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Mobile Platform for Helping Visually Impaired Citizens Using Public Transportation: A Case Study in a Portuguese Historic Center

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***Abstract*—**

In this paper we present a case study, developed in the Historical Center of Viana do Castelo, a city on the north of Portugal. Using mobile technology at the service of disabled people, namely visually impaired people, we have developed a solution to help them use public urban transportation and help solving a limitation these people feel in their daily routines. In concrete, when using public transportation, they have difficulty in knowing where they are and when to ring the bell to leave the bus. We present the solution architecture that comprises a backend to manage all routes and reference points and mobile applications that tells the user where he is along the way. Finally, we present the evaluation of the solution.

Keywords*— *Visually impaired; mobile navigation; public transportation.

I. INTRODUCTION

Mobile solutions are commonly used today for several purposes and domains. The evolution we have been assisting in these last few years regarding technology, processing power, supported sensors and functionalities made possible the development of a large range of different applications targeting different domains such as tourism, health and care, businesses, transportations, etc. In fact, mobile solutions can help us in our daily lives simplifying our routines. The relevance and utility of mobile application largely increase when we refer to disabled people, such as visually impaired people (VIP), to whom the benefits of mobile applications are greater than to the rest of the population. The limitations these people have prevents them, plenty of times, from walking alone in the streets which is one of the biggest problems VIP face: mobility. They can only go to places they previously learned with a sighted guide which means they can´t handle simple tasks available to everyone else without any disability such as going to the City Hall or the Supermarket. Getting lost is a huge problem and asking a person who is nearby can sometimes be the only solution but of course there are no guarantees there will always be someone nearby. Another limitation has to do with public urban transportation, a service most cities provide to their citizens to allow them to reach a given part of the city without using their own car. This service is also very relevant for VIP but using these transportations is not always easy and problems come up such as knowing where they are and when to leave the bus. Again, the solution most of the times is to ask someone who is on the bus. Some of the most adequate technologies to systems to help solve these issues are GPS or RFID, but there are definitely some trade-offs in both. GPS cannot guarantee an accurate precision and can fail in routes between high buildings. On the other hand, a mobile solution can be relatively cheap when comparing to a RFID based-system that requires the streets to be prepared with tags in the sidewalks. The benefit of this solution is that centimetres precision can be achieved.

In this paper, we present the first version of a platform to help VIP, developed as a case study in the Historical Centre of Viana do Castelo, a city in Portugal. The project had two main purposes from the beginning: a mobile solution to help VIP to perform walks between strategic points of the city and another mobile solution to help VIP to use public urban transports. In this paper, we will focus only on the second goal (mobile solution to use public urban transports).

The rest of this paper is organized as follows: in the next chapter we will present a literature review. Next we introduce the prototype implementation, starting with the contextualization of the project and the objectives; next we present the architecture and the detail of each component. Finally, we present the tests results and conclusions.

