

A RFID SYSTEM TO HELP VISUALLY IMPAIRED PEOPLE IN MOBILITY

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Abstract: *Orientation and mobility for visually impaired people are very difficult, especially in environments unknown or not designed with assistive purposes.*

In modern Welfare States, for guaranteeing autonomous living and social inclusion of blind and partially sighted people, independent mobility is an important objective to achieve. In this paper a novel ICT system, namely RadioVirgilio/Sesamonet, relying on RFID technologies to support indoor/outdoor navigation of visual disabled is introduced. RadioVirgilio/Sesamonet has been developed with the intent of giving users a non-intrusive, usable and safe way to move in urban environments. The authors approach - integrating traditional assistive technologies with wireless and RFID technologies to realize an intelligent and easy to use navigation system - is described, along with the functionalities and the physical and logical architecture of the system. A brief discussion on planned application scenarios, results from a preliminary usability tests, and ongoing effort to extend the system complete the contribution.

Keywords- Blind mobility, RFID navigation system

1. INTRODUCTION

Independent mobility of visual impaired pedestrians is difficult. Generally, to explore the space, sightless people use other senses (i.e. hearing, touch and smell) to compensate their disability.

More in details, in familiar settings they learn how to orientate in the spaces by recognising known features (points of reference). Nevertheless In unknown environments,

navigation often becomes harder or even dangerous. Besides, in pre-designed environments, wherever indoor or outdoor, orientation may also be achieved by perceiving regularities in the objects around (reference lines). Actually in addition to traditional assistive tools, as the white cane and the guide dog, also other supports in blinds mobility are diffusing, as for instance Tactile Ground Surface Indicators [1].

RadioVirgilio/Sesamonet is a research project that aims to design and implement a reliable system to assist visually impaired citizens' independent mobility in urban settings. The proposed approach foresees to augment the effectiveness and the usability of the aforementioned supports by the exploitation of innovative ICT's (Information and Communication Technologies) hardware and software components.

More in details the RadioVirgilio/Sesamonet solution intends to improve blind and low vision users' mobility experience by coupling tactile perceptions with hearing aids. To this extent, wireless technologies (RFID and Bluetooth), hand-held devices (PDA and Smartphones) and specific system and application software for mobile device (e.g. Text To Speech, database, etc) are combined together.

Recent works

To increase the mobility and/or safety of disabled pedestrians, over years many ICT-enhanced support for mobility have been proposed in literature (e.g. in [4], [5], [6]) and various industrial patents were registered (e.g. [2], [3], [8]).

Although each system has its own peculiarities, recurrent limitations for these navigation systems are the following:

- Systems relying on Global Positioning Systems (GPS) technology have limited precision in detecting the user position, also urban canyon and indoor site are no suitable environment due to technological limits in GPS signals capturing ;
- Alternative solutions based on infrared devices needs a direct line between the device and the reference position;
- Other devices are frequently complex, expensive, and require continuous power supply.

In respect with some of these weaknesses, the adoption of Radio Frequency Identification (RFID) technology may represent a viable way to overcome them. Actually, although broad applications of RFID include those for supply chain management, security, and the tracking of object [15], in very recent years also RFID-based guide system for blind navigation have been proposed.

Advantages of RFID technology for navigation systems are:

- Small and easy to use devices
- Possibility of their application in both outdoor and indoor places
- High availability and low prices of tags (that can also be recycled from animal identification tags)
- Affordability and endurance of RFID devices in respect to damages of environmental factors or vandalism

More in details in [7], *Kulyukin, Gharpure, Nicholson and Pavithran* present a robotic guide for visually impaired. This robotic guide is composed by a Pioneer 2DX commercial robotic platform, a laptop connected to the platform's controller and an RFID reader. This system locates RFID passive tags that act as stimuli for local navigation behaviours to achieve global navigation objectives.

The invention of *Piotrowski* [8] discloses a navigation system for the general public using RFID passive tags. The RFID tags are used as location markers e.g. in a shopping mall. A receiver capable of providing navigation instructions in accordance with a predetermined code read from such a tag is also described.

Willis and Helal [9] developed a system using a RFID tag grid. Each tag contains spatial coordinates and information sent to a reading system in the blind's shoes. The reader communicates RFID data to a PDA via

Bluetooth and a dedicated software application in the PDA helps the blind in obtaining relevant environmental information.

2. SYSTEM FUNCTIONALITY

In terms of supported functionalities RadioVirgilio/SesamoNet offers various aids for the autonomous mobility of visually impaired persons:

- Keeps the user inside a safe path;
- Provides information about turns and obstacles on the path;
- Checks the right direction (useful if user falls or is disoriented);
- Provides general and specific environmental information on demand;
- Provides on-line help and assistance (via GSM).

