A Blind Navigation System Using RFID for Indoor Environments

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A Blind Navigation System Using RFID for Indoor Environments

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***Abstract*-A location and tracking system becomes very important to our future world of pervasive computing, where information is all around us. Location is one of the most needed information for emerging and future applications. Since the public use of GPS satellite is allowed, several state-of-the-art devices become part of our life, e.g. a car navigator and a mobile phone with a built-in GPS receiver. However, location information for indoor environments is still very limited. Several techniques are proposed to get location information in buildings such as using a radio signal triangulation, a radio signal (beacon) emitter, or signal fingerprinting. Using Radio Frequency Identification (RFID) tags is a new way of giving location information to users. Due to its passive communication circuit, RFID tags can be embedded almost anywhere without an energy source. The tags stores location information and gives it to any reader that is within a proximity range which can be up to 10-15 meters for UHF RFID systems. We propose an RFID-based system for navigation in a building for blind people or visually impaired. The system relies on the location information on the tag, a user's destination, and a routing server where the shortest route from the user's current location to the destination. The navigation device communicates with the routing server using GPRS networks. We build a prototype based on our design and show some results. We found that there are some delay problems in the devices which are the communication delay due to the cold start cycle of a GPRS modem and the voice delay due to the file transfer delay from a MMC module.**

I. INTRODUCTION

In a pervasive computing world, location information is very precious. Several new emerging applications is based on location information. For example, location information can be used to help users find what they need and where it is from the current location of the users. A tracking system can be used to prevent lost kids in a shopping mall by attaching location devices to them to locate their current location. Similarly, a navigation system is used to guide users to a certain location. For example, a car navigator is used to guide a driver to a destination based on the current location of the vehicle in real-time or turn-by-turn. The location given to the navigator is typically calculated by Global Position System (GPS) receiver that receives reference radio signals from GPS satellites. Thus, the GPS-based navigation does not work for indoor navigation. An indoor navigation is important for some applications. For example, people can utilize an indoor navigation system to locate devices throughout a building, tourists can use it as a tour guide in a museum, or fire fighters can use it to find an emergency exit in the smoky environments where it is difficult to see the way.

Several techniques have been proposed for indoor navigation system. For example, a fingerprinting technique is used with Wireless Local Area Network (WLAN) to calculate a current location of a device [1]. A radio signal emitter is used to broadcast a beacon as a reference to calculate a distance from the emitter to a device [2]. A Radio Frequency Identification (RFID) tag is used to store its location as a reference point to an RFID reader [3]. Some navigation system has proposed a hybrid solution using both GPS and RFID to retrieve location information for disabilities [4]. Similar work of RFID-based on-foot navigation for outdoor and indoor environments with experiments is shown in [5] and [6]. An active RFID-based navigation system is proposed to use radio signal strength of the active RFID signal, and the result shows little accuracy improvement [7].

In this paper, we proposed an RFID based navigation system for in-building navigation for blind people. Our proposed system helps blind people to find a shortest path from his current location to a destination. It also helps to them when they get lost by automatically detecting the lost and recalculate a new route to the same destination. Our proposed system embeds RFID tags into a footpath that can be read by an RFID reader with a cane antenna. Our proposed work can also be used as a tourist guide system for a museum or a navigation system for a rescue in hazardous environments where it is difficult to find an emergency exit.

For the rest of this paper, we discuss some related work in Section II, and discuss our proposed work in Section III. The experiment and results are explained in Section IV. We conclude our work and suggest for future work in Section V.

II. RELATED WORK

A group of researchers at National Institute of Standard and Technology (NIST) has proposed an indoor navigation for first responders or firefighters using RFID system [3]. Each RFID tag is attached a location in a building as a location information reference. The RFID reader is attached to a firefighter and an inertial sensor system. When a firefighter moves, the inertial sensor records the movement and estimates the location of the firefighter. The location of the firefighter is adjusted when he passes through the point of location reference which is the location of RFID tags. The feasibility study of such navigation system has shown that it is possible to locate users in a building with the location error of 10% - 15% of the distance between waypoints.

