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Low Cost System For Management And Visualization Of The Medieval And Modern Heritage Of Madrid (Spain)

J.J. Zancajo[1], T. Mostaza[1], J.C. Ojeda[2], R.Velázquez[3] and M. Farjas[2]

[1]Universidad de Salamanca, E.P.S. de Ávila, Ávila, Spain
[2]Universidad Politécnica de Madrid, Madrid, Spain
[3]Ayuntamiento de Madrid, Madrid, Spain

Abstract:
This paper approaches the question of the management of heritage information by using low-cost systems. The aim is to reduce costs by using Free Software —if possible, Open Source software, for the management and visualization of heritage. In order to manage the spatial information of heritage, it is necessary to use GIS technology. Therefore, we will have to find free GIS software to explore and analyze its possibilities. Moreover, we will make the adaptations and developments required for this software to be used for the management and visualization of the Medieval and Modern Heritage of Madrid (Spain).

General terms: Low-Cost, Heritage, Data Management, Spatial Database.
Additional key words and phrases: GIS, Open Source technology.

1. Introduction

Cultural Heritage is one of the main assets for current and future development, the production of new and more abundant resources and the creation of new services and companies linked to high-quality cultural tourism [TB06].
Heritage information is characterized by its diversity of sources and layouts, among others. In this respect, there are two questions to deal with, these being the following:

- The first one relates to how to make an inventory of so vast and varied cultural heritage. In order to do so, it is necessary to apply a wide range of data acquisition techniques. Nowadays there are some instruments which offer new ways for the documentation of archaeological sites. The same instrument can offer both metric data (cartography) and non-metric data depending on the processes applied, as well as the documentation provided through traditional archaeological work.
- The second one deals with the management and visualization of this kind of information. The information can only be integrated and managed by properly structuring it in Spatial Databases.

Spatial information management is of central importance, since it shows the synergies which are or may be generated in the surroundings of the location of the various elements. Spatial management involves, in turn, the integration with other cartographic documents.
In this paper, we are dealing with the second question.

1.1. Case study description

Madrid, the capital city of Spain, is located a few kilometers away from the geographical centre of the Iberian Peninsula, next to the River Manzanares [Con11]. It originated in the time of Mohamed I (852-886), a Muslim emir who built a fortress on the left bank of the River Manzanares.
King Alfonso VI conquered Madrid in 1083 and King Felipe II moved the Court to the city in 1561. Thereafter, the town was transformed under the impulse of the monarchs of the House of Habsburg.
It was King Carlos III who modernized the city in the 18th century, when the main streets of the city [Con11] were designed, such as Paseo de la Castellana, Paseo de Recoletos, Paseo del Prado and Paseo de las Acacias.
Madrid has a lot of famous monuments and buildings [Con11] and the Royal Palace is the most widely known. The city has important churches, such as San Isidro, San Francisco el Grande, San Jeronimo el Real, los Salesianos Real and Calatravas, convents like las Descalzas Reales and La Encarnacion, fountains such as Cibeles, civic buildings such as la Puerta de Alcala and la Puerta de Toledo, the Palace of Communications, the City Hall, the impressive Main Square and the well-known Puerta del Sol.
Since Madrid has a wide variety of buildings located throughout the city, heritage management becomes a complex task and spatial location is essential to understand the development of the city and the layout of buildings.
Madrid's Medieval Heritage has one of its main assets in architecture in late Gothic art [Art11]. An example dating

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from the Medieval Period is Los Jerónimos church (Fig. 1), which began to be built in the late 15th century and was finished in the early 16th century. It is a church closely linked to the Spanish monarchy, as it performed all the solemn acts within its walls for centuries.

Figure 1: *Examples of Madrid's Cultural Heritage. On the left, Los Jeronimos church, an example of Medieval Heritage. On the right, the Royal Observatory, and example of Modern Heritage.*

An example of Modern heritage is the Royal Observatory of Madrid (Fig. 1). Its origins [Ign11] go back to the reign of King Carlos III, who ordered the construction of the Royal Astronomical Observatory of Madrid at the proposal of Jorge Juan, a famous sailor and scientist. The construction of the first building, designed by the architect Juan de Villanueva, began in 1790 in the current Retiro Park, which at the time was a hill on the outskirts of Madrid.

2. Free software: free GIS

For the last few years we have seen an increase in the use of Free Software [Whe07] due to the emergence or development of high-performance programs, whose performance is even higher than that of commercial software.

