RadioVirgilio/Sesamonet[1]: an RFID-based Navigation system for visually impaired

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Abstract

An innovative and cost effective guide system for blind people is presented in this paper. Thanks to the spread of handheld hardware and software technology such as PDAs (Personal Digital Assistant) and smartphones, wireless communication, TTS (Text To Speech) and database software for mobile devices, the authors achieved to build a portable, easy to use orientation and navigation aid which still has a great development margin. The cost effectiveness is due to the recovery of RFID identity tags from cattle slaughtering: these tags are then burrowed to create a grid used for navigation. After a first prototype running in the RFID-Lab in La Sapienza University, a proof of concept on a larger scale is planned for the end of this year.

Introduction

For visually impaired people, outdoor pedestrian mobility is very difficult and often dangerous. The visually impaired commonly rely on a cane and/or a guide dog to assist them in efficiently reaching a desired destination without harm. However, this approach is successful only if the majority of the path to the destination is already known to the affected person (or to the guide dog).

In a world in which perception extends to the tip of the blind's cane, orientation is very difficult, especially in environments which were not designed for blind people. To better understand the problem we should point out that orientation is essentially based on the recognition:

[1] The RADIOVIRGILIO/SESAMONET project is a joint venture project between the Institute for the Protection and the Security of Citizen (IPSC) of the EC Joint Research Centre (JRC) and the RFID LAB of the University of Rome "La Sapienza"

- of **patterns** in previously seen areas (especially indoor or small places). This gives *absolute* orientation.
- of **buildings'** and **streets' angles** (in new outdoor places) or **wall angles (**indoor). This can provide *relative* orientation in places one has never been before.

Unfortunately, both tasks are quite difficult, sometimes even impossible, for a blind person who can sense differences in patterns with his cane only in his close proximity (and on the floor, which rarely changes from a point to another nearby point) and can't guess with good approximation the amount of degrees he turns one way or the other.

Thus, the realization of a navigation system for visually impaired or blind people represents a social challenge, focusing the attention of the most sensitive part of the scientific community. For example, Piotrowski (Piotrowski, 2003) proposed an indoor, robot assisted navigation system. In outdoor environments, applications for visually impaired people are usually GPS-based (Z. Hunaiti et. al., 2005; Pressl and Weiser, 2006). While having no infrastructural costs, they are inaccurate (at best, 2 meters accuracy) thus failing to warrant the safety of the user.

The authors tried to develop a user-friendly navigation system, capable of safely guiding visually impaired people along both indoor and outdoor marked trails.

General description and system overview

The system is composed by four actors:

- The tag grid
- The handheld (and Bluetooth earpiece/headsets)
- The RFID reader cane
- The navigation data server