On this purpose a grid of RFID tags has been designed to provide information about the path the blind should follow in order to have a safe navigation. Such a grid, and the related acoustic signals, guide him along a route and alert him when the reader exits from the safe grid area. Actually when the user cannot easily perceive relevant points of reference, the designed system alerts the user via synthesized speech output, possibly also generating sounds to identify additional and useful reference lines.

As opposed to *Willis and Helal* [9], the authors did not store navigation information on the tags themselves in order to increase read speed and thus reliability.

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3. SYSTEM DESCRIPTION

As depicted in Fig. 1, a disabled interacts with the system simultaneously using three different devices: a RFID Cane Reader, a PDA, and a Bluetooth headset. Together with the tag grid, they constitute the physical architecture of the system.

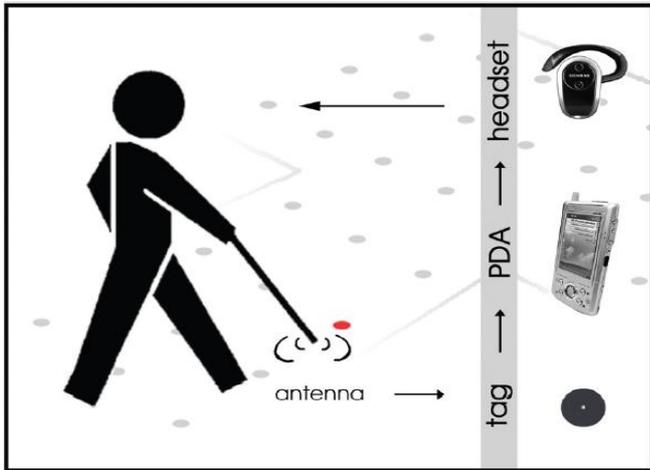


Figure 1: Physical architecture of the system

The tag grid, by which absolute orientation is achieved, is made by tags burrowed into the ground up to 4cm. The tags used by RadioVirgilio/Sesamonet were previously used for animal identification [10] and, after slaughtering, they are recycled for this purpose, reducing the cost of both the transponder and its encapsulation, due to the fact they are already in a plastic or ceramics envelope.

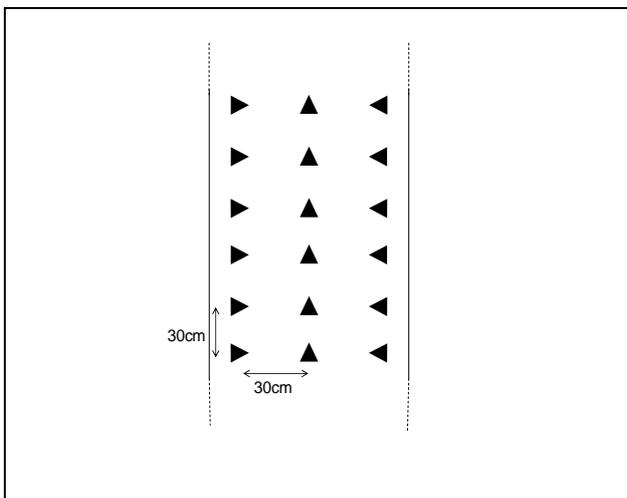


Figure 2 Layout of RFID tags in the path

In the current RFID grid the 134.2 KHz channel is used because of the minimal radio frequency noise from interposing environment (i.e. concrete, water, etc) by which the signal is affected. This allows a reading range of up to 15cm. Transponders have associated data and ID memory blocks. The uniqueness of the number stored in the read-only ID memory block is guaranteed by the European Patent Convention (EPC) for animals' identification. Each tag is associated with a position along the path (right, left or centre) and each position is

associated with a different short sound. Fig. 2 shown how the path is organized.

In Fig.2 left arrows pointing inside the path indicate with a specific beep the left tag border; similarly the opposite arrows indicate the right border with another beep. Central line also gives the blind relevant environment information generated with a text to speech.

The current version of the cane is close to the one used by blinds: white, light and easy to use. Inside the tip of the cane an RFID antenna is integrated. The handle hosts the RFID controller, as well as the rechargeable batteries and the Bluetooth 1.2 terminal. The reader is set to either operate on demand or in continuous read mode, while holding a button on the cane handle. In continuous read mode the battery lifetime is about three hours.

