Abstract

A set of different technology areas led to a new type of system, the Mobile Geographic Information Systems (GIS).

Through Mobile GIS it is possible for people to see their location on a map at any time via a mobile device. This feature opens the door to several attempts to exploit these systems. Currently Mobile GIS are used in several areas such as tourism, sales and to collect data in the field.

In this paper we present the application MobileTrails, which was developed in the context of improving the nature tourism in the Peneda-Gerês natural park.

MobileTrails is an innovative application for mobile devices, preferably with embedded Global Positioning System (GPS) receiver. This application is aimed for tourists in general, offering them a unique experience of acquiring knowledge through geographic information (maps), texts and audio related to Routes and Interest Points.

Keywords: Mobile SIG, Localization, GPS, Tourism, Geographic Information, Trails, Interest Points.

1 Introduction

The Mobile devices, like PDA, have suffered a huge evolution during these last years. They are no longer seen as task support instruments (or electronic calendars), but they are seen as potential tools for data processing [1].

Mobile GIS were originated from the union of the following three technologic areas [1]: SIG, Mobile Computing and Location Systems. A Mobile GIS composed by these technologies can give to its users the ability to view and edit geographic information, know their location, and all of this in a mobile environment (Figure 1).

![Figure 1: Mobile GIS application main aspects.](image)

Nowadays natural park tourists use tourist guides, paper information and GPS devices to turn their visits more rich and easy. The use of this kind of help may help the tourists in their visits but it is not enough.

For example a tourist can reach a natural park and don't get any available tourist guide in that moment to take him to visit the park. This problem will be a waste of time if the tourist chooses to wait for a tourist guide, otherwise if the tourist chooses to take the visit all alone, he wouldn't have such a rich visit like he would have with the presence of the tourist guide knowledge's of the park.

When we above mentioned paper information, we were talking about geographic information like maps and information about flora and fauna of the park.

It's easy to deduce that few people can correctly read a map in the field and make correct use of it, as it's also difficult for many people make the best use of all the flora and fauna information of a natural park during their visit despite having it.

As an alternative of maps, many people use GPS devices to view their correct location. Although this solution gives the tourist his correct location, he still needs to use paper maps to see witch trails he can make in the park.

Analyzing what we said so far, we can say that if it existed one mobile GIS application that could center in it geographic information, flora and fauna information and have the ability to know the location of the mobile device where the application is running, it would be a huge help to
improve the quality of the natural park tourists visits. Therefore it is around this paradigm that we developed the application that we will show ahead in this paper.

2 Related Work

In this chapter we will present some specific mobile applications.

All the following applications provide users the possibility to see the location of a mobile device on a map, interact with that map and view interest points in it. Although the great similarity between the applications, they are all different from each other due to some specific characteristics of each one.

2.1 MacauMap

MacauMap [2] (Figure 2) is a mobile application used for tourism only in Macau. This application help people visit Macau, because using it people get help about how to get to a certain place. This application gives to its users the best way to go to a place and which public transports users can take to get there.

![Figure 2: MacauMap interface.](image)

MacauMap have a good feature which allows users to view different details of maps. This application was developed in order to be used only in Macau.

2.2 Yeliu Geological Park Mobile Tourism Guide

Yeliu Geological Park Mobile Tourism Guide [3] (Figure 3) is an application used for tourism in a natural park. This application was developed to be used only in this natural park.

![Figure 3: Yeliu Geological Park Mobile Tourism Guide interface.](image)

With this application users receive information from interest points through images, text and audio according to user preferences.

2.3 Cruso

Cruso [4] (Figure 4) is an application used for tourism in cities.

![Figure 4: Cruso device/interface.](image)

This application was designed in order to help tourists to visit particular places. This application can be used all around the world since the device application has the needed data to work properly. With this application users receive information from interest points through images, text and audio according to user preferences.

2.4 TomTom Navigator 7

TomTom Navigator 7 [5] (Figure 5) is a mobile application used to help people to get directions about how to get to a certain place.

![Figure 5: TomTom Navigator 7 interface.](image)

TomTom Navigator 7 is a very complete mobile application and has a large number of
features that facilitate its use and provide to its
users an essential aid.
This application can be used all around the
world since the device application has the needed
data to work properly.

2.5 Google Mobile

Google Mobile [6] (Figure 6) is a mobile
application used to help people to get directions
about how to get to a certain place.

Google Mobile has a very good functionality
which allow the user to obtain the location of the
mobile device without the need of the GPS. This
feature is very useful due to malfunction of GPS in
some places (near tall buildings, areas with tall
trees).