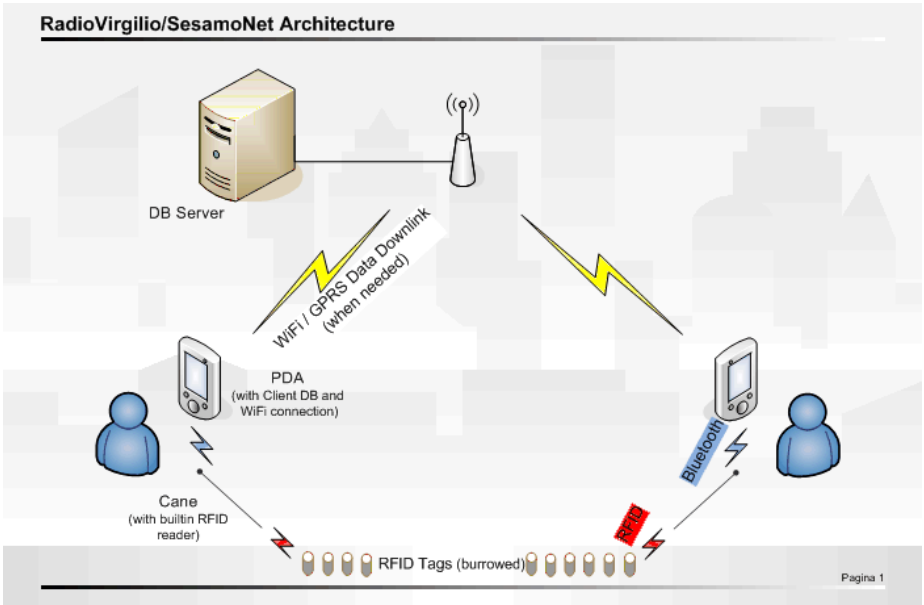

Fig. 1. RadioVirgilio/SesamoNet Architecture

As Shown in Figure 2, the reader in the cane reads the tag's ID by RFID communication. It then sends this information through a Bluetooth channel to the PDA device. The ID string and navigation data are processed and then an output is sent through another Bluetooth channel to the headsets which finally produce the audio output that is used by the visually impaired person. Navigation data can be periodically updated from a server, provided that an Internet connection[2] is available.

The key system in the system is the PDA, on which the SesamoNet/RadioVirgilio client software is running. Moreover, the PDA holds the client database that stores the data needed to reference the readings made by the RFID reader in the cane. The mobile device uses the tag ID string provided by the RFID reader to reference the position and deliver navigation and static environmental information. This information is sent by a text to speech software to the standard output, which can be a standard or Bluetooth headset.

This way the user can be given useful hints on whether he is going along the right path or walking away from it. He also can request a list of nearby points of interest, such as a pharmacy or a bus stop.

It is important to emphasize that the data stored on the mobile device is only a part of the whole set of available navigation data. To ensure reliable and fast reaction on mainstream mobile devices, a small memory footprint is mandatory, not only for the main program but also for the database client. Thus only the information needed to guide the impaired person in the nearby area is stored in the PDA's memory. This nearby area is called *cell*[3] and is planned to extend from 40 to about 150 meters across, depending on the environment.

The system is suited for both indoor and outdoor use as the RFID tags used are very resilient to environmental stress.

The navigation software is also easy to maintain because of it's modular structure.

The mobile device

Development and tests were done on mainstream device while data is stored on a Secure Digital (SD) memory card in order to ensure maximum memory availability for the SesamoNet/RadioVirgilio application.

Standard batteries provide at least three hours of continuous use while Bluetooth communication is on. To further increase battery duration, the use of 2.0 standard is auspicated for Bluetooth interfaces.

The tag grid

The tag grid, by which absolute orientation is achieved, consists of LF tags burrowed into the ground at about 4cm. The tags essentially consist of a protection capsule holding a radio frequency identification transponder. These tags are used primary for animal identification but, after slaughtering, they can be recovered, reducing the cost of the transponder and possibly of the encapsulation, due to the fact

[2] GPRS, WiFi, WiMax and even USB access points with synchronization software may be used
[3] The term is directly taken from mobile TLC

that they are already protected. In this study the 134.2 kHZ channel is used as it has minimal disturbance from interposing environment (i.e. concrete, water, etc) while still allowing a 10 cm read range.

These transponders have data and ID memory blocks. The uniqueness of the number stored in the read-only ID memory blocks is guaranteed by the European law for animals identification. The protection capsule is originally designed for use in animal identification. More specifically, in this embodiment the capsule has the form of a bolus, as described in EP 0 849 989 for use with ruminants such as cattle. Since RFID tags are available at low cost, the packaging of the latter has become a significant cost factor. The reuse of such animal identification tags significantly reduces prime cost of encapsulated transponders.

Also note that this system is useful for mapping both indoor and outdoor areas. While the secondary information delivered is of different type (shops or bus stops outdoor, office names indoor), the navigation and core processes are identical.

The navigation system is net based: paths are associated to lines while intersections to nodes. Paths are stripes of ground upon which a visually impaired people should feel safe to step. They are either delimited by tag lines acting as borders or evolve around a central line of tags, according to environmental dictated requirements.

