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Ray: Smart indoor/outdoor routes for the blind using Bluetooth 4.0 BLE

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Abstract

This work describes the implementation of a cost-effective assistive mobile application aiming to improve the quality of life of visually impaired people. Taking into account the architectural adaptations being done in many cities around the world, such as tactile sidewalks, the mobile application provides support to guide the visually impaired through outdoor/indoor spaces making use of various navigation technologies. The actual development of the application presented herein has been done taking into account that the safety of the end user will very much depend on the robustness, accuracy and timeliness of the information to be provided. Furthermore, we have based our development on open source code: a must for applications to be adapted to the cultural and social characteristics of urban areas across the world.

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Keywords: Beacon ; Bluetooth 4.0 BLE ; blind ; smart path ; indoor route ; outdoor route ; navigation ; smart traffic light ; mobile devices

1. Introduction

According to the World Health Organization[1] (WHO), nowadays, there are 285 million people with visual impairment, of which 39 million are completely blind and 246 million have low visibility disabilities. To improve the social inclusion of these citizens, novel technological solutions are being explored and developed by many different organizations: research centers, industrial players and public agencies[2].

In this paper, we present a novel mobility solution to assist the visually impaired through their daily journey. The mobility assistant does not only provide guidance to the blind through his/her day-to-day journey, but it also serves as a valuable source of information to city managers. Many mobility assistants have been reported in the literature. Two of the main issues addressed by most works have centered around their usability and operability[3]. The latter refers

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to their ability to operate both in outdoor and indoor environments[4]. Most outdoor solutions have relied on the use commercial GPS systems[5], while in the case of indoor environments, various technologies, such as RFID[6,7], wireless LANs[8] and computer vision[9,10] are being explored. As for their usability, system prototypes have been tested and evaluated in various sites. Such studies have taken into account, up to a certain extent, the cultural and architectural features of the target environments. The results have proven their potential on improving the quality of life of people suffering from visual impairments.

In an effort to provide a friendly environment to the visual impaired, many cities[11] have invested into traffic lights incorporating sound systems, tactile and accessible sidewalks. Many cities are already working on implementing smart traffic lights synchronized in real time based on the traffic and people mobility[12]. In fact, this feature makes part of the enhancements to the infrastructure of Smart Cities recommended by the ISO 37120:2014[13]. However, the high costs involved in the deployment of such facilities requires the careful planning and the development of low-cost reliable solutions. Power efficiency is another major issue to be addressed[2,14]. An overall solution also calls for the synchronization of a large number of devices enabling the timely and reliable operation of the overall solution.

In this context, our work has been implemented considering the limitations of other technologies. We have developed a hybrid system that visual impaired people may use in indoor/outdoor environments based on the use of GPS and Bluetooth 4.0 BLE technologies along with a mobile device[15]. The latter is mainly characterized by the low-power requirements, making it a cost effective and reliable solutions.

Regarding the implementation of the outdoor functionalities of the mobility assistant proposed herein, they comprise a smart traffic light controller and the development of an application based on the Google Directions API and Google Maps Geocoding API. The controllers have been designed to be installed at the traffic lights. They provide the required infrastructure to communicate with the mobile assistant application via Bluetooth. In this way, users may get timely and accurate information all along their journey. As for the indoor environments, the mobility assistant relies on the use Bluetooth beacons devices strategically placed to identify the different areas of a building. The application makes use of the pedometer and gyroscope sensors found in most smart phones. In this way, the user can be accurately guided through indoor spaces.

As for the user interface, being an application for the visually-impaired, it is launched by pressing the volume button. Finally, the user can interact with the application through a voice recognition system implemented using the TextToSpeech Google API.

2. Ray: A low-power smart mobile assistant for the blind

Recent developments have enabled the implementation of low-power controllers and communication interfaces. We have based our design on an AVR micro-controller. As for the communication interfaces, we have made use of Bluetooth 4.0 devices[16,17]. Bluetooth 4.0 devices can operate in two different modes: Bluetooth Low Energy (4.0 BLE) and Enhanced Data Rate (EDR 2.0). In both modes, the devices basically implement the sames tasks: digital transmission, tele-control and data acquisition. The main differences between both modes rely on the power consumption and the achievable data transmission range. Figure 1 shows the circuit diagram and the picture of the traffic controller and the Bluetooth 4.0 BLE device.

2.1. Smart Indoor routes

One of the main features of our mobile assistant has been centered on the design of a friendly and reliable service. Voice messages guide the users in indoor environments. Voice messages include ”Go ahead” or ”Turn left or right” indications. These services have been implemented based on the pedometer, gyroscope and Bluetooth interface already integrated into most smart phones. The latter is used to keep in touch with the Bluetooth beacons strategically placed in the building.

We define a Beacon-Zone, an ambient where a beacon can be detected. The beacons provide guidance through current area in which the user is located. In order to ensure the accuracy of the estimated position of the user, each Beacon-Zone has a CP (checkpoint). The users are then directed from one CP to another, i.e. a route is made of a sequence of the CPs. Figure 2 shows the experimental deployment of our solution. The coverage area of each beacon