The RFID cane reader reads the tag ID and sends this number, via Bluetooth, to the PDA; the PDA software associates the received ID to a mobility information and, after converting it in a suitable message, sends it to the headset. RadioVirgilio/SesamoNet software runs on any Windows CE based portable device having a Bluetooth antenna to communicate with the RFID cane. The system now works with a Bluetooth 1.2 interface but the authors are looking forward to upgrade it to Bluetooth 2.0 or ZigBee standards.

Logical Architecture

The software, still under development, is based on Microsoft .Net (but we are also developing a JAVA version) and can be divided in the following blocks:

- *Bluetooth Cane Connection Manager*: keep the BT connection channel open between the RFID reader and the PDA for tag ID string transmission. The user is not supposed to perform any task when navigation session starts or the BT manager is resumed after any loss of connection with the cane.
- *Navigation Data Interface*: it retrieves navigational data from a local database, providing the Navigation Logic with extended data related to a tag ID.
- *Navigation Logic*: this is the core software which handles navigation and tag data in order to provide the user with mandatory (safety-related) or on demand (environmental) navigation informations. It also checks if the direction is right and not reverted. This module "tells" the user he is

probing the central tag or one on the right or the left hand side of the path¹. Eventually it can send a text string containing more complex navigation or environmental information to the TTS component [11].

- *the Text To Speech component*: it currently using a Loquendo (www.loquendo.com) library.

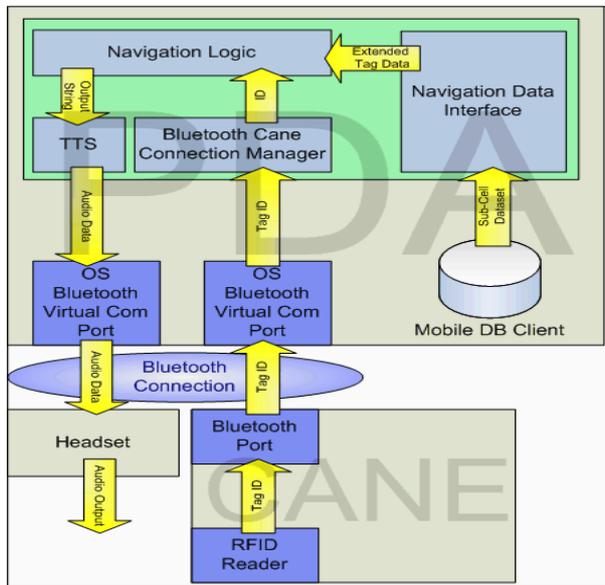


Figure 3 The overall logical architecture

4. TESTS

The analysis of the interaction of visually impaired persons with the system is important in order to have a usable system that enhances the standard cane and gives an added value to a blind person. For this reason the authors started a preliminary series of tests to check the system and its functionality with a small group of experts and blind users. Several critical points of RadioVirgilio/Sesamonet have been identified and the results obtained from the test execution and from the discussion that followed it provided an input to the authors that are now calibrating the system by modifying tones and synchronizing the time when they are generated.

This evaluation activity confirmed that RadioVirgilio/SesamoNet could be used as a relevant augmentation tool to provide additional information with respect to a normal

¹ A sweep of the cane usually probes an arc in front of the user and it takes about one second. This means that, if three tags are probed while drawing a single arc, three output should be generated in this time. Thus we decided that spoken messages are not suitable (too long) so tones are used for the main three (and more frequent) navigation signals.

cane already gives (physical objects identification). More details about these preliminary tests are in [12].

We are now planning a second usability test with a large number of blind users. This test, will be based on a standard methodology for the identification of human factors in man-machine interaction (scenario, tasks, observer, questionnaires, etc.). The management software Techsmith Morae² will allow to evaluate the usability of the system, the error rates, and a learning curve, and highlights and proposes solutions for other problems that may eventually arise.

5. EUROPEAN INCLUSION POLICIES

RadioVirgilio/Sesamonet project aims to be a valuable support for the independent mobility and living of visually impaired persons.

A key success factors for the adoption of the proposed system is related to initiative supporting the diffusion and availability of predisposed RFID grid in public places, especially in socially relevant ambient as for instance subway stations, crosswalks, and malls.

At European level, social inclusion policies and measures have been receiving more and more attention. In several European Councils the importance of these issues has been stressed; they have been also considered relevant aspects to take into account in the Information Society.

Through a line of continuity in the European Action and Strategic Plans (eEurope 2002, eEurope 2005, i2010-European Information Society) eInclusion and eAccessibility related activities have been priority issues.

