THE LAST DEVELOPMENT OF ARCHEONAV: AN OGC COMPLIANT NAVIGATOR FOR ARCHAEOLOGICAL SITES RUNNING ON A POCKETPC

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ABSTRACT

In the last years the development of LBS applications has become an issue of great importance in the GIS sector. Navigation through the use of palmtop PCs and pocket GPSs is usually based on schematic maps at a little scale and hence characterized by a low precision. But in order to setting a navigator for archaeological aims it is necessary to produce map with a good level of precision, so that the problems of positional accuracy of GPSs can be reduced.
The building of a regional or national infrastructure for extracting on demand maps of archaeological sites requires also a standardization action of map format that can be useful to extend the usability of data to all kind of hardware used for navigation.
This paper shows the last improvements carried out at the Dipartimento di Rappresentazione of University of Palermo on ArcheoNAV, a pocketPC navigator that uses positional information coming from a pocket GPS, giving to the visitor information on heritage of an archaeological site of great extension. In this stage of development of the application, an object that can read information from a GML file (OGC compliant), describing the archaeological site, has been realized, in substitution of the GIS object from MapInfo previously used, so that it is possible to download standardized data from a remote server of a regional infrastructure.

1. INTRODUCTION

The aim of the research is mainly the improvement of the integrated system composed of a *PocketPc* and a *Pocket GPS*, with a software application by which is possible to define, in real time, the position of visitors in an open archaeological site giving them the information on goods existing in the area.
Usually only traditional topographic instruments are used in archaeological surveys 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, creating suitable maps for the specific aim and the whole GIS infrastructure.

The research project is organized into six 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. collection and/or creation of a medium scale base maps suitable to aims;
3. tests on pocket *GPS*s in order to choose the areas for the experimentation;
4. construction of an application for navigation inside the archaeological site (the multimedia guide software);
5. development of an application that uses advanced data structures like GML;
6. implementation of a data server which the application can be connected to.

The first step was developed in the first phase of the research; the step 2, 3, 4 have been partially developed, but they still need further analysis. Defining last two steps, with other small improvements, represents the last enhancement of the multimedia application, making it usable for actual use in archaeological sites.

2. PRELIMINARY EXPERIMENTATION ON TEST AREAS

In the first stage of the research the necessity of further experimentation on the behaviour of GPS in different kind of archaeological sites arose. Actually archaeological sites can be characterized by many different features such as:

- presence of trees;
- height drops and great slopes;
- different height of the remains (residential buildings, temples, walls, . . .).

Besides, technology evolves very quickly so that in the last year some new GPSs, with greater sensibility and accuracy, have been put up for sale.
This experimentation has been carried out in various sites, to test the application and the receivers in different conditions of sky's visibility, presence of obstacles or different altimetrical conditions.

Tests have been performed using wireless GPS receivers, shown in next pictures. GPS receivers are connected by Bluetooth interface to the palmtop computer, except for the Magellan Sport Track Map, that is connected by the RS-232 port.

Next table resumes main characteristics of these receivers:

	Channels	RMS [m]	Cold start [s]	Chip
EMTAC	12	10	< 80	SIRF star II LP
HOLUX	20	5	42	SIRF star III
MAGELLAN	12	< 7	< 120	Motorola
TOMTOM	12	10	< 50	SIRF II E LP

Table 1 – Main characteristics of GPS receivers

Figure 1 – EM-TACS CruxII BTGPS

Figure 2 – Holux GPSlim 236

Figure 3 – TomTom Wireless GPS (9821X)

Figure 4 – Magellan Sport Track Map

3. GPS TESTS

The previous part of the research was steered to verify the capabilities of this integrated system (GPS with PocketPC) in the typical Sicilian archaeological areas.
In fact we identified the typologies of the archaeological cities in Sicily, and some tests on these areas was carried out.
According to some considerations based on the structure of these cities, it is possible to explore them in two ways:

1. proceeding along predefined paths;
2. walking without constraints.

A first test, which results were presented at the ISPRS Conference 2004, has been carried out in the archaeological site of *Solunto* (near Palermo) with instruments using the second kind of navigation.
The two pocket *GPS*s used in that experimentation were:

– a Magellan Sportrack Map;
– a Bluetooth EMTAC GPS with Sirf II LP chip.