3 Development Technologies

The Mobile GIS application that we developed
will be used in outdoors (urban and rural places),
use geographic information and a tracking
system. Regarding these aspects the application
will have the following main requirements:
• Maps visualization.
• Maps navigation.
• Spatial data association to attributes.
• Read positioning data from a GPS device.
• Query to attributes.

It will be weed thinking on these requirements that
we will choose the better framework for the
application development.

3.1 ArcPad

ArcPad [7] is a product from ESRI enterprise.
ArcPad support all the format files that we
could work with, support GPS and have a low
price. But despite that, this framework have a
huge problem, it is not possible to develop
adaptable solutions for a specific problem with it.

3.2 ArcGIS Mobile

ArcGIS Mobile [7] is also a product from ESRI
enterprise.

This framework supports all the format files
that we could work with, support GPS and support
the development of adaptable solutions for a
specific problem.
But despite all this advantages ArcGIS Mobile
have a high price because this product from ESRI
can not be bought separately from ArcGIS Server.

3.3 Map Suite Pocket PC .Net GIS Component

Map Suite Pocket PC .NET GIS Component
[8] framework is a product from ThinkGeo
enterprise.

This framework does not support GPS, and
some important data formats, but it supports the
development of adaptable solutions for specific
problems. The price of this product is accessible.

3.4 GIS .NET

GIS .NET [9] is a product from Geoframeworks
enterprise.
This framework as characteristics very similar
to Map Suite Pocket PC .NET GIS Component.
GIS .NET framework does not support GPS, and
some important data formats, but it supports the
development of adaptable solutions for specific
problems. The price of this product is accessible
(lower than Map Suite Pocket PC .NET GIS
Component).

4 MobileTrails

4.1 Design

MobileTrails [10] is an innovative application
developed by SIQuant for PDA devices,
preferably with a GPS receiver. MobileTrails can
be sought by any entity that wishes to provide to
its audience a rich experience of visiting a place
without the presence of tourist guides.
This application support and complement the
experience of tourism in natural parks, urban
centers or historic cities. MobileTrails takes
advantage of its integration with additional
equipment (GPS) to detect the user's
geographical location at any time. MobileTrails
trails content information as been prepared by
specialists and provides tourists high quality
information services. The visits offered through
this application enable tourists to enjoy the visits
at their own rhythm.
The visitor only have to get the equipment where it is available (in a natural park door, tourism center information, or reception of a hotel) and he will receive information through a very simple and intuitive application (Figure 7), as he progress in its visit. It also could be possible to provide the application and application data via Web.

MobileTrails is complemented by a web application (WebTrails), which allows the various contents to be managed and updated by content managers. The content managed in WebTrails are exportable in an open format, XML, in order to be installed on the PDA, and therefore they can be viewed and used under MobileTrails. This content can also be found directly on the Web, through the address: www.webcomfort.org/percursos/.

MobileTrails has the following general features:

- **View general information**: Ability to view general information about the place (Natural Park, Historic Center City), contacts and useful information for the tourist.
- **View trails**: Ability to view trails and its interest points. The visualization of the trails (with its interest points) takes the advantage of a geographical information map, through a planimetric view, and joint operations like zoom, pan, and more.
- **View/search information about natural species**: Ability to view/search plant and animal species guides. The search can be performed using the following criteria: alphabetically, kingdom and extracts.
- **View/search interest points**: Ability to see the details of interest points. The search can be performed using the following criteria: alphabetically, by interest point type, or by trail.
- **Make a trail**: During the journey the visitor will have access to a range of features supported by the existence of the GPS receiver (make a trail, receive alerts, end a trail, see statistics about the trail visit and save the trail visit).
- **Import database content**: Possibility to download a zip file with the current version of the database system, and update the PDA local database.
- **Configuration mechanisms**: Ability to customize and configure all aspects of the running application (relevant interest points, activate/disable interest point proximity alerts, GPS configuration and trail alerts).
- **Maps navigation**: (Zoom in, Zoom out and Pan).

### 4.2 Implementation

MobileTrails uses Microsoft .NET Compact Framework (.NET CF) and was developed using Visual Studio 2005. This choice was made because the .NET CF enables the possibility to share tools and programming models, obtaining a lower cost and increasing efficiency in the development of mobile applications. .NET CF provides a robust and secure environment to execute code. The .NET CF supported code model increases the reliability of the code, reducing the defects in the software. At the same time, the security model through .NET CF ensures that malicious code does not have access to security features of the system.

We used the ThinkGeo framework Map Suite Pocket PC. NET GIS Component to view maps. When we choose this framework among those discussed in Chapter 3, we didn’t regard the GIS .NET framework. This framework only appeared in this project context further to replace ThinkGeo framework due a problem that we faced. ThinkGeo framework was chosen over ArcPad, because ArcPad didn’t fulfill our needs to develop all the features we wanted to MobileTrails.