II. LITERATURE REVIEW

As a consequence of the growing research and development for disabled people, several platforms and systems have emerged in the last few years. One of such systems is detailed in [1] where the authors present a novel prototype application of a system supporting street navigation and independent, outdoor movement of the blind. The system is capable of finding the route from the indicated source to chosen destination, using dedicated digital map and a set of various sensors. Subsequently, the system supports the movement of the blind along the found route. The user's position is obtained with the use of DGPS receiver. In order to further improve accuracy, particle filtering method is used. The system operates on a casual smartphone and communicates with the blind by the touch screen and by the voice messages generated by speech synthesizer. Nandish et. al present in [2] a research of a navigation system for blind people in order to provide more precise location information. To identify the position and orientation and location of the blind person the authors rely on Global Positioning System (GPS) technology, TTS (Text-to-Speech) program and Google Maps APIs in order to provide navigation with voices. Another solution of a navigation scheme has been proposed in [3] where the authors materialized a solution for the blind and low-vision people in order to provide precise location information using Android smartphone. The navigation scheme uses TTS for blindness in order to offer a navigation service through voice and Floyd-Warshall algorithm for suggesting the shortest paths. Also, it uses Google map API to show the route information. The proposed scheme, as an independent program, is fairly cheap and it is possible to install onto Android-based smart phone in an easy manner which allows blind and low-vision people to access the program interactively. Another solution is presented by Dornhofer et. al [4] is motivated by the fact that affordable technologies are not accurate enough to navigate blind persons on a safe trip. The authors defend positioning should be improved by telling the user the surrounding environment. They present a comparison between three different tools to route people (PgRouting, OpenTripPlanner and OpenSourceRoutingMachine). Finally, they present a prototype for Android to route blind people to a given destination with the following functionalities: allow the user to explore the whole trip on the screen, provide turn instruction by turn instruction, periodically speak the distance to the next crossing point. Yet another proposal is discussed in [5] where the authors introduce a system that provides indoor navigation by using Radio Frequency Identifier (RFID), outdoor navigation by using Global Position System (GPS) as well as obstacle detection by using ultrasonic sensor. User will give the starting and ending location then this system will give voice instruction to reach at destination by detecting obstacle also. This system can specially use in big campus like industries, big institutes where it will act as guiding map.

III. IMPLEMENTATION

A. Contextualization and objectives

As afore mentioned, the work presented in this paper is a case study for VIP to use public urban transports within the historical center of Viana do Castelo, a city in the North of Portugal.

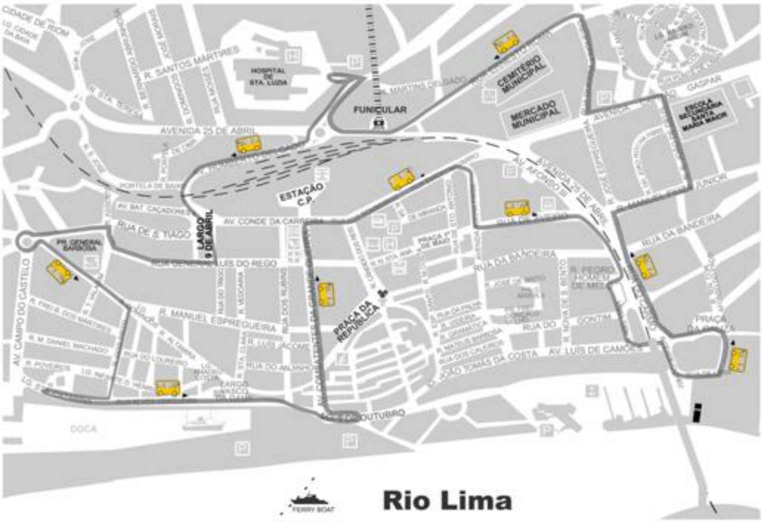

Fig 1. Urban transport route in the city of Viana do Castelo

Previously to this project, several routes (one for buses and several for pedestrians) have already been defined and they were used for this project. In concrete, there is currently one route (Figure 1) that two buses perform during the week from 9:30 to 13:00 and from 14:00 to 18:30. One of the reasons to develop a mobile solution from scratch and not use MeoDrive or Google Maps is that they lack significate reference points. Also, we don´t want the best route from a given destination to another; we want a specific route that can change by a variety of reasons.The purpose of the mobile application was to help VIP use these urban transportations what didn´t happen before. The main difficulty felt by VIP people was to know where they should ring the bell for the driver to stop the bus (this type of urban transportation have no pre-defined stops; they stop everywhere as long someone rings the bells. After a VIP enters the bus, they easily loose the notion of where they are and as a consequence they don´t know when to ring the bell to leave. The current and only way to solve this problem is to ask someone to tell them in what street they are or a reference point so they can know if it is already time to ring the bell. Reference points are the main aspect of the solution and this was one of the reasons we could not use Google Maps. There are indeed a lot of reference points but they are too much and plenty of times they are not relevant because are little coffee-shops that not everyone knows necessarily and, for that reason, can not be used as a reference point. Routes can change for several reasons: because it was decided the bus had to go through an additional street or, most likely, because one of the streets in the route is under construction/maintenance. This has conditioned the architecture of the solution requiring a backend to define the routes and support making quick changes to the route. Also, with the routes drawn in a map in the backend, it is easy for the administrative people that will use the backend to guarantee there are enough (and not too much) reference points along each route. All this leads to the architecture of the solution that we present in the next section.