The following considerations came 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;
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 GPS*s tested show a different behaviour probably due to different *GPS* chips used.
In order to know the behaviour of the last GPSs, some tests have been carried out in diversified areas, with different characteristics, that is possible to find in the different archaeological sites:
- tests in wide uncovered area (parking area);
- tests in area with trees (with dense or sparse distribution);
- tests in area with low buildings (Piazza Magione).

These first tests show that the most recent GPS instrument (Holux) is more efficient than others in critical zones (es. under trees), even though it shows some failings, like others, when the user stop walking.

4. THE ALGORITHM IMPROVEMENT

After first tests, and after some considerations about using the fixed-up instrument, it was decided to implement dual way of using it. In the first version of the software you can freely explore a site, and the visitor receives a message only when he is into a certain area. This kind of navigation isn't enough to enjoy a site, as going along a predefined path may be interesting too.
Paths can be defined for specific reasons, like the historic evolution or thematic information, as building's typology, area's roles, . . . For this purpose the GIS, which the software is based on, has been enhanced: it contains at least two main informative layers: 1) classified areas, 2) predefined visit paths.

After suitably setting the smallest distance between visitor and a predefined path, when he begins walking the track he follows is linked by a specific algorithm to the nearest predefined path.
To do this it's necessary to build topology on paths, combining them with their direction, so that the software can understand the sense of moving and provide information on goods located along the path, that aren't easily reachable or in which is forbidden the entrance. Evaluating the relative position of the visitor is important to link correctly the track to the nearest predefined path: in order to evaluate this distance an algorithm has been implemented.
The software initially performs a SearchWithinDistance investigation to find out what paths are within a predefined distance.
This search permits to locate the nearest path. But sometimes some errors occurs so, if the previously followed path is farthest than another path between those found, the choose falls upon the followed path (the is a minimum distance imposed).
Once a path is chosen it is necessary to establish which element of the path is pertaining to the position of the visitor. This estimation may be carried out by the subsequent formulas.
Supposing that

$P_i(x_i, y_i)$ is the i_{th} point surveyed by GPS

$P_{iNj}(x_{Ni}, y_{Ni})$ is the projection of P_i on the element j of the path;

ϑ is the angle $\overline{S_j P_i}$ and $\overline{S_j E_j}$

we can calculate

$K = \dfrac{P_i S_j \cdot \cos\vartheta}{S_j E_j}$ where K is the parameter giving the relative position of P_{iNj} along $\overline{S_j E_j}$.

On the basis of the value assumed by K, the position of P_{iNj} can be:

- if K<0 then the projected point P_{iNj} is outside the segment near starting point (S_j);
- if 0<= K <= 1 then the projected point P_{iNj} is comprised between starting (S_j) and ending point (E_j) of the examined segment;
- if K>1 then the projected point P_{iNj} is outside the segment near ending point (E_j) of the examined jth segment;

Coordinates of the projection of the visitor's position are:

$$x_{Ni} = x_{Sj} + K \cdot (x_{Ej-} - x_{Sj})$$

$$y_{Ni} = y_{Sj} + K \cdot (y_{Ej-} - y_{Sj})$$

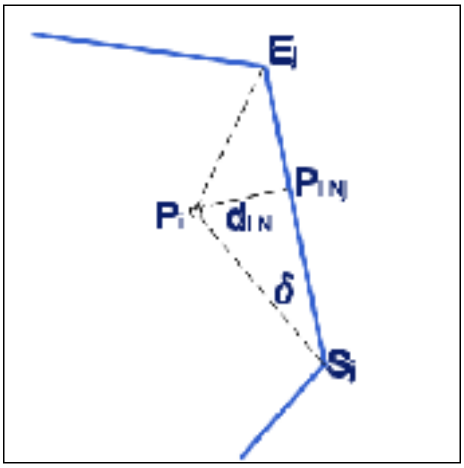

Figure 5 – Algorithm's schema

The track of the visitor must be linked to the pertaining element with reference to the followed path. In fact it might happen that the visitor is erroneously linked to a part of the path that seems nearer than others. In this case a control is applied, knowing the first and the last point of the track between two consecutive nodes. The application gives information to the visitor with a little delay, because it reckons two previous points and two subsequent points (some tests are still in progress to define the most suitable parameters). This delay doesn't invalidate the correct working of the system, because the visitor walks at low speed.

