

# Indoor and Outdoor Audio Guide System Using Smart-Phones and Electronic Tablets

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**Abstract**— This paper presents an audio guide system based on indoor and outdoor location implemented in smart phones. The now proposed geo-referenced audio-guide is developed using android phones, and a complete solution for the audio guide management system is implemented using Google Earth. To the best of the author's knowledge the now proposed system is the first that allows indoor and outdoor guided systems simultaneously.

**Keywords**—Audio Guide, Geo-referenced contents, indoor entertainment, touristic applications, WiFi, GPS, Outdoor.smart-phones

## I. INTRODUCTION

Touristic applications using geo-referenced services are becoming a viable solution for autonomous visiting in several countries [1-2-6].

In that sense the correct location either in outdoor but also in indoor scenarios is a potential application for most of the smart phone enabling technologies.

Although there are several studies and implementations of indoor location systems [5], most of the commercially available solutions are mainly outdoor audio-guides, using GPS, indoor solutions normally requires user interaction as a mean to provide inputs so the system can trigger events at the right location.

Nevertheless most of the touristic routes include visits to museums and historic places that include locations where the GPS signal is too weak to give an accurate location. This is the reason why a correct indoor location is fundamental in this type of scenarios, and it can be a high value to tourists travelling in autonomous ways. Systems like OWPLS [5] obtain great results using WiFi signals for indoor location but it uses complex infrastructure in a server-side computation of user's location.

The now proposed implementation uses the WiFi signal in a simple way. The signal is used to trigger events, not necessarily knowing the users location. This way, the mobile device is standalone in all process.

In this paper a new touristic application that implements an audio guide with automatic indoor and outdoor triggers is presented, as a new protocol that is based on GPX [3], which is a protocol used in several GPS commercial navigation systems.

We will start by presenting the implemented audio-guide scheme and system flow, by then explaining the data-base procedure and the implemented protocol for content delivery. Finally the implemented software will be presented.

## I. IMPLEMENTATION SCENARIO

The touristic audio-guide that is proposed in this paper is based on a protocol that is implemented in a LUD file. This file describes which contents should be played in each position. The position for each point is saved in the file either in GPS format, or in WiFi MAC format. Fig. 1, presents both of these scenarios. The first scenario happens in an outdoor environment, where the software package mainly compares the GPS value with each marked point, and if they are close enough (this distance is set by the user) the audio starts playing.

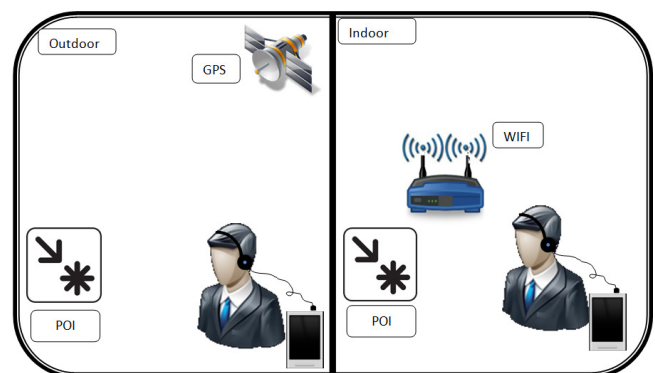


Figure 1 – Scenarios Applications

In the second approach GPS signal is not available, then the audio is triggered by WiFi signal, this scenario allows the audio guide to be used either in outdoor, but also in indoor environments.

## II. SYSTEM FLOW OF OPERATION

The developed Smart-phone application implements the process described in the flowchart of Fig. 2.

When the application starts, it loads a file given by the user in a proprietary format (LUD), based in GPX protocol, where predefined information about the Points of Interest (POIs) is saved.

Using a build in map application, data read from the database file is used to overlay Geo-referred POIs on it.

Next step is to switch on all the necessary hardware interfaces needed to determine the user position, which are the GPS and the WiFi receiver.

The application runs in two different modes that converge to a unic outcome, which is an audio file being played.

