MULTIMEDIA GUIDE IN ARCHAEOLOGICAL SITES BY GIS-GPS TECHNIQUES, POCKETPCS AND POCKET GPSs

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ABSTRACT:
Archaeology is one of the sectors that can benefit by new surveying techniques (i.e. those ones related to the use of GPS) for the representation and the management of an archaeological site. Another aspect of the archaeological sector that can take advantage from the use of both GPS and GIS instruments is guided visits of archaeological sites. Today, during visits in museums, visitors often use some electronic equipments as sound players, special headsets or personal computers equipped with multimedia applications. All this is possible because archaeological goods are in a relatively small covered area, where there are also people that can help the visitor at every time. On the opposite, about visiting open archaeological sites, some other problems or needs come out connected to the big dimension of the area, to the scattered distribution of archaeological goods and to meteorological conditions. So enjoying the site with traditional electronics equipment become impossible. On the contrary both Pocket GPSs and PocketPCs, connected together, may be very useful if used for multimedia guided visits of archaeological sites. This paper treats of the creation of a GIS multimedia guide running on PocketPC connected to a Pocket GPS by the Bluetooth interface, developed with Enhanced Visual Basic®. The system is in the testing stage in some archaeological sites in Sicily.

1. INTRODUCTION
Sicily has always been, due to its geographical position, land of conquest and occupation for peoples interested to control the Mediterranean sea. The invasions left many examples of urban structures and buildings; the remains are sometimes embedded in the cities, but very often they are sited in the countryside. Since the beginning of 19th century, many excavation campaigns have brought to light interesting archaeological sites that are the witness of ancient people who lived in Sicily. Archaeological goods are public property under the control of a Regional Office for Cultural Goods (Soprintendenza Regionale ai Beni Culturali) which has given the support for the development of this research. Archaeological sites are also a good tourist resource to promote Sicily Region and therefore an important economic resource. So it is a primary action to build information infrastructures to enjoy this goods through a visit on site or virtual tour. The main goal of the research project is the creation of multimedia guides to support tourist’s visit of archaeological sites in Sicily. The goal is achieved through the use of pocketPc and Pocket GPS and a software application by which is possible to define in real time position of visitors in an open archaeological site, and to give them, also in automatic way, the information on goods of visited areas.

For the different archaeological sites in Sicily, general maps at large scale (1:2000) and surveys at very large scale (1:20 for detailed architectural representation) are often available. Usually only traditional instruments are used in surveying activities and a digital map doesn’t exist or it is never used as base map. Even in the better situations, only a scanned raster map is available. Besides GIS or WEB-GIS technologies are rarely used in the archaeological sector. So in order to develop the research, it has been necessary to start with base operations as like creating suitable maps for the specific aim. The research project is organized into four main stages:
1. Investigations on typological and dimensional features of archaeological sites in order to establish needs and hence the suitable equipments to carry out the project;
2. tests on pocket GPSs in order to choose the areas for the experimentation, collection and/or creation of a medium scale base maps suitable to aims;
3. collection of historical and typological information, design and construction of a GIS for chosen sites;
4. construction of an application for navigation in the archaeological site (the multimedia guide).

The satisfaction of proposed aims is also due to the evolution of GIS and GPS instruments. During last years, some important changes are introduced in the GPS field so to make possible the development of this research: the elimination of SA error by U.S.A. Army and the activation of WAAS-EGNOS differential correction system, that is of primary importance for the use of pocket GPS in the shown experimentation.

2. PRELIMINARY EXPERIMENTATION ON TEST AREAS
In the early stage of research development, some tests have been carried out in the campus area of University of Palermo, to validate some ideas assumed as basis for the entire process.
In order to check the possibilities of the use of pocket GPS instruments, many measurements and observations has been made on different kinds of predefined paths, according to the
possible configurations of really existing paths of visitors in archaeological areas.

The experimentation regarded:
1. accuracy measurement along a path;
2. precision measurement going along the same path many times;
3. stability of measurements over a fixed station point;
4. influences on measurement by external factors as presence of trees, buildings, etc.

All the tests were carried out referring to high accuracy measurements made with a GPS in static way. The check of the results were made according to U.S. National Standard of Spatial Data Accuracy. During the tests, the operator went along the test path at a moderate walking speed, simulating the same behaviour as going around in an archaeological site.

The test path is composed by straight and curve elements (these last ones with a radius of 3 meters) and, along the path, some check points has been defined, surveyed by a GPS with a static method. So, after these operations, it has been verified that the use of GPS is suitable for open sites also with dispersed trees, and then it has been started a second stage of tests in two archaeological areas (Solunto, Monte Jato) carrying out both a cinematic survey and a static survey (this last in order to define some reference points).