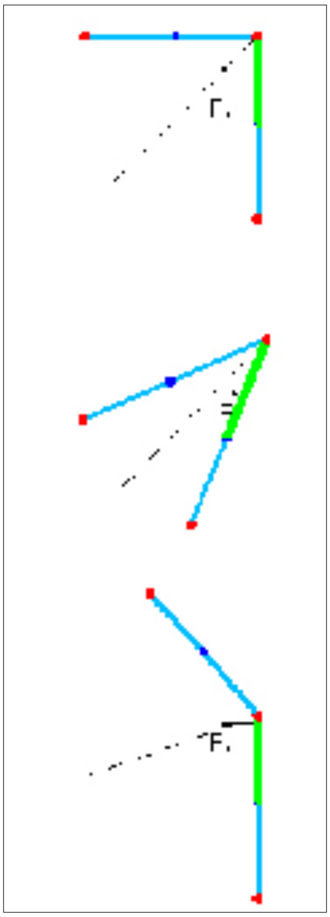

Figure 6 – Positioning matters on pertaining element of the track

In the figure 7 are both shown different kind of paths and situations that can generate misunderstanding about the right path to snap to.

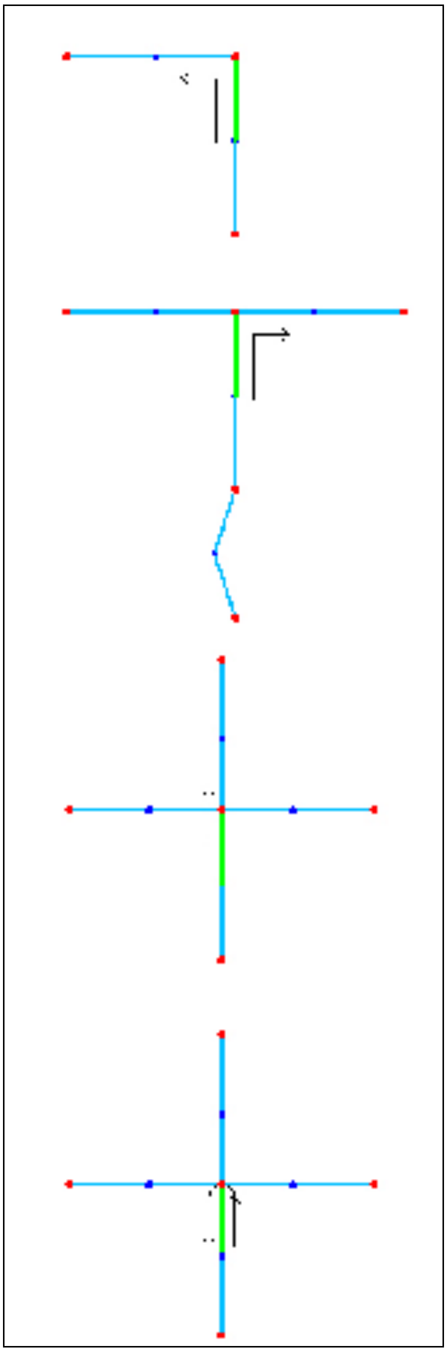

Figure 7 – Path typologies

5. POCKETARCHEONAV – THE MULTIMEDIA GUIDE

The multimedia guide has been realized using Enhanced Visual Basic® for Pocket PC 2002 and MapInfo MapX Mobile SDK® and runs on a HP IPAQ 5450 with 64 MB of RAM, equipped with an expansion memory SD card of 256 MB.

Figure 8 – Paths with its own direction

MapX Mobile SDK gives the application all the base GIS functions to manage base maps and the geodatabase.
The support for managing *GPS* data was written, by the research group, in order to manage the data received by *GPS* units. 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.

Figure 9 – The PocketPc used for the experimentation

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 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.

6. USE OF GML

Since few years the *Open Geospatial Consortium* has developed a language called GML (*Geography Markup Language)*, that allows the transmission of geographical information faster and easier.
GML is an XML coding system, specialized for geographical information, that can be handled like a text file, with advantages for reading and writing.
GML is an open data exchange format, that make easier interoperability: it can describe geographical objects with there attributes and, if necessary, topology structure (GML 3). In order to setup a regional infrastructure that gives services on geographical information about archaeological sites, by which the information can be downloaded from different internet access point, the application has been equipped with a function for importing GML data into Mapinfo or shape layer.
Today the function permits to import only some simple geographical objects strictly necessary to visualize and query the archeological site in a schematic way.
The next step required is the development of an object to include in the enhanced visual basic or C++ code in order to use in a dynamic way the GML data structured received querying the remote GIS server
An advantage of this kind of system is the memory saving on the PocketPc, as well as the possibility to modify easily the data source, without any intervention on a single PocketPc.

