Information and Assisted Navigation System for Blind People

Karen Duarte, José Cecílio, Jorge Sá Silva, Pedro Furtado
Department of Informatics Engineering
University of Coimbra, Portugal

***Abstract*—Nowadays public buildings are changing constantly, often people have to take different routes to reach known destinations. At the same time, new services and places are made available to attract more people to the shopping center. This dynamic environment is usually signalled and labelled with visual marks and signs which are not appropriated for blind persons. Therefore, blind users are unintentionally deprived of a full participation in the society. With the purpose of equalize the access to services and spaces among all persons, this work proposes an innovative indoor navigation and information system for public buildings, namely shopping centers, based on existing technologies not used for this purpose. Intending to allow a comfortable and helpful aid on blind persons trips to the shopping center, this proposal system relies on users smartphone and wireless sensors deployed in the environment.**

Index Terms*—Assisted Navigation, Indoor, Blind People, Blind Assistive Technology

I. Introduction

The World Health Organization estimates that there are 285 million visually impaired people worldwide, mainly in developing countries. Visually impaired persons are defined as those with reduced visual capacity. They can be blind or partially sighted people. These conditions often limit peoples capabilities to perform common tasks and affect their quality of life.

On the spectrum of daily activities and needs of visually impaired people, navigation plays a fundamental role since it enables, or disables, the person to independently move or safely walk. Currently, there is several visual information that helps visually enabled people to move in a right way (e.g. takes a right direction, avoid obstacles, choose the shortest path to a destination). Text information and arrow indications are frequently used, however this information is inaccessible to visually impaired people. Often blind people are unintended withdrawn from the society with the lack of an alternative path for information. Based on this real context we focused our work on developing assisting technologies that may help blinding people bringing them back to the society.

In order to improve the quality of life for visual impaired people, in this work we focused on new technologies to help those persons in the access of public buildings, in particular shopping centers. Shopping centers have the great feature of display a lot of visual information to attract customers and orient them into the building. Therefore this work intends to play a special role in this field providing as much information as possible for visual impaired people, allowing them to take a comfortable navigation (e.g. short paths, shops, products) inside the building. To build a prototype focused on users and their interests, we are developing this study in partnership with the national association of blind and partially sighted people, ACAPO - *Associação dos Cegos e Amblíopes de Portugal*, and a sociology research group from University of Coimbra, CES - *Centro de Estudos Sociais*. This work aims to build a system to assist people with disabilities. The system intends to help them and not solely be an appendix providing information or useless knowledge. One important requirement is ease deployment and usage, in other words the developed system and support application (software) must be able to be used with much ease and low cost hardware by visual impaired persons. Generally speaking, this study is intended to contribute for the enhancement and independence of visually impaired people in society, as well as their inclusion and participation.

The next section brings up a brief overview over state of the art of technologies designed for assist blind people on similar environments. The third and fourth sections explain in detail our proposed system and its various modules and functions. The last section is the conclusion and future work.

II. Related Work

There are several systems designed to assist visually impaired persons on daily tasks. For instance, ShopTalk[12] is a system designed to help visually impaired people finding specific products inside a supermarket, the system guides the user to the vicinity of the desired product with vocal instructions. A directed graph representing the topological map of the store is used for route calculations whose nodes are decision points like aisle entrances. Instructions delivered are set as done by user with a keypad, so the system is unaware of the user's position or orientation. Product recognition is performed by scanning barcodes on the shelves, once a barcode is scanned and identified, user's actual position is known. Although this system allows user positioning, guiding and finding specific products, it is a whole new device composed of a processor, a numeric keypad and a barcode scanner. ShopMobile is a proposal updated version of ShopTalk running on a mobile phone. Barcode scanning is performed by mobile phone's camera[9].

BlindShopping[10] is another system designed to assist blind persons on the supermarket. The floor is covered of Radio-Frequency IDentification (RFID) tags creating an RFID map used for user's location and guidance. When a route is calculated the user is guided to the destination through voice instructions and once in the vicinity of the wanted product it can be found by QR (Quick Response) code, RFID tag or barcode. The user will use personal smartphone and an RFID reader attached to the white cane. Information travels via wireless network and central server processes all information.

RoboCart[4] is a robot that guides the user to the vicinity of the selected product and helps finding it by scanning product barcodes on the shelves. As other systems, the floor of the store is converted into an RFID-enabled surface, where each RFID tag had its own 2D coordinates. This RFID tags are used as recalibration areas, when the robot reaches a recalibration area its localization is well known.

A different system places voice emitters near sections on the supermarket that displays information when a person approaches them[5]. Detection of proximity of a person is performed by infrared sensors, and the proximity distance can be set from 10cm to 50cm depending on establishment preferences. Information displayed can be used for costumer guidance, not only blind or visually impaired costumers. This system just delivers additional information to the blind user path, being the path definition customer's responsibility.