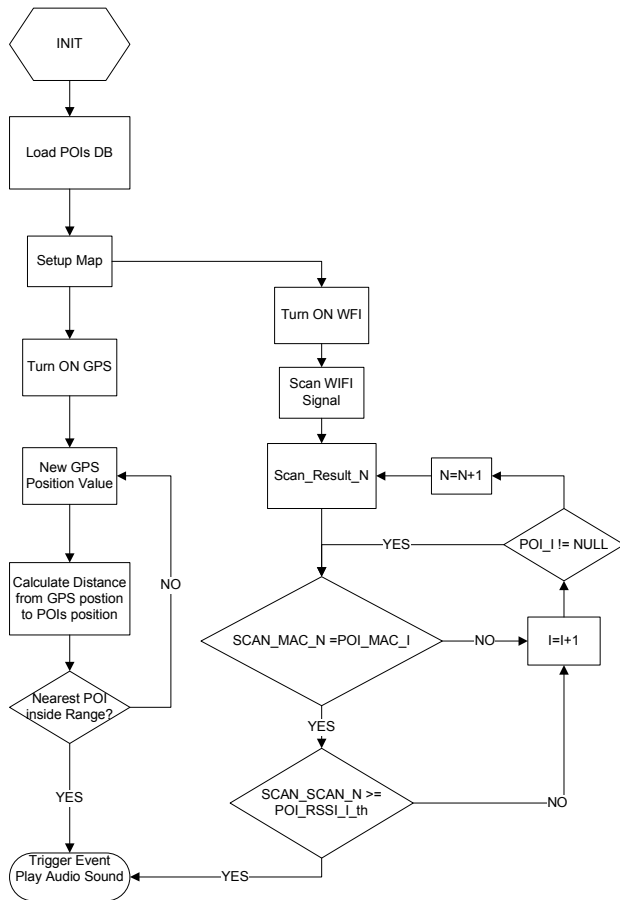


Figure 2 – Application Flowchart

One mode of operations is implemented by using a listener that reads new data from the GPS receiver. When this listener is triggered, the application calculates the distance from the obtained position to every POI location. If the user position is inside the range area of the nearest POI, a trigger event will be triggered and the audio file related to that POI is played. A flag is used to determine if the user is inside or outside each of the various areas. This prevents the system to be cyclically playing the same audio file once the user enters a trigger zone and remains within.

In the other mode of operation, the WiFi system is used. In this case, a scan for WiFi signals is initially performed and the MAC address of each captured WiFi signal is compared with the MAC address relative to each POI of the database file. If there is a match, the scanned WiFi signal strength is compared with the POI WiFi signal threshold. If greater or equal, the relative audio file is played. This can happen in inside and outside areas, when WiFi signals are received.

### III. CREATING THE DATABASE FILE

The database file is a structured file, with the “.lud” extension, that contains all the information about the points of interest.

```

<wpt lat="40.63003263485877" lon="-8.658904340791057">
<mac add="00807e3d72c3" rssi="-90"/>
<category>4</category>
<name>STIC - Serviços de Tecnologias de Informação e C<
<desc>Os Serviços de Tecnologias de Informação e Comuni
<link href="TOUR_Campus_Aveiro/Loc_1"/>
<sym>Waypoint</sym>
<extensions>
<gpxx:WaypointExtension xmlns:gpxx="http://www.garmin.c
<gpxx:Proximity>50</gpxx:Proximity>
<gpxx:DisplayMode>SymbolAndName</gpxx:DisplayMode>
<gpxx:Address>
<gpxx:StreetAddress>Campus Universitário da Universidac
<gpxx:City>Aveiro</gpxx:City>
<gpxx:State>Portugal</gpxx:State>
<gpxx:PostalCode>3810</gpxx:PostalCode>
</gpxx:Address>
<gpxx:PhoneNumber>+351234666666</gpxx:PhoneNumber>
</gpxx:WaypointExtension>
</extensions>
    
```

Figure 3 – Data relative to a POI in the “LUD” file.

To help create this file format, a java application was developed. A capture of the application interface is present at **Figure 3 - KML2LUD Application** Fig. 3.