Actually the term e-Inclusion has a double meaning; as stated in [16] eInclusion, other than prevent risks of digital exclusion from the Information Society, it also means tapping new digital opportunities for the inclusion of socially disadvantaged people.

These socio-economic goals have also influenced the EU research agenda, being continuously proposed and refined in the form of themes and challenges all over the Framework Programmes. Actually, in according with an important strategic goal of the Lisbon agenda (i2010), one of the challenges of the recently launched 7th Framework Programme explicitly address ICT-mediated support for the needs people with disabilities and elderlies tend to have. Looking at the opportunities to exploit

² www.techsmith.com/morae.asp

ICT for social cohesion, promoted by the challenge "ICT systems and applications for better inclusion and independent living of all citizens", RadioVirgilio/Sesamonet addresses many of the objectives settled-up. In between of Assistive Technology and Ambient Intelligent domain, the RadioVirgilio/Sesamonet system provides:

- user-centred 'always-on' mobility services based on location-aware enhanced personalised services such as context-aware personal communications and always-available information access.
- An higher mobility of people and goods across different transport modes through the provision of accessible and reliable information services;
- Increase personal independence, prolonging active participation in society and integrated care processes for the ageing and disabled population.
- It also realizes the integration of a number of advanced technologies, e.g. low-cost GNSS receivers, software defined radio technologies, high-accuracy hybrid positioning systems combined with dynamic navigation services, as well as technologies such as RFID and smart tags in combination with advanced sensors, communication and mobility management systems;

6. CONCLUSIONS AND FUTURE DEVELOPMENTS

Further enhancement and expansion of the current system features implies the need further investigation in many directions

Finding objects

With the application of RFID tag on objects, like keys or wallet, the cane could support the user to find them in a domestic environment.

RadioVirgilio/Sesamonet could also help the blind to move in a shopping mall, while the system supplies the needed information about the tagged products on the shelves: e.g. the name, price, description, and other types of information [13].

Mapping spaces

The future living space will be covered by a large number of tags according to the characteristics of intelligent buildings and of pervasive computing. RadioVirgilio/Sesamonet will be able to read every kind of environment information from these tags and help the blind to make mental maps of such spaces.

Personal assistant

The under development software will allow in the near future to easily customize the interaction environment according to user preferences and profile. The blind will be able, as it now done by GPS navigators, to select the destination and the paths, to store in the system's memory the user preferences and past selections in terms of locations and most frequently selected paths [14].

Integration with the RFID glove

In future there will be the possibility of integrating RadioVirgilio/Sesamonet with another application: GLIDEO (GLove for Identification and Description of Objects) created by Marta Mei, as final thesis at Politecnico of Milan University, which is being prototyped by RFID Lab of "La Sapienza" University.

This system, in order to overcome the inability of blinds in recognizing objects before tactile contact, is able to provide them audio information about objects, in a way compatible with the software of RadioVirgilio.

The GLIDEO tech-glove is a sort of technologic wearable accessory that allows the user to store essential information about objects, and to listen them, using RFID tags and a PDA (connected to a Bluetooth headset), on which the software and the information's database are installed.

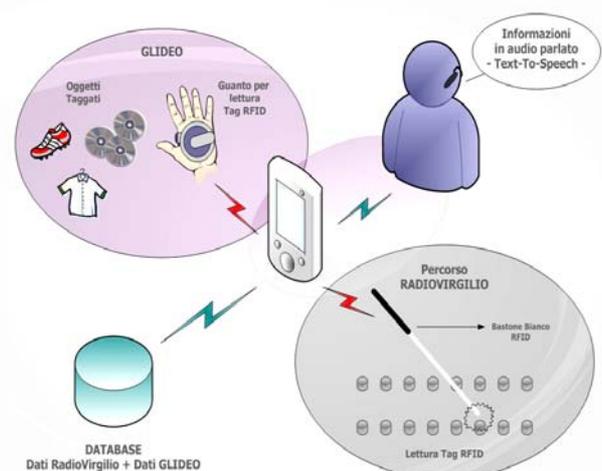


Figure 4 Schematic representation of the interaction between RadioVirgilio/Sesamonet and Glideo

System's applications

RadioVirgilio/SesamoNet system is expected to be implemented in airports, rail or metro stations, shopping malls, universities, post offices, etc.

In order to understand and plan in the best way the industrialization phase and the commercial exploitation of the prototype, when the system will be used on a large scale, it's necessary to investigate the economic opportunities and threats. An organization and business modelling, a market analysis, and an evaluation of possible application scenarios are necessary to know: the stakeholders, the organizational impact and possible funding resources to cover the costs of installation, management, and maintenance in a public and/or in a private environment.

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