Although ArcGIS Mobile framework satisfies our needs to develop MobileTrails, we chose to use Map Suite Pocket PC. NET GIS Component due to its price. The price of ArcGIS Mobile is quite high because this product from ESRI can not be bought separately from ArcGIS Server.

We chose to use data from a XML file on MobileTrails application, this choice was made because this way we can easily pass information between WebTrails and MobileTrails. The XML file will never have a large disk size and since the file is formatted in XML it will be easy to interpret, since there are many libraries that help with XML interpretation.

MobileTrails code was structured in three components (Figure 8): Menus, Objects and Session objects. In addition to these components
there are two files that exist at the same level of those components, that are the Program and Sound. The Program is the file where the application is started. Sound is a file where it is defined the class that allows MobileTrails to play audio.

Figure 8: MobileTrails Software architecture

5 Tests and Results

All MobileTrails tests were made using a PDA TDS Nomad 800L (Figure 9). This PDA has the following characteristics:

- High strength (impermeable to liquid and dust - cert. IP-67)
- Windows Mobile 6
- Marvell XScale 806 MHz Processor
- Memory: 128MB + 1GB
- VGA screen, Bluetooth, WiFi, USB
- SiRFStar III GPS (2 meters precision)
- Long battery life (12 hours)

There were made several tests to monitor MobileTrails correct functioning throughout the application development. These tests can be separated into two categories: usability and information validation.

In the development tests we detected a serious problem with the framework of ThinkGeo. This framework threw an exception that could not be treated in the application compromising the correct function of MobileTrails. This exception occurred after some map interactions (Pan, zooms).

There were made two types of analysis to test the usability of MobileTrails, one analysis using an analytical method and other using an empirical method.

The analytical evaluation was made using Nielsen Heuristics (NH) [11]. This evaluation was made by a group of 5 people with ages between 24 and 26 years old. The result of the evaluation can be seen on Table 1.

<table>
<thead>
<tr>
<th>NH</th>
<th>Description</th>
<th>Result (+,-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NN-1</td>
<td>System state always visible</td>
<td>+</td>
</tr>
<tr>
<td>NH-2</td>
<td>Talk user’s language</td>
<td>+</td>
</tr>
<tr>
<td>NH-3</td>
<td>User controls and exercise free will</td>
<td>+</td>
</tr>
<tr>
<td>NH-4</td>
<td>Standards consistency and adherence</td>
<td>+</td>
</tr>
<tr>
<td>NH-5</td>
<td>Avoid errors</td>
<td>+</td>
</tr>
<tr>
<td>NH-6</td>
<td>Recognition rather than memory</td>
<td>+</td>
</tr>
<tr>
<td>NH-7</td>
<td>Flexibility and efficiency</td>
<td>+</td>
</tr>
<tr>
<td>NH-8</td>
<td>Screen design aesthetic and minimalist</td>
<td>+</td>
</tr>
<tr>
<td>NH-9</td>
<td>Help users to recognize, diagnose and recover from errors</td>
<td>-</td>
</tr>
<tr>
<td>NH-10</td>
<td>Give help and documentation</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1: NH results.

The empirical evaluation was performed by the same group of 5 people. This evaluation was used to adjust the application interface throughout its development, with some of the users relevant suggestions originated from it.

The information validation was made on two levels: at the level of GPS information and geographic information.

The GPS information was tested recording some GPS readings from the PDA GPS device. Once recorded these values, they were inserted in GoogleEarth to see if the values were consistent.

Then we tested these recorded values with MobileTrails geographic information.
In Figure 10 and Figure 11 we can see trails made in Mirandela and Alameda/Lisboa respectively with the correct integration of GPS values on the geographic information.

In Figure 10 we can see a part of the trail with some instability on the data recorded from the GPS. This occurred due to the big buildings that exited in that part of the trail.

MobileTrails is being used in a real scenario in the Peneda-Gerês natural park (PGNP).

PGNP is one of the more emblematic protected areas in Portugal. To improve the conditions of the natural park tourism and to promote the knowledge of the park natural and cultural values it was created a solution by the enterprise SIQuant. This solution was promoted by the PGNP Development Association (ADERE-PG) with the partnership of the local mayors.

PGNP has some physical facilities strategically located throughout the park, designated as park gates. It is in these ports that visitors go to get information about the natural park and to better plan their trip. At the front desk they can order PDAs, learn some instructions to use the device and the application MobileTrails.