3. TYPOLOGIES STUDIES ABOUT ARCHAEOLOGICAL AREAS

Starting the research, a deep investigation on dimensional and distributive features of many archaeological sites in Sicily has been carried out, in order to set the methodology and the procedure to developing the project.

The analysis of every site, the emerging observations comparing the different sites each other and also with Greek models permitted to extrapolate the grammar and the syntax of urban Hellenistic architecture.

Through this activity it was possible to define the typological structure of archaeological cities in Sicily, that is resumed as follow.

The urban plan is characterized by an orthogonal grid, that characterizes Hellenistic urban planning also known like hippodamian, from the name of architect Hypodamus of Miletus (Fig. 1).

The hierarchical layout of the plan is organized in main longitudinal streets, large from 6 to 10 meters, intersecting in an orthogonal direction secondary streets, large from 3 to 6 meters, concurring to form rectangular blocks, 28-40x60-190 meters, (Fig. 2).

The acropolis, the holy space that hosts main temples, is situated in the upper part of the city, and it is characterized by its own city walls and by a spatial layout that includes buildings and big open areas (Fig. 3).

The public space constitutes the nucleus of these urban plans; inside it, there is the agora, usually delimited by arcades, the bouleuterion (building including a semicircular cavea for meetings of local senate), the theatre, the gymnasium, the thermae, etc. (Fig. 4). All the buildings, in this area, were assigned to people services: sometimes they had small dimensions, and were integrated by wide and articulated open spaces.

According to previously exposed considerations, it is possible to say that the exploration (seen as visitor moving) can be of two types:
1. paths along the orthogonal streets, and hence in long and thin spatial areas;
2. paths without constraints in sacred areas and in public spaces.

Besides the verification of applicative potentiality of the integrated GPS-GIS, for navigational purposes in archaeological sites, must be developed starting from the limit situation, represented by minimum and maximum width (3-10 m) of streets of whatever urban plan; in this case it is necessary to use instruments with a positional accuracy within 1 meter (about).

A first test has been carried out in the archaeological site of Solunto (near Palermo). The activities were aimed to survey the site with GPS instruments in order to correctly georeference the available raster map.
Initially a static survey has been performed with dual frequency receivers and differential post processing error correction, choosing some clearly visible points, both on the maps and orthophotos at a scale of 1:10000. Five points (distributed in the area at regular distance) has been surveyed stopping on every points for 30 minutes. The survey has been carried out with 3 dual frequency receivers (Topcon mod. Legacy-E-GGD), one of which positioned over a point of known coordinates and the others over the surveyed points of the archaeological site. So it was possible to obtain both the relative position and the absolute position of surveyed points, in UTM-WGS84 system. In order to test the two pocket GPS receivers, the survey, carried out by these ones, has been exported in shape format and superimposed to georeferenced map. The two pocket GPSs used in this experimentation are:
- a Magellan Sportrack Map;
- a Bluetooth EMTAC GPS with Sirf II LP chip

The following considerations come out from this comparison:
1. the starting time of EGNOS differential correction is about of 10-15 minutes;
2. usually only signal from the IOR Egnos satellite is always received; signal from AOR satellite is not constant;
3. the GPS receivers show good positioning accuracy going along a straight path;
4. when the surveyor stands on a point, the received position varies within a circle of 2.5 meters, but the first position, received when the surveyor stops, seems to be the best (Fig. 5);
5. tracks saved in the memory of the receivers are characterized by a positioning accuracy varying from 1 m and 3.5 m with a similar precision. Generally, this kind of accuracy makes these instruments suitable for fruition of an archaeological area of this typology, but the pocket GPSs tested show a different behaviour probably due to different GPS chips used (Fig. 6).

With reference to figures, it is possible to say that the Bluetooth EMTAC GPS with Sirf Star II LP performs better than Magellan Sport Track Map (Fig. 7); actually the EMTAC is the most suitable instruments for the aims proposed. the Bluetooth EMTAC GPS performs well also in complex paths as that of Fig. 8. But obviously, it is necessary to produce extensive tests to find all pocket GPS suitable for this kind of use.
Another activity, that engaged the research group, was the creation of geographical database to use in the pocketPc, with the aim to integrate geographical information with multimedia information. This activity has been carried out referring to Solunto layout (the same considerations may be done for other sites with hippodamian plan).