A different system based on RFID technology[13] allows the user to travel through the space and to find objects or points of interest as long as they are tagged with an RFID identifier. Each tag is documented and has associated a voice instruction or information used to guide users. The user's device is an RFID reader and a headset, and a central server is used to perform decoding of identifiers and send back the user's device the respective information. A strength of this system is that the central server enables easily modifications on information, in contrast the environment must be fully covered of RFID tags.

A smartphone and RFID based system, BlindAid[11], uses an external RFID reader and the user's own smartphone to guide them to a specific destination. An effective tags placement enables user localization everywhere and direction of travel calculation in order to plan route and deliver the right instructions to the user. Path calculation is performed by Dijkstra's shortest path algorithm. User inputs are received through voice inputs or mobile phone's keypad.

Smart-Robot is presented as wider system enabling navigation indoors and outdoors[14]. Indoor navigation is performed using RFID technology and outdoor by GPS. The robot is equipped with an analog compass for orientation, ultrasonic and infrared sensors for obstacle avoidance, a speaker and a vibrating glove for instructions delivery, and a keypad for user inputs. A great advantage of this proposal is the obstacle and user's orientation detection, for this the robot is equipped with an analog compass, ultrasonic and infrared sensors.

Another robotic solution is RG, a robot intended to escorts the user in unknown environments[7]. Indoors navigation is performed by potential fields and by finding empty spaces around the robot. Potential fields is an algorithm that calculates robot motion by attracting it to the desired end and repulsing it from obstacles. This technique enables the robot to follow corridors without orientation sensors. RFID may be added to robot positioning and navigation.

III. PROPOSED SYSTEM

In this work we propose a system to assist blind and partially sighted people in the accessing of public buildings, in particular a shopping center. The system must provide sufficient information to the blind user, avoiding the need of asking for assistance. The system must be able to perform navigation through the building and find available services, stores or spaces as well as desired destinations or points of interest, without high volume of information that can confuse the user. The main objective of the proposed system is to enhance autonomy of visually impaired people and to make resources (e.g. text information, direction arrows) available for everyone, especially those usually only presented by visual means.

Another important feature of the system is that it is based on low cost and common technologies, facilitating the deployment on public buildings and the access to users. The system relies on existing technologies which allow users use their own smartphone, eliminating the cost of acquisition and learning to use a new device. However, the environment where the system is deployed must be equipped with sensors enabling localization of the user, as well as a complete database that is used to select the information given to users during their navigation inside the shopping center.

Following this context and the project goals, several studies were made in order to estimate the best location sensor to be used. In presented proposal we are using Bluetooth emitters. A great advantage of this technology is its market acceptance, low cost and its presence in a major group of smartphones.

The following table (table I) exposes the identified advantages and disadvantages of the presented Bluetooth based system.

TABLE I: Pros and cons of the proposed system.

Advantages	Disadvantages
Performs navigation inside the building.	Does not provide assistance on getting to the building.
Constant user positioning where the sensors are placed.	May present several errors on positioning related to space, crowd or sensors.
User guidance through calculated routes.	Position update may not follow the walking speed of the user.
Based on existing technologies, such as smartphone and Bluetooth emitters.	The environment must be equipped with sensors.
Strong information system enabling the user to know available spaces and services.	Obstacle detection relies on user abilities.

IV. MODULE DESCRIPTION

The proposed system architecture follows the scheme presented on figure 2. This architecture is divided into four major modules: voice module, information module, location module and route module. Each module plays a distinct and fundamental function. They are described next.

A. *Voice Module*

Figure 2 emphasizes the Voice Module remarking the importance of touch independent and visual independent interfaces as the system is designed for blind and partially sighted people. The voice interface implemented uses Android built in tools, such as TextToSpeech for the voice outputs and the Google Voice Recognizer API.

TextToSpeech synthesizes speech from text. It is used whenever there are information to be displayed. A server-client approach is followed by voice module, where Voice Recognizer part communicates with the server to processes information and send it back to the user as text.

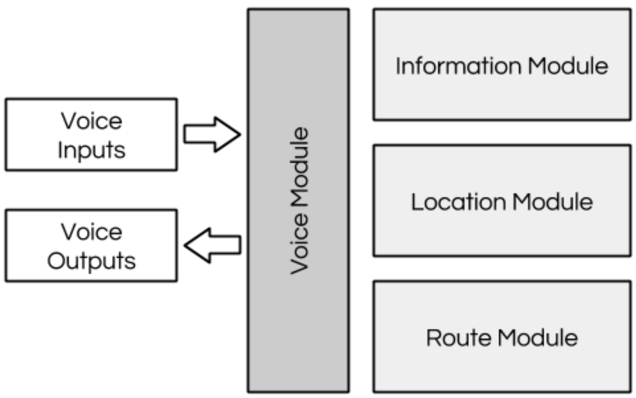

Fig. 2: Proposed architecture.