B. Architecture

The architecture of the solution, shown in Figure 2, comprises a mobile application, a visually impaired person in a bus, the global positioning system – GPS, a backend, a set of PHP Web Services and a MYSQL Database.

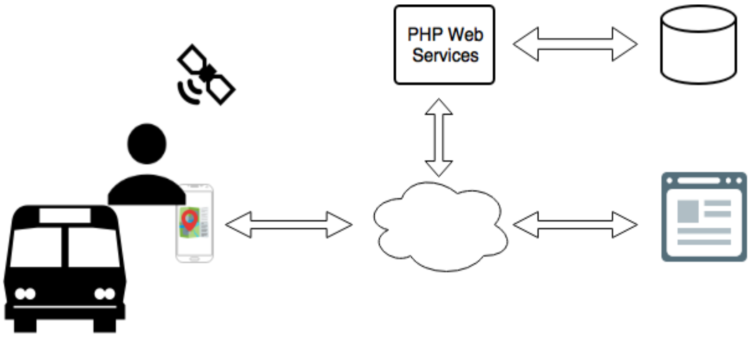

Fig 2. Architecture of the mobile solution for visually impaired people to use urban public transportation

The mobile applications (Android and iPhone) are used by a VIP in a bus in order to know where he is and when to ring the bell to get out. The mobile applications communicate with a GPS to obtain coordinates so it is possible to obtain the reference points close to where the bus/VIP are. The reference points are obtained from a web service that communicates with a MYSQL database, where data (routes and reference points) is inserted via a backend. Next we detail each of the architecture components.

C. Components

<u>Backend</u>

The backend was developed in PHP and has the main following functionalities, some of them illustrated in Figure 3:

- Manage (add, update, delete) a route (pedestrian or bus)
- Manage reference points
- Manage crosswalks (not fundamental for this project but for the pedestrian)

Whenever a change is made to one of this information, the last update date is updated so mobile applications can know they have to update their local data. The backend will also allow, in a near future, to mark dangerous places, under construction areas, traffic signals, etc.

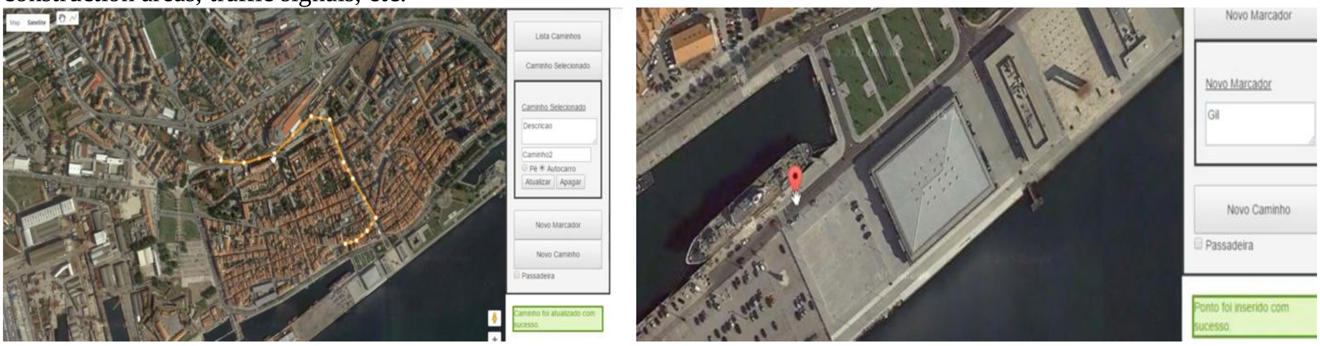

Fig 3. Backend main functionalities: a) add route and b) add reference point

The urban transport route that VIP will use and that is represented in Figure 1 had to be drawn using the backend, along with several reference points along the way. The representation is shown in Figure 4.