To create POIs using the referred application, the input can be a KML file containing a folder with Placemarks, a GPX file or create the POIs manually using the application interface.

Relative to each POI, there is a set of fields that must be filled-in, which are:

1. Latitude
2. Longitude
3. Mac
4. RSSI
5. Local Name
6. Address; City; Country; Postal Code
7. Phone
8. Description
9. Proximity
10. Category
11. Audio File
12. Image
13. Tourguide Name

“Latitude” and “Longitude” identifies the points of geographical position in GPS format.

The “MAC” and “RSSI” fields, are used for the indoor location and identify each WiFi signal that is associated to a POI; they are, respectively, the address of a WiFi signal source and the corresponding signal strength threshold that triggers the event.

“Local Name” is a name to be associated to the position.

The next fields, “Address”, “City”, “Country”, “Postal code” and “Phone”, are optional but important to offer a greater level of information about a place.

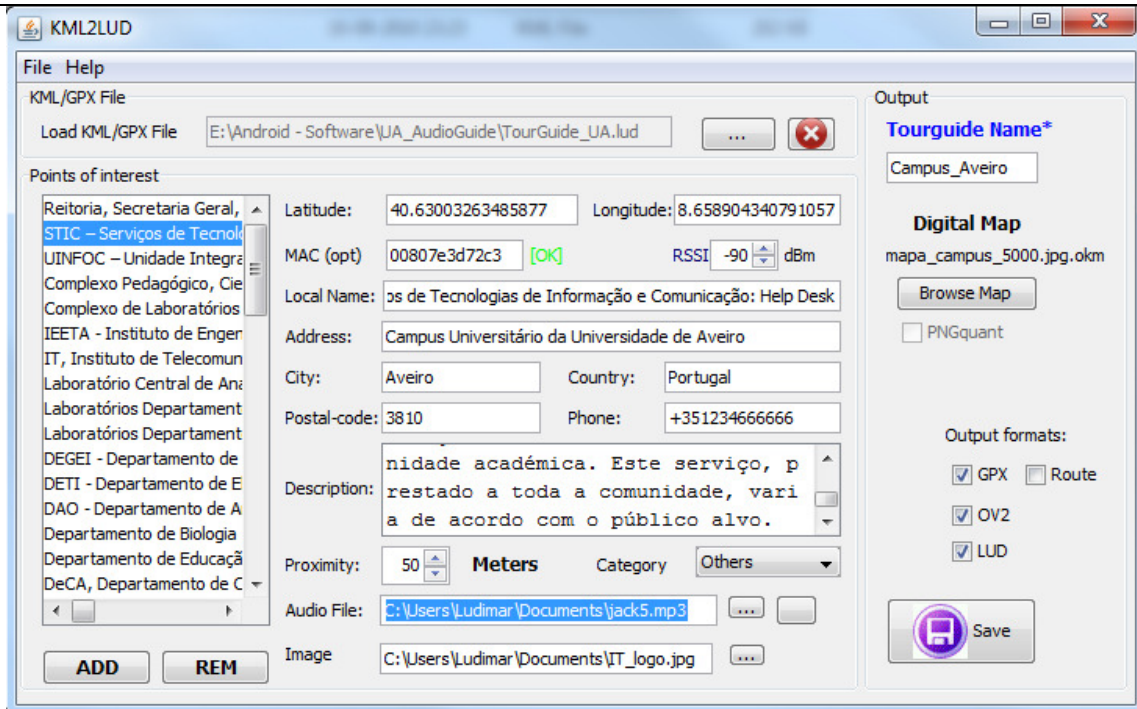


Figure 3 - KML2LUD Application

The field “Proximity” is very important; it determines the radius (in meters) of a circle centered at the position given by Latitude and Longitude, i.e., the area where the event should be triggered. For indoor POIs this parameter is irrelevant because the trigger is based in RSSI signal value.

The “Category” field gives the ability to classify the point based on its type (Museum, Monument, Hotel, Eating and others).

At the “Audio file” field, a path to an mp3 file must be inserted. The file contains the audio to be played when the event fires.