B. *Information Module*

The information module comprises all data related to points of interest in the building. Every location, store or service is associated to one specific category, subcategory or sub-subcategory. Most categories have subcategories sectioning the amplitude of category. Additionally, tags or keywords, that identify the subject of the category, are associated to each category and subcategory.

Complementary, each store and service has a unique description provided by the brand or store owner. This information must be clear and concise once it will be used for the selection of stores or services. It will be delivered to the user by synthesized speech.

Search a store or service: Since our work intends to help visual impaired persons in their navigation inside shopping centers, four methods to find a point of interest (e.g. store, restaurant, toilets, lifts, etc) were defined.

The first method enables the user to select a category among the full list of categories, then a subcategory related to the selected category. In some cases there are also sub-subcategories that are also presented for selection. As soon as the chosen category, subcategory or sub-subcategory is selected, a list of associated points of interest is presented and the user can select the desired destination.

The second method uses words introduced by the user to find the related categories or subcategories that are then presented to the user for selection. Once a category or subcategory is selected, the associated stores or services are presented.

The third method uses the introduced words to find specific stores or services: a short list is presented to the user and he/she may select the desired destination.

The last method enables users to find stores or services on the vicinity. When user walks through the environment receives information about stores or services that are near of his/her position. If the user desires, he/she can hear a short description associated to the store or service.

The voice module is used by all of these methods to interact with users.

C. *Location Module*

The localization module was designed to, constantly, monitoring the position of a user. The presented solution is based on Bluetooth emitters and triangulation techniques using Bluetooth signal strength.

The fundamental mathematical idea is that knowing at least three signal strength (that are roughly related to distance) and the precise position of each signal emitter, the user's position may be estimated, with some accuracy.

D. *Route Module*

This module has two major functions: creation of the weighted graph and calculation of the shortest path between two points.

Information about the vertexes and edges used to build a graph are imported from XML files, enabling to easily modify information about the space or points. Each vertex is associated with spatial coordinates and, may include information about stores or services there near of its coordinates. Each edge links two vertexes with a specific cost (related to distance and user preferences, such as to pick stairs or lifts). It also includes a list of other vertexes and its links associated with correspondent costs.

The route between two points is calculated using the Dijkstra's shortest path algorithm. This algorithm uses a start vertex and calculates the distance between it and other vertexes in the graph iteratively. The iterative process stops when a minimal distance between start and end points is found. Once the user defines destination, system will calculate the shortest path between user's actual position and the destination point.

A practical usage of this technique is shown in figure 1. Black dots and lines are respectively vertexes and edges defining points of interest and routes. Assuming that a user is in front of the lift 3 in the Department of Informatics Engineering of University of Coimbra and wants to go to D3.20 office, the red route is returned by the system and corresponds to the shortest path from the lift to the D3.20 office. We are effectively installing the developing system on Department of Informatics Engineering of University of Coimbra.

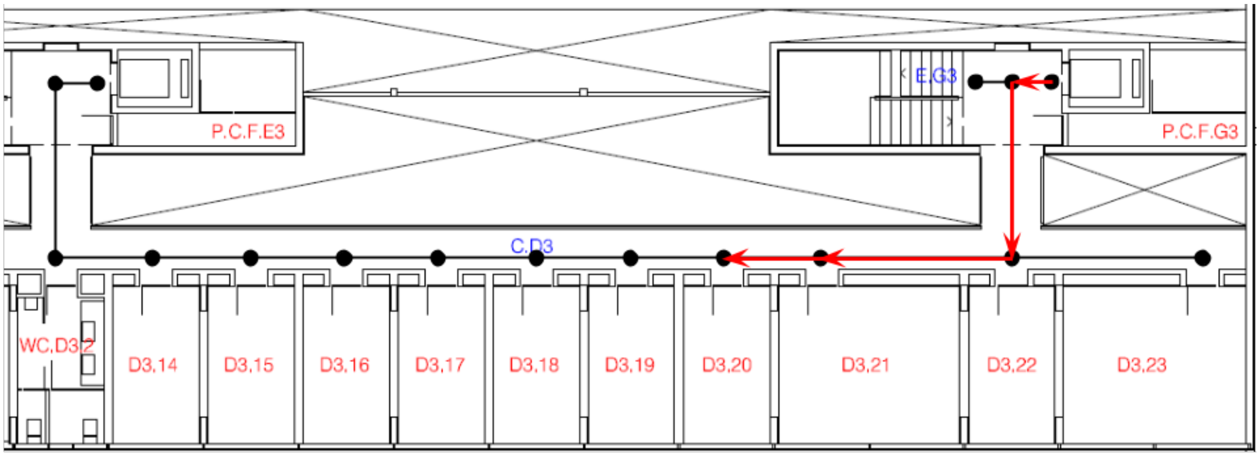

Fig. 1: Applied weighted graph.