The system information developed for PGNP is generically composed by the following two applications (Figure 12):

- **WebTrails**: content management application;
- **MobileTrails**: application for content visualization in a PDA with GPS environment.

WebTrails is a web application, which was developed using Microsoft ASP.NET technology. There is only one instance of the application WebTrails installed on a single place, through which various technicians and managers of PGNP can build, manage and update content. It is through this application that they do a dynamic management of all the PGNP information.

This information can be viewed via Web and later exported and installed on MobileTrails. Any update of the MobileTrails content must be made through the WebTrails and then exported to the MobileTrails.

This solution tests were made in 2 phases. The first phase includes the tests made by the developers and the end customer throughout the development. The second phase includes the tests of the final product itself in PGNP. For the final acceptance tests, two elements that participated in the development of the solution went to the natural park and tested the proper functioning of MobileTrails on the ground, with people from ADERE (Figure 13).

During two days of field tests, some problems detected were fixed, as well as some changes requested by ADERE were implemented. At the
end of two days we were able to test the proper application functioning in all aspects / requirements, despite the problem with the framework Map Suite Pocket PC. This problem was very critical, and as consequence MobileTrails could not be available to the public until a solution weren’t found and implemented.

6 Conclusions an Future Work

6.1 Conclusions

After the conclusion of this project we can say that MobileTrails can be used in a completely autonomously way, at any time and anywhere, since it’s used by PDAs with Windows Mobile and .NET CF support.

All the requirements initially set to be implemented were successfully completed with the exception of the problem originated by the Framework Map Suite Pocket PC.

The problem originated by the framework led to an unexpected high effort to obtain a solution for the respective problem. We initially reported this problem to ThinkGeo, from who we expected a solution. But ThinkGeo didn’t give us a solution to this problem over a long period of time, then as consequence we decided to use another framework. We decided not to wait any longer, due project deadlines between SIQuant and ADERE-PG.

GIS .NET was the framework chosen to replace the framework Map Suite Pocket PC. All application development with the new framework was made by a member of SIQuant due my lack of time caused by professional reasons.

MobileTrails functionalities provide to its users all the features mentioned above in this paper through a simple and practical interface. All features provided by MobileTrails are presented with a good quality of information and performance.

MobileTrails features give to its users an easier way to visit places and to access geographic information in the field in real time. This was the main objective of the application and it was achieved. This feature is possible by other applications on the market, but all the other possible MobileTrails features make this application unique in the tourism market. Features like being able to save routes in more than one format, configurable quantity of information displayed in the screen, interest points proximity alerts and trails alerts, are features that make MobileTrails unique as a whole.

Analyzing these factors we can state that the project objectives initially set have been successfully achieved.

6.2 Future Work

Like GIS is a constantly expanding area which uses powerful levels of information that provide all means necessary to create innumerous new features, there is an endless range of proposals for future work for MobileTrails.

A new feature that MobileTrails could have is different maps details support. When we talk about maps details, we are mentioning maps resolution, and maps layers. This feature could give the user the possibility to choose which resolution he want to use in the map (image Mrsid), as well as which layers he wants to see (layers such as roads, lakes, buildings).

We thought in this feature because not all PDAs have a powerful processor, then this feature would transform MobileTrails in an application available to a larger number of PDAs and as consequence to a larger number of users. Allowing the user to choose which maps layers he wants to see, will led to improve the performance of the PDA as well as improve the application customization (improve which information the user want to see in the screen).

Another feature that was thought would be the introduction of a Multimedia Tourist Guide. This new feature would be very important because the main objective of MobileTrails is to be used for tourism in outdoors, and many PDAs suffer from some screen invisibility due direct contact with the sun. In addition to the visual information already provided by MobileTrails, it would be possible for users to receive multimedia information, including audio about the trails and alerts. As consequence the user would enjoy its visit, as if it was with a real tourist guide. MobileTrails already plays audio, then the development of this feature wouldn’t have a high effort.

This application is intended to be used in tourism, then it’s normal that many people of other nationalities would like the opportunity to use MobileTrails. So it’s important that the application support various languages.

As GPS sometimes looses its signal, or suffer from significant errors in certain areas (in the middle of trees or tall buildings), it would be interesting to find another way to obtain information about the location of the device. This new feature would end the problem of bad signal reception, and would also enable the possibility to use MobileTrails in other contexts, such as tourism inside buildings (museums visits).

In order to enrich the way like geographic information is shown to the user, MobileTrails could have an altimetric perspective to display maps. This feature would allow users to have a better understanding of the trails displayed in MobileTrails.
All these features were thought in order to make MobileTrails even more appealing and unique. Despite that MobileTrails would reach a larger number of users and types of use.

7 References