Another RFID-based navigation system is proposed for a user friendly guidance system for disabilities [4]. The system utilizes several technologies for the guidance including a GPS receiver attached to a Pocket PC to get location information, an RFID reader to get information from embedded RFID tracks, a Infrared sensor to get a traveling direction. The improved prototype replaces the Pocket PC with a GPS-enabled mobile phone. The system has been tested with 46 persons including visually impaired, blind, low vision, hearing impaired, wheelchair users, physically impaired and elderly.

Our proposed system is similar to that proposed in [4] except that our system is for indoor environment that utilizes only RFID system for location information retrieval. In addition, our proposed system adds a routing system that is used to help users to navigate to a destination with a shortest path. The routing system is also used to help lost users to find a new route to the same destination.

Figure 1. The guidance system for a blind person [4]

III. BLIND NAVIGATION SYSTEM

The proposed blind navigation system is composed of three subsystems, the track infrastructure, the navigation device, and the navigation server as shown in Figure 2. The track infrastructure is composed of RFID tags. Each tag can be embedded into a stone block and put it on a footpath. The RFID stone block is also used by blind people for navigation. Alternatively, each tag can be installed at sign posts along a pathway. The type of RFID tags is selected upon the usage. For the stone block, we select the LF RFID tags since the radio signal penetrates the block better. The tags can be installed along the footpath or at least at the junction of the footpath. The tag stores the tag ID, and the tag location. To reduce the massive amount of location information for users, the location can be hierarchically divided; for example, each tag location is identified by a location area, a path, a link, and a node in term of latitude and longitude. The location area is identified by a set of paths, the path is defined by a set of links, and the link is defined by a set of nodes.

Secondly, the navigation device is an embedded system that is equipped with a microprocessor unit (MCU), an RFID reader, a communication module, a user interface module, a memory module. The proposed device is shown in Figure 3. The MCU is PIC18LF4620 with 3986 bytes of SRAM, 64 Kbytes of Flash memory, and 1024 bytes of EEROM. The RFID reader is from IET operating at 134.2 kHz that is compliant to ISO11784/5 standard. The reader is connected to MCU via RS-232 Serial port. The reader retrieves the information from a tag and transfers it to the MCU for further processing. The communication module communicates with the navigation server to send a request and to receive a planned route from the server for navigation. We use the GPRS module to convey information via cellular networks. The connection to the server is only when the navigation starts or when the user navigates out of the planned route to reduce the communication cost.

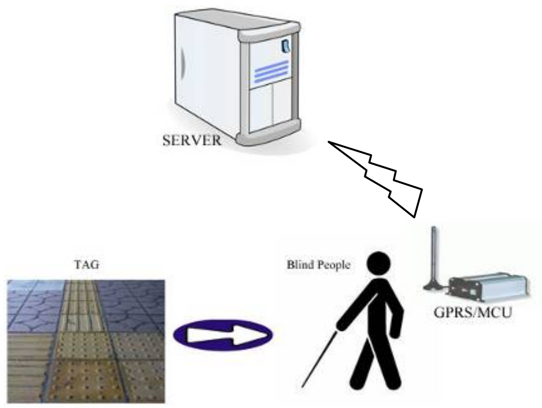

Figure 2. The proposed blind navigation system

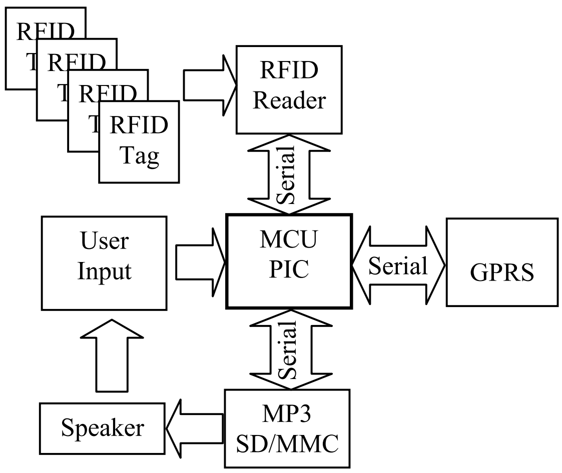

Figure 3. The proposed navigation device

Last, the navigation server receives tag information of the current location and the destination location. Then, using the shortest path algorithm the server calculates the shortest route according to the distance. The whole route is returned to the device for navigate. Users may navigate outside the designated route or get lost; therefore, the device detects the incident according to the location information from tags along the route, and sends a new request back to the server to calculate a new route to the same destination based on the new current location information. Figure 4 shows the flowchart of the navigation program that explains how the navigation works.