If an image file path is entered at the “Image” field, it will be used together with the description, at the Smart-Phone device, to offer more information about the place (Fig.5).

At last a name for the tour guide is entered in “TourGuide Name”.

Besides “lud” files, this application can output the POI in two other formats, GPX and OV2, so they can be used in commercial GPS devices.

In “Digital Map”, a calibrated raster map can be associated with the tour, to be used in indoor situations or where Google Maps® is not available.

#### IV. ANDROID APPLICATION

An application for Android mobile devices was developed in order to implement the proposed touristic solution. This application is responsible to read the content of the created POI database, explained in section III, overlays this data in a map and fires an audio events when near a POI.

To a correct functioning of this application a database file is required to be load. After this, the audio guide is ready to start.

As shown in **Erro! A origem da referência não foi encontrada.**Fig.4, the POIs present at the database are loaded and overlaid in the map (Google Maps®). If a raster map is related with the tour, it will be overlaid in the map too. When the default map is not available or does not provide the best detail, e. g. in indoor locations, the raster image works like a background map. The raster overlay can be turned ON or OFF at any time.

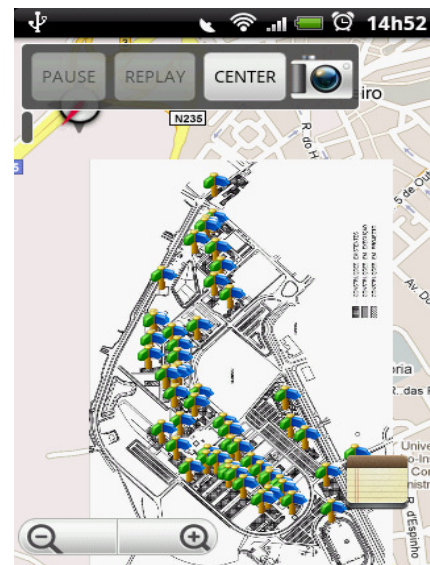


Figure 4 - Android Application Map Screen

When an event is fired, the relative audio sound is played. While playing, the sound can be paused and resumed.



Figure 5 – Image and description of a point.

The proposed application allows taking pictures using the phone camera and saving them with the position information in KML® format.

All POIs can be listed at anytime and all information about them is available, also listen to the sound relative to each of them, or use the Google Navigation® to get turn-by-turn indication to reach a POI location(Fig.5).

## V. TESTING AND RESULTS

The implemented audio guide application was successfully tested using several Android phones. All the tested Android mobile phones were equipped with a GPS receiver and WiFi. Several database files were used, some with more than 60 POIs.

To evaluate the performance of the implemented audio guide, it is necessary to divide it in two parts: the GPS and the WiFi system. But it is important to know that both systems runs sumultaneously, i.e., in outdoor where GPS is present, the system is always scanning for WiFi signals, and in indoor locations, where GPS signal is weak, it keeps trying to obtain a fix on the current position. For this reason, there is no handover delay; delay is only present when the user goes from indoor to outdoor, while the GPS receiver tries to get a fix on the position.

GPS is a very reliable source of location, so it is not a surprise that the audio guide works pretty well in outdoor locations. In indoor location, some problems occur because WiFi signals are not constant in time at the same location. This is a problem because the RSSI value is

used as the last trigger parameter. With RSSI trigger values of -65 dBm to -55 dBm correspond to trigger distance of less than 5 meter. These values are, obviously, dependent of the location scenario and have to be selected after a location survey. On other side, with higher rates of WiFi scan, one second or less, it becomes more reliable to control the trigger zone with the RSSI value.

## VI. CONCLUSION

This paper presents an implementation of an audio guide for mobile devices, able to hold outdoor and indoor points of interest. It uses GPS in outdoor locations and WiFi for indoor locations. For this first case, the trigger zone is defined by the distance from the device to the POI. Using WiFi, this zone is defined by the area where the RSSI value is higher than a user defined value. The system works pretty well in most of the tested zones, and it become a commercial solution for touristic applications.

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