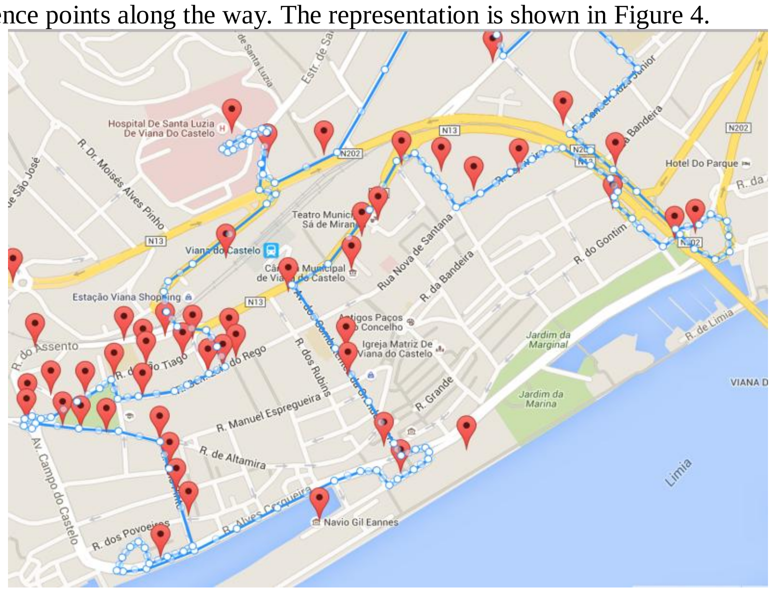

Fig 4. Representation in the backend of the urban transport route, along with several reference points along the way

Database and web services

The database that supports the backend is a MYSQL database and has the structure shown in Figure 5.

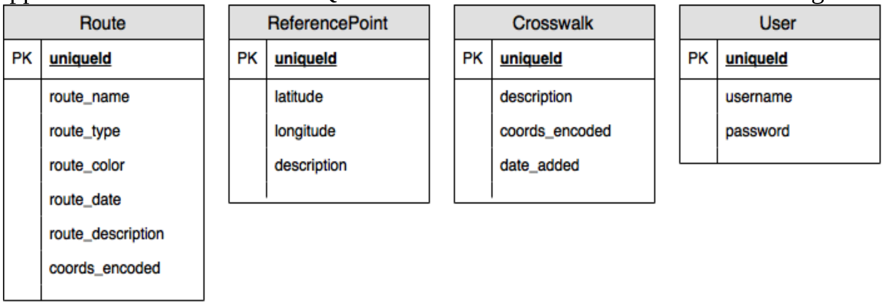

Fig 5. Backend supporting database

The database has 4 tables: one for the several routes where each route has name, type (pedestrian or bus), color, added date, description and encoded coordinates; another table is to store reference points and another one for crosswalks. Finally, one for the users that use the backend.

A set of web services were also developed so the data can be loaded from the mobile applications. For this project, three web services were needed:

- getRoutes() – so the mobile applications can get updated routes
- getReferencePoints() – so the mobile applications can get reference points
- getUpdatedDateTime() – so the mobile applications can check if their internal last update date is equal to the one on the server and update routes and/or reference points if necessary

Layout concerns

Before specifically addressing the mobile applications, it is important to first mention the concerns in the layout creation. Creating an application for a VIP is very different from creating an application for a person without visual difficulties. The VIPs that accompanied this work mentioned there are a lot of visual diseases. And while some people can see a map others rely completely on voice commands only. So in a first draft of the application, we were thinking of simply indicating the name and distance of the next reference point but then we chose to design a "normal" application (as for people without any visual disability) but always guaranteeing voice support either with TalkBack [6] or VoiceOver [7]. Strong colors were also something to avoid as some VIP have trouble visualizing them.