In a city, for example, when walking alone, blind people usually follow the walls of buildings which are a trustworthy aid. In this case we use only one tag per cross section and will tell the user he has a wall he can use as primary guide on one side.

In an open area, such as a park, we advise the use of two or three tags per cross section to boost chances of finding again the trail if the user steps outside it. More tags per cross section can also be used to create redundancy when a fail-safe system is needed or failure is expected due to exceptional environment stress (i.e. hazardous areas, crossings, etc).

Thus a path's cross section can be made by one, two or even three tags, while distance between nearby cross section may vary from 40 to 100 centimetres.

RFID reader cane

The RFID antenna is custom made and placed inside the far end of a white plastic cane, similar in shape to the usual blind's cane. In this way, the visually impaired is not bound to use this technology, and can always use the stick in the usual way. The other end holds the RFID controller, the Bluetooth interface and the batteries. The reader may be set to operate either in continuous or on demand read mode.

Navigation data server

The data server holds the database containing all the information that is used for navigation: tag position, tag sequence and all kind of environmental information. All data is organized in geographic cells. The server also has an interface for client data synchronization so the device can download up to date data when approaching a cell.

In this way, any update (due to remapping, work in progress along the path, or environment information changes) is readily transmitted to the client application.

SesamoNet software

The software under development is based on Microsoft .Net architecture and can be divided in separated modules:

- Bluetooth cane Connection Manager: keeps a Bluetooth connection channel open between the RFID reader and the PDA for tag ID string transmission. The user will never need to use the Bluetooth interface as it is completely software-managed
- Navigation Data Interface: it's task is to retrieve a cell's data from the navigation data server to a local database, extract sub-cell datasets and provide Navigation Logic with all the accessory data associated to a tag's ID
- Navigation Logic: this is the core process and it is used to
  - Check whether the direction is right and not reverted
  - Inform the user whether he is probing the tag on the right (left) hand side[4]
  - Eventually send a text string containing more complex navigation or environmental information to the TTS component
- Text to Speech Software[5]: translates the text string submitted by the Navigation Logic to a spoken words audio stream that is the true output.

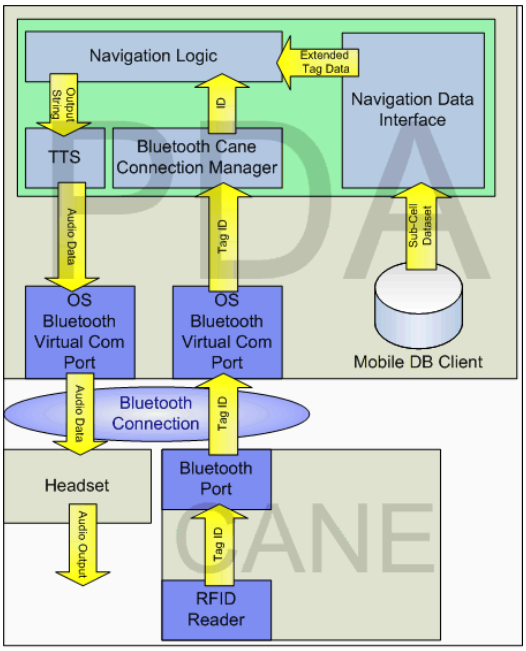

Fig.2. Sesamonet/ RadioVirgilio Data workflow

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[4] Because a sweep of the cane usually evolves in an arc in front of the user and it takes about one second, this means that, as one can probe up to three tags while drawing a single arc, there have to be three outputs in a second's time. Thus we decided that a spoken message is not suitable (too long) and we instead used tones for the three main (and more frequent) navigation outputs.

[5] Plans are that this module will be further developed into a full fledged input/output user interface, probably including an Automated Speech Recognition (ASR) software

RFID cane. A special ackwnoledge to the ISPRA Sesamonet team: Graziano Azzalin, Marcello Barboni, Marco Sironi

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