7. TEST AREAS

A part of this research was oriented to examine various typologies of archaeological sites located in Italy. We identified various kind of structure of these areas and represented them with similar test areas. The areas chosen for tests are located in Palermo:

- Piazza Magione, a big open area with some buildings that are 15 meters high;
- parking area inside university campus of the city, a wide open area;
- garden area, with dense or sparse distribution of trees.

All this maps were rectified in UTM-WGS84 system, using some ground control points, obtained with a static survey performed 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 test areas, choosing some clearly visible points on the existing maps. These points (distributed in the area at regular distance) has been surveyed stopping on every points for 30 minutes.
Using dual frequency receivers and differential post processing error correction, it was possible to obtain both the relative position and the absolute position of surveyed points, in UTM-WGS84 system.
Next step was the navigation in these areas with code-based GPS, connected to the multimedia application on the PocketPC.
All the tests have been realized walking at low speed.
In the next images different tracks, followed in Piazza Magione, are shown, walking on low walls next to a building.

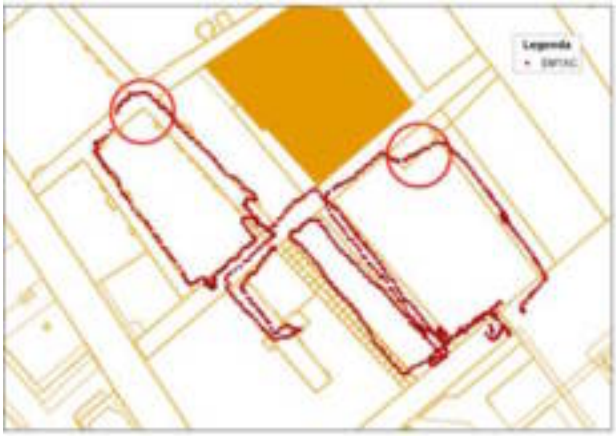

Figure 10 – A track using the EMTAC receiver

Figure 11 – A track using the Holux receiver

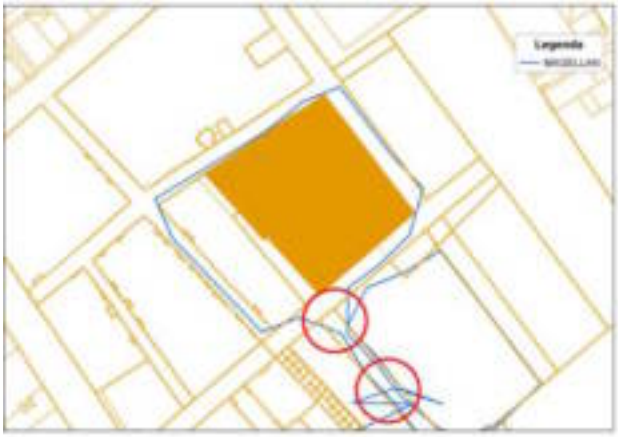

Figure 12 – A track using the Magellan Sport-Track MAP receiver

In the previous images some red circles are shown, that indicates the zones where each receiver gives its worst performance.
It is important to underline that curves are often critical points, after those receivers can mantain the correct direction, but not the absolute position, that is often wrong. Probably it is due to the algorithms implemented in the receivers, optimized more to maintain a straight direction than to fix absolute position with high accuracy. The next images shows the results of the experimentation among trees: during these tests GPS receivers are positioned on the head of the walker, fastened to a short sunhat.

Figure 13 – Tracks using GPS receivers among trees

This image shows that there is no GPS receiver that gives the absolute position exactly, but the accuracy varies from 0,5 meter to various meters.In the next image some tests in a wide area are represented: this is a parking area, but it looks like a wide and open archaeological area. In this case we can have the shortest error in absolute positioning, because there aren't obstacles to "see" satellites.

Figure 14 – Tracks using GPS receivers in open area

8. CONCLUSIONS

The application has reached a good technical maturity, and GPS receivers with new chipset can fix the position with a good accuracy.
Some problems about positioning persist in critical zones, like walking near buildings or under trees.
At this time we don't know exactly if GPS producer implemented algorithm to enhance navigation along straight routes, and this topic can be next step of this research.
Anyway, this built-in system can now be used without any critical problem for open archaeological sites fastening the receiver, for example, to a jacket or on a hat; a further enhancement of this system, with a better positioning accuracy, can be obtained combining it with a RFID checking system.

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