Free Software has distinct advantages over commercial software [FP10]:

- Costs: the decrease in costs is significant, not only for the initial license fee, which is cheap and sometimes free, but also for the subsequent updates, i.e. maintenance.
- Independence of the policies established by the software provider, sometimes with a high impact.
- Flexibility to be adapted to individual needs.
- System security: Open Source software usually has a higher degree of security.
- Use of international standards, which guarantee compatibility and integration with other applications.

In order to manage heritage spatial information, the so-called Geographic Information Systems (GIS) are used, which provide tools for the management of the spatial database.

In the field of GIS, the increasing use of Free Systems –these often being Open Source Systems, has been significant. Nowadays there is a wide variety of systems which meet users' needs at all levels and range from desktop systems to web servers. Standards are very important, for example, to interchange information and so are they in the field of GIS, where they are essential for the management and visualization of spatial information. The Open Geospatial Consortium (OGC) develops standards to work with spatial information [Ogc12] and Open-Source GIS follow these standards.

A disadvantage of free software is the cost in system customization. Proprietary systems often have a more advanced development and customization is easier.

2.1. MapWindow GIS

Today there is a wide range of applications, with various degrees of development and functionalities, which are used for heritage spatial management. The choice between one or the others will be determined by several factors [MPE*11]. In this paper, we have used the MapWindow GIS Open-Source software, developed by Idaho State University.

The MapWindow Project started in 1998, when Daniel P. Ames along with other colleagues at the University of Utah began to develop a basin modeling software [Ame11]. MapWindow is an Open-Source programmable Geographic Information System which supports manipulation, analysis and visualization of geospatial data and associated attribute data in several standard GIS data formats [Ames11]. MapWindow is a mapping tool, a GIS modeling system and a GIS Application Programming Interface (API), all in one convenient redistributive Open-Source form. This system only works on Microsoft Windows.

To sum up, MapWindow can work as an alternative Open-Source desktop GIS. Moreover, we can develop and distribute customized spatial data analysis tools and we can even develop a fully customized interface for the management and visualization of heritage information.

3. Management of Heritage Information

In the introduction to this paper we mentioned the dissemination of heritage elements, which is something to be taken into account for the management of heritage information. Spatial information management is of great importance because it highlights the synergies which are or may be generated in the surroundings of the location of the various elements.

For an accurate visualization, it is necessary to integrate archaeological information with other cartographic documents, which results in a precise georeferencing of the elements of cultural heritage on spatial environment.

On the other hand, heritage information may include non-spatial information, such as pdf and multimedia files, which is associated with the elements and cannot be easily incorporated into a spatial database. However, the management of these documents is essential for the accurate documentation of heritage information. In order to solve this problem, the systems offer two possibilities [AA09]:

- The development of specific plug-ins, integrated into the global GIS system interface.

- The development of a specific interface for information management based on an Open-Source GIS, yet independent of the chosen system.

MapWindow GIS makes it possible to develop both plug-ins and a specific interface for information management, using OCX, which provides access to MapWindow classes to manage spatial information easily.

4. Formalization of the Spatial Database

The first step in the research project was the formalization of a spatial database. In order to do so, first we made an inventory of the heritage elements for the time period indicated. Once we listed the heritage elements, we analyzed its characteristics, these being the attributes to be introduced in the spatial database.

The formalization of the database was carried out according to the attributes shared by all heritage elements. A list of the elements and their attributes was stored in EXCEL® due to its ease of use. Besides, its table structure would make the subsequent structuring of the database easier. The table includes two coordinate fields for the location of every entity in the Spanish official reference system, ETRS89 and UTM projection. (Fig.2).

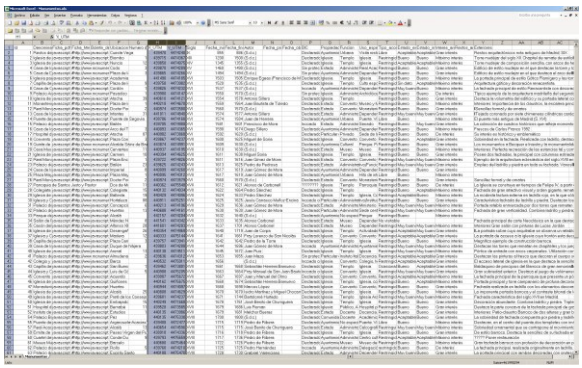

Figure 2: *EXCEL® table showing the attributes of the elements. The coordinate fields are highlighted.*

The point is the geometrical shape ascribed to heritage elements. Two coordinates are assigned to each element for its georeferencing. Then, the heritage information which had been stored in EXCELL® is imported and the coordinate fields are used to do the georeferencing successfully. To this end, the plug-in Spatial Converter, included in the MapWindow GIS distribution, is used. Among other operations, this plug-in allows for the importation of EXCELL® files to generate a spatial database in 'Shape' format, a vector format managed by MapWindow GIS.