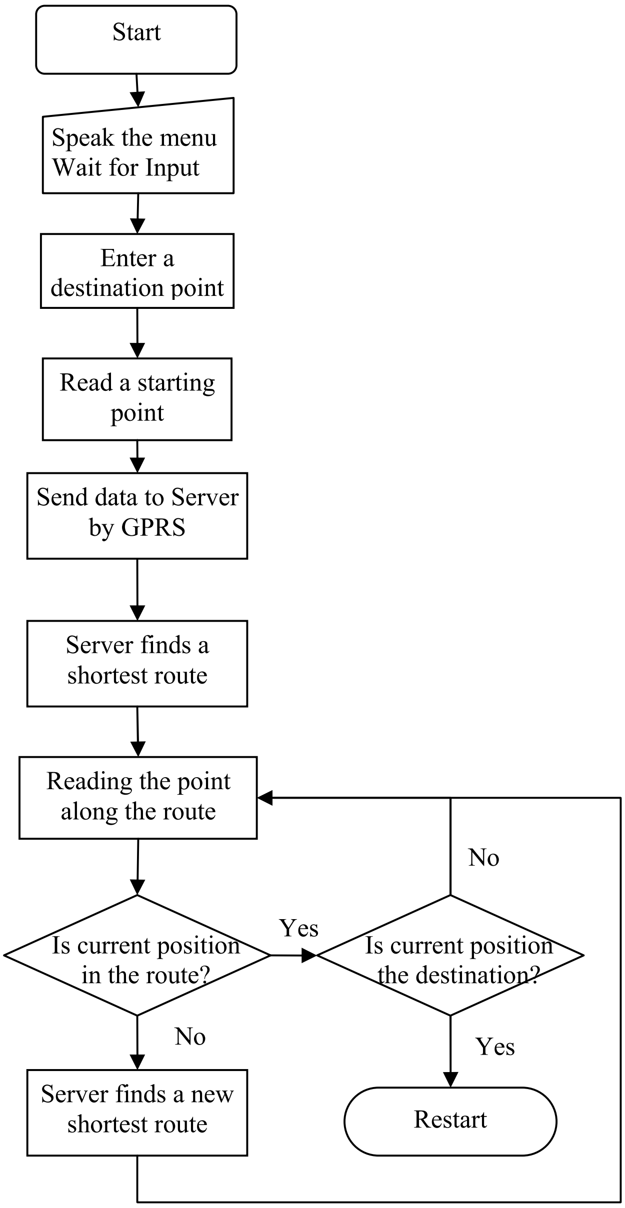

Figure 4. The flowchart of the navigation program

IV. EXPERIMENTS AND RESULTS

We have built a system prototype including a simulated map of 16 tags to form a grid of 4x4 paths. Each tag contains Tag ID and its location. All locations of the tags are used to calculate the distance between tags used as the routing cost of the shortest path algorithm. Figure 5 is the snapshot of the Java-based navigation server program that shows the tag locations on the left and the monitoring window on the right of the figure. Between each tag is the cost of the routing in term of distance.