The blocks, defined by this layout, have a rectangular shape of 40x80 m about, organized in different levels, with smaller side looking towards main streets. Going along main street it is possible to see (in ordered sequence):

1. a little block hosting thermal baths;
2. residential blocks, whose houses become more important going towards public area (atriums and arcades);
3. public area where are the remains of sacred buildings, of agorà, of a theatre, of a little bouleuterion, of a gymnasium and of a collective tank.

Solunto, that gained in the 4th century B.C. the layout as today seen, was built on the east side of Catalfano Mountain looking the sea, in an area strongly sloping towards East direction, from an altitude of 230 m to an altitude of 150 m above sea level.

The layout of Solunto is defined by main streets going from N-E to S-W (large 6.50-8.00 meters) intersecting less important street (large 3.00-5.80 meters), this last ones oriented about the maximum sloping, and so consisting very often in stairs (Fig. 9 and Fig. 10).

On the basis of the study carried out, the site has been divided in five main areas (Fig. 11):

A) public area;
B) thermal baths area;
C) wealthy people houses;
D) craftsmen blocks;
E) popular houses blocks.
Geographical objects are grouped into 3 classes (Fig. 12):

1. public and craftsmen buildings (sacred buildings, stoà, gymnasium, thermal baths, public services buildings and infrastructures);
2. residential buildings (building units characterized by decorative, functional and typological features);
3. streets (main and secondary constituting the layout of the city).

Streets layout is hierarchical relevant as it is the connection element between other areas (all other features).

The information relating to the upper enumerated areas are connected, in the database, to streets that are crossed from. Every street is mainly defined by a code and a name (that was attributed by archaeologists or public owner).

A code is associated to every part of these. Public and private buildings, and their open spaces, constitute geographical elements which are connected with specific information, regarding building reference types, spatial distributive features, the presence of decorative elements (mosaics, frescoes and other artistic elements), the type of use, the stages of constructions (deriving from specific archaeological studies), etc.

All this entities are defined by a code and a name.

The multimedia guide has been realized using Enhanced Visual Basic© for Pocket PC 2002 and MapInfo MapX Mobile SDK©. MapX Mobile SDK gives the application all the base functions to manage base maps and the geodatabase.

So the Pocket ArcheoNav has got the main functions of a geographic client to query the database and to change the thematic representation of geographical objects (the features).

The support for managing GPS data was written, by the research group, in order to manage the data received by GPS units.

After the launch and map loading, the application goes in moving map state when the GPS button is pressed.

When the visitor goes around and enter into any feature area, the software performs a simple calculation to check if the visitor has never been in this area, and in affirmative case the guide message starts. To be sure that a point is really inside an feature area, a subroutine has been written that may calculate both the average value on a predefined number of points, received by the GPS unit, or the percentage of a predefined number of point that fall inside the feature area. The most suitable way to estimate the visitor position is through the second method: the position is given good if the 80% of 5 points are inside a feature, but the percentage value or the number of points may be changed.

The PocketPc used for the experimentation is a HP IPAQ 5450 with 64 MB of RAM (Arm Xscale processor), equipped with an expansion memory SD card of 256 MB. The speed of the processor is of main importance for this kind of application.

4. POCKETARCHEONAV – THE MULTIMEDIA GUIDE

The geodatabase is built using ArcGIS® then exported in MapInfo© by which is created the MapInfo geoset, that is also supported by MapX Mobile SDK®.

Sound data files are converted in MP3 format to save space. The database has a minimal dimension and structure in order to save memory and to improve the execution speed of the application.

Every point is received, by the GPS, in geographical coordinates in WGS84 datum and is converted by a subroutine
in plane coordinates in UTM-WGS84 format. No other type of conversion is performed in order to minimize errors. For this reason, all the maps, as previously said, are georeferenced in the UTM-WGS84 system through an accurate GPS survey. In moving map state (Fig. 13) the application also show the position of the visitor on the screen, moreover an option permits to visualize labels relating to each feature area of some interest.

5. CONCLUSIONS
The application still requires a period of test to make it more user friendly. The buttons on pocket PC can be used to perform some simple actions as starting the navigation, re-launching the instructions about an area or stopping the message. Today, the test on the use of the software application, showed here, is carried out in the archaeological site of Monte Jato. But there are some important activities to carry out:

• to realize of an open GIS support for managing the geodatabase;
• to carry out some other tests on many other GPS systems (of bluetooth type or applied to a pocketPC by a jacket), checking the accuracy of positioning in relation to the chip used to build them, also looking for the less expensive GPSs;
• to better investigate the possibility to standardize the description of archaeological sites by GIS, also for the virtual fruition through a WEB-GIS system.

The global aim is to extend the use of the system to all open archaeological sites of Sicily.

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