An orthophoto of the city of Madrid at a scale of 1:5000 has been used, as it is an important document to show the structure of the city and offers a very good visualization. (Fig. 3).

5. Development of specific software for the management of heritage information

The first problem arises when each element can be associated with several documents with various numbers and formats, such as pdf files, photographs and other multimedia documents, which cannot be easily incorporated into and managed in the spatial database. So as to solve this problem, the best option is, from our point of view, to develop specific software for the management of heritage information.

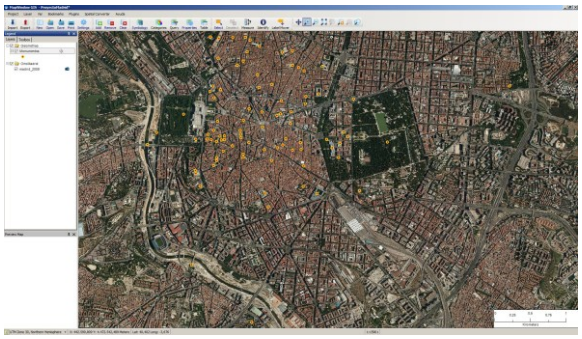

Figure 3:. *Display of the heritage elements on the orthophoto of Madrid in MapWindow GIS.*

MapWindow GIS allows for the development of a complete interface independent of a desktop environment. This is one of the possibilities offered by the MapWindow development team for the customization of tools.

The interface is based on MapWindow OCX, which makes it possible to do the common operations associated with the map window. Furthermore, access windows can be customized in order to solve the problems derived from the use of the desktop version. Common operations related to management of view, such as zoom, can be done. Besides, the software gives access to the tables of the attributes more easily and directly.

One of its main characteristics is the access to non-cartographic information of a particular element, which enables users to easily access additional information, such as pdf and multimedia files.

The access customization is complete, as the necessary specific management tools can be developed, such as data import, visualization of information and attribute updatings, as the following image shows. (Fig. 4).

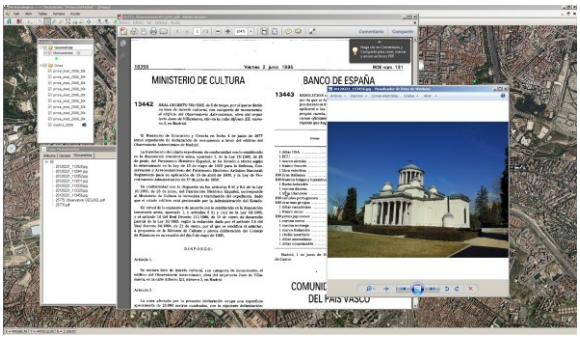

Figure 4:. *Display of the heritage elements on the orthophoto of Madrid in MapWindow GIS.*

6. Conclusions

Nowadays Open Source GIS offer a set of tools for the management of the information associated with heritage elements. However, desktop versions have some limitations for non-experts GIS users.

In order to overcome these limitations, specific developments can be used through plug-ins or development interfaces for information management. From our point of view, the best option is to develop specific interfaces so that non-experts GIS users can access information more easily.

MapWindow GIS offers a powerful Open-Source desktop version, yet with the limitations typical of these systems. Although it is possible to develop small applications through plug-ins, in our point of view the best option is to develop specific applications due to the special characteristics of heritage information.

The versatility of MapWindow GIS OCX becomes then essential for this kind of developments, which are less expensive than commercial GIS. Although the latter may have more sophisticated management tools, they do not solve the problem about accessing non-cartographic documents.

In this work we have checked the versatility and the ability to manage heritage information through the development based on MapWindow GIS OCX. Then we have generated specific software to solve the problems associated with the management of this kind of information.

The next step involves exploring the possibilities of free software on Android tablets for data collection to use it on the ground by georeferencing heritage elements directly using GPS devices, using multimedia files such as photographs and structuring the spatial database.

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