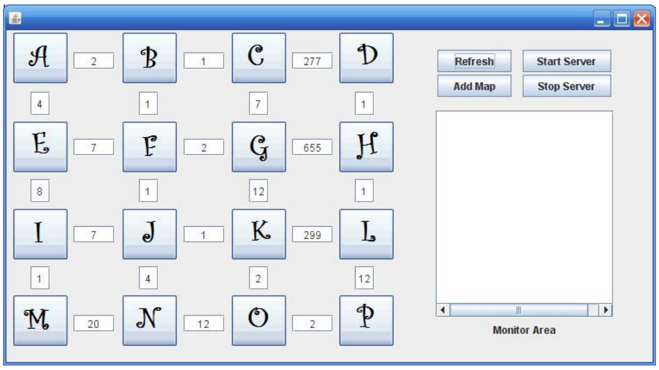

Figure 5. A simulated map formed by a grid of 4x4 paths

The prototype of the navigation device is shown in Figure 6. The actual size of the prototype is about 12 x 18 x 6 cm in dimension and about 0.5 kg by weight, not including the tag reader. The tag reader is about 22 x 12 x 5 cm in dimension and about 0.4 kg by weight. The device is portable equipped with a headphone for blind navigation where only voice is used to guide the users to navigate. The device is operated by a rechargeable 9V battery that can last about 6 hours. The device is attached to a user as shown in Figure 7 with a navigation cane for blind people.

Figure 6. The prototype of the navigation device with a headphone

We have tested our system by a simulation of the navigation. First, a user is at Point A to start the navigation and to go to Point P as his destination. The server finds a route according to the user request, and the result is shown in Figure 8. We then test if the routing cost or the distance between points is changed; a new route from Point A to Point P is returned. The new route given to the user is shown in Figure 9.

Figure 7. The navigation device attached to a user with a headphone and the RFID antenna built-in cane

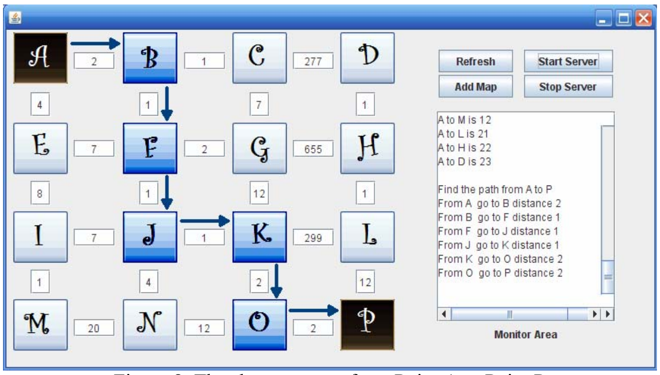

Figure 8. The shortest route from Point A to Point P

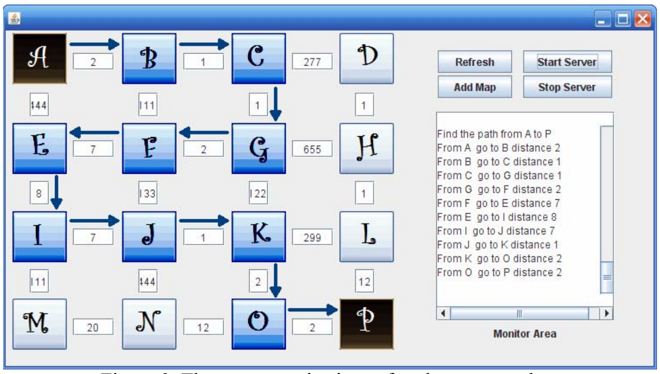

Figure 9. The new route is given after the user gets lost

V. CONCLUSION AND FUTURE WORK

We have proposed an RFID system for blind navigation which can be used by blind people, by tourists, or by fire fighters for a rescue in a building with smoke. A system prototype which includes RFID tags embedded in a footpath block, the embedded system as a navigation device, and a navigation server which is remotely connected to the device via the Internet. The system prototype has shown the promising result although its size is still large. We also found some communication delay in the device to connect to our server for the first time. This is due to the cold start cycle of the GPRS module. There is also some delay in the voice playback where the voice file is read from MMC module. In our future work, we will reduce the cycle delay by using a pre-start cycle. Additionally, we will improve the voice playback module by storing some frequently-used words in the ROM and pre-load some words in the RAM module for faster speech transfer or using a speech synthesizer to generate voice.

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