management of environmental data. Environmental data are evaluated in terms of some criteria that concern the user needs and skills. More specifically, the system uses a simple decision making model called SAW for ranking different information and select the one that seems most suitable for a user. We plan to extend this work by improving the reasoning mechanism of the system.

References