V. Conclusion and Future Work

Blind people are frequently faced with the lack of approachable and appropriate signaling when visiting public buildings. Such difficulties often lead blind people to avoid spaces ideally designed for everyone. Thus, with the intention to promote the integration of blind people in society, we proposed a new approach based on Bluetooth and normal smartphones.

Among the related work stands out the relevance of recurrence of RFID technology, which allows simple and inexpensive location and identification. However, to use this technology the system must integrate an RFID reader device to recognize the presence of RFID tags. The system presented in this paper aims to highlight the user's device integrating it with devices and technologies already used by users, as their own smartphone. So the location system is being developed based on Bluetooth technology, present in most parts of the mobile phones.

After the environment is equipped with sufficient sensors, the system is able to locate the user and send him/her instructions that lead to the desired destination. Another important feature of the system is the accessible information system: the system allows the user to receive information about available stores, services or spaces.

In a future version of the proposed system it may be interesting to allow the introduction of marketing information in the user's application, allowing blind users to easily be aware of recent promotions and products. A functionality with this objective must be optional and enable introduction of user preferences, ensuring that excessive or uninteresting information is not delivered. This additional feature may brings commercial relevance to brands and store owners since it enables publicity of services and products to a wider audience.

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References

[1] AL-KHALIFA Hend, *Utilizing QR Code and Mobile Phones for Blinds and Visually Impaired People*. Computers Helping People with Special Needs. Lecture Notes in Computer Science Volume 5105, 2008, pp 1065-1069

[2] BELLOTII et al., *Guiding visually impaired people in the exhibition*. Mobile Guide, 2006.

[3] BRASSAI Sándor, BAKÓ László and LOSONCZI Lojos, *Assistive Technologies for Visually Impaired People*. Acta Universitatis Sapientiae, Electrical and Mechanical Engineering, 3 (2011) 39-50.

[4] GHARPURE Chaitanya and KULYUKIN Vladimir, *Robot-assited shopping for the blind: issues in spatial cognition and product selection*. Intel Serv Robotics, 2008, 1:237-251.

[5] *Induction voice system capable of performing shopping guide for blind people*. https://www.google.com/patents/CN202775358U?cl=en Google Patents, 13 March 2013.

[6] KRISHNA Sreekar et al., *A Wearable Wireless RFID System for Accessible Shopping Environments*. BodyNets '08 Proceedings of the ICST 3rd international conference on Body area networks, Article No. 29.

[7] KULYUKIN Vladimir et al., *RFID in Robot-Assisted Indoor Navigation for the Visually Impaired*. Proceedings of 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems. September 28 - October 2, 2004, Sendai, Japan.

[8] KULYUKIN Vladimir and KUTIYANAWALA Aliasgar, *Accessible Shopping Systems for Blind and Visually Impaired Individuals: Design Requirements and the State of the Art*. The Open Rehabilitation Journal, 2010, 3, 158-168.

[9] KULYUKIN Vladimir and KUTIYANAWALA Aliasgar, *From ShopTalk to ShopMobile: Vision-Based Barcode Scanning with Mobile Phones for Independent Blind Grocery Shopping*. RESNA Annual Conference, 26-30 June 2010, Las Vegas, Nevada.

[10] LÓPEZ-DE-IPIÑA Diego, LORIDO Tania and LÓPEZ Unai, *Indoor Navigation and Product Recognition for Blind People Assisted Shopping*. Third International Workshop, IWAAL 2011, Held at IWANN 2011, Torremolinos-Mlaga, Spain, June 8-10, 2011.

[11] MAU Sandra et al., *BlindAid: An Electronic Travel Aid for the Blind*. The Robotics Institute - Carnegie Mellon University, Pittsburgh, Pennsylvania. May 2008.

[12] NICHOLSON John, KULYUKIN Vladimir and COSTER Daniel, *ShopTalk: Independent Blind Shopping Through Verbal Route Directions and Barcode Scans*. The Open Rehabilitation Journal, 2009, 2, 11-23.

[13] VARPE Kanchan and WANKHADE M. P., *Survey of Visually Impaired Assistive System*. International Journal of Engineering and Innovative Technology (IJEIT), Volume 2, Issue 11, May 2013.

[14] YELAMARTHI Kumar et al., *RFID and GPS Integrated Navigation System for the Visually Impaired*. 53rd International Midwest Symposium on Circuits and Systems (MWSCAS). 1-4 August 2010.