Mobile applications

The mobile applications have the main purpose of showing the user a map with its current location within the bus route. When the application is opened, and if there is Internet, a web service is called to verify if there have been some changes in the route and, in affirmative case, the new route is obtained and saved in the local database. After that, or in case no Internet connection exists, a map is shown presenting the bus route and the user´s current location, along with the reference point near it (Figure 6a). If more than one reference point is near the user, the application groups this information in order to present it to the user (Figure 6b).

In the top of the screen, the next reference point and the distance to it is presented to the user so he knows where he is and help him to decide when to ring the bell to ask the driver to stop.

In the bottom of the screen, the user can find the name of the current street, if the application has internet connection as this information is being obtained through geocoding through the received GPS coordinated.

All this information is read to the user by TalkBack or VoiceOver, as this is fundamental for most visually impaired people.

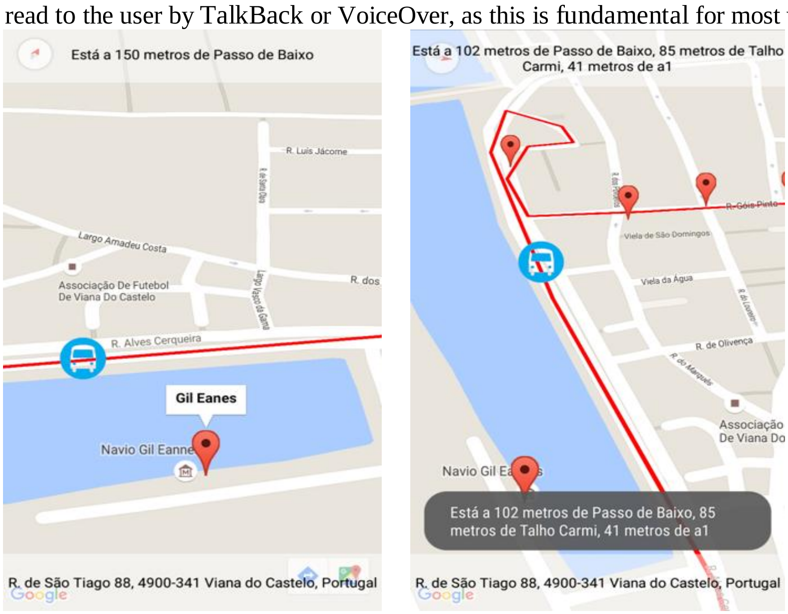

Figure 6. Mobile application user interface: a) one reference points; b) several reference points near the user location

IV. FIRST RESULTS AND TESTS

At this point, we have performed unitary tests that show a very good response of the application. The tests comprised several situations such as:

- no internet availability (in which case the street number is not shown),
- entering the bus in several locations and assuring a correct detection of the route and reference points
- existence of several reference points near the current location and assuring they are all indicated to the user on time

With these tests, we have adjusted the number of maximum meters' reference points can be from the current location in order to be indicated to the user. That parameter was first tested 100 meters but we have concluded it was very low because when the information was read the reference point has already passed, considering a moving bus. So we changed this number to 150 meters and the behavior is as expected: the user has time to hear the instructions regarding reference points and ring the bell to leave if he wants.

The amount of information presented to the user (reference points and current street) has also revealed to be correct and possible to read all of it before the next instructions appear.

V. CONCLUSIONS AND FUTURE WORK

The developed applications (both Android and iPhone) revealed suitable to be adopted by visually impaired people. To use them, routes and reference points should previously be inserted via a backend and updated whenever changed occur so mobile users can also receive updates. We had to consider some layout issues so the mobile interfaces can be used by all people, despite the type and level of visual disease.

Before the application goes into production we will perform some additional tests with visually impaired people to correct some last details.

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