Personal Augmenting Device and Assistive Living Model for visually impaired

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Abstract

Personal capacities of those with reduced visual capabilities might be augmented using specialized devices. Multi-sensorial wireless systems equipped by antennas operating near the human body in a multi-path environment might deliver the adaptive proactive help. We propose the combined use of the hi-tech wireless setup based on the RFID-enhanced white can for visually impaired users, cooperating with the urban infrastructures, equipped with GPS localization and additional sensing/heuristics to offer some augmentation. We interact with visually impaired via speech synthesis interface, where the proactive behavior is studied to simplify daily tasks.

1 Introduction

Stockman has explored the human vision system [1] stating that the vision of the world is a virtual artifact maximizing the information about. Visually impaired people walk lacking some critical information that can affect their pedestrian's safety, having often difficulties to perform elementary daily mobility activities because of the limited awareness about surroundings.

Some research is focused on way finding by blind people [2]. Another direction is the cooperative use of the wireless technology [3]. The main element characterizing ICT-featured systems for visually impaired is the stick, or the "white can", enhanced by adding some new technologies [4]. Being heavily impaired visually, the pedestrian is unable to interact with maps and street signs, acquiring information about the environment using different means. Similar need in orienting themselves have almost all visually impaired travelers walking in an area they never went before. However this category of users is not using necessarily the stick.

Many personal navigation systems are made available by major vendors for car drivers, and several specialized versions of such solutions are also available for pedestrians. Using Global Positioning System (GPS hereafter) technology only, the context awareness might be acquired approximately, with no precision suitable to assist visually-impaired user. The proactive behavior in such systems, which is essential to assist in guidance visually impaired, is lacking.

The exploitation of cooperative capabilities of modern wearable devices appears intuitive, and interfacing them with existing urban infrastructures becomes a challenge, with an example in the Radio Frequency Identification (RFID hereafter) use. However this beneficial approach poses several practical problems, because requiring embedding in the roads, sidewalks, metro station's pavements, and similar entities, of many RFID tags, implying their registration in a public interoperable database, maintained by Public Authorities, owners of urban infrastructures. In northern Italy there is a couple of experimental initiatives applying the above-mentioned approach: the connection between Porta Susa railway and metro station with the ophthalmic hospital in Turin, and RFID transponders embedded into the Laveno city sidewalks.

It is known that the wireless communication technology is energy-consuming, impacting on the usability of smart devices in outdoor environments lacking the possibility to recharge the battery, and on the usability by special categories of users with difficulties to fulfill such additional operations even in indoor environments.

The apparently intuitive use of the walking stick by blind users becomes questionable thinking about the use by visually impaired but not blind.

Our research question is how to set up the optimal assistive technology augmenting capacities of visually impaired. The vision of the Internet of Things technology, available now, appears challenging to the described research.

2 Discussion

It appears clear that visually impaired user of urban sidewalks has difficulties to interact with the outdoor reality being unable to account maps and street signs directly. We might adopt a kind of ubiquitous "Travel Agent" releasing some context-related information and indications about the possible behavior leading to solve the mobility task. Handheld devices are available and might be used to embody an augmenting agent.

Geographical Information Systems (GIS hereafter) and Spatial Databases are two technologies used to capture, represent and store information about buildings, sidewalks, constructions, doorways, crosswalks etc. GPS technology helps to provide geo-referencing, while Voice technology with Speech Synthesis – also known as the Text To Speech - is useful to enable the augmentation device communicating with the assisted.

The outdoor sidewalk corridor might be defined as the portion of the technology-enhanced pedestrian system from the edge of the roadway to the edge of the right-of-way - the property line - between street corners. In major cities an additional problem is the traffic requiring an improved precision in the localization, which is not offered by GPS currently.

The RFID and Near Field Communication (NFC hereafter) technologies offer the possibility to identify items, and the way to exploit these findings in reality is described in [5]. Blind users might interact with the sidewalks using the RFID-enhanced sticks, while "stick-less" visually impaired ones might obtain the cooperation with infrastructures through NFC-enhanced handheld smart phones or similar devices.

The RFID transponder's embedding into the urban sidewalks and the NFC transponder's embedding into the infrastructures would be the first step towards the RFID-enabled augmentation of visually impaired. The next step would be linking them together in a network, or GRID, making available the database of tags maintained up-to-date or keeping the live-link with the remote site offering such data/service.

An antenna introduced in a blind person's cane or an equivalent device activates each RFID/NFC chip while passing over/near, and the tag responds saying its unique identifier. The embedded receiver has the context awareness now, but needs to translate the numerical data into a semantically meaningful message, which can be understood by visually impaired. This requires an access to the database of tags to retrieve the updated description. The above-described approach is reactive, because the context awareness acquired follow the action "walked over", while the proactive action is compulsory needed to protect the assisted against possible accidents.

Actual use case scenarios described in literature see the use of smart phones complementing the white can, where mobile devices are equipped with a local database of navigation information that maps the RFID tag identifiers to locations, becoming urban anchors, or Points-of-Interest.

In the state-of-the-art vision, the assisted person might receive specific and localized information through a wireless headset linked to the phone, which is an interesting option. However both the blind and visually impaired pedestrians use the sound as a guide listening to all traffic sounds before deciding the mobility action to undertake, especially in crossing the street. It is important to allow the person to hear, minimizing the use of the headset.

The energy scavenging/savings becomes an additional problem in above-mentioned devices, because the induction of RFID transponders uses some energy, the computation is possible until the clock alimentation is constant, and the wireless availability is energy-consuming.

The use of ultrasounds and the acoustic signal interface is proposed [6] to notify users about obstacles. The information about static obstacle in front of user might be checked also by ultrasound pairs and delivered to the processor analyzing the information. However the dynamic obstacles are more complex to manage. The capability to raise an event instead of pushing a constant flow of acoustic signals, e.g. adverting proactively would be the intended behavior to achieve.

Being considered insufficient the alarm given only by acoustic signals, appears preferable providing the user with vocal guidance using the state-of-the-art text-to-speech software.

Considering all above-mentioned points the complexity of the system becomes high. We pose the applied research question about the cost/benefit and real life reliable implementation.

3 Proposition

Considering the fact that sidewalk's embedded RFID tags cannot ensure the 100% reliability, we propose to improve the reliability of the cooperative system by redundancy, placing multiple RFID tags increasing the probability of the antenna passing over. We propose to duplicate tags on infrastructures (semaphores and similar) to enable the stick-less use of the technology in info-islands.

An outdoor localization system with personal navigation capabilities for visually impaired is designed exploiting the grid of RFID/NFC tags. We propose to program each transponder before embedding it into the sidewalks or infrastructures with spatial coordinates and information describing explicitly the surroundings to achieve the immediate context awareness by self-description, without a need to query external databases at run-time. The localized information system with no dependency on a centralized database or wireless infrastructure for communications might be achieved in such a way (Fig. 1), an important factor for real-time systems and energy-savings on wireless communication. Considering that the road maintenance should update the tag or database, and the Municipality to control the result, it appears the cheapest option to keep the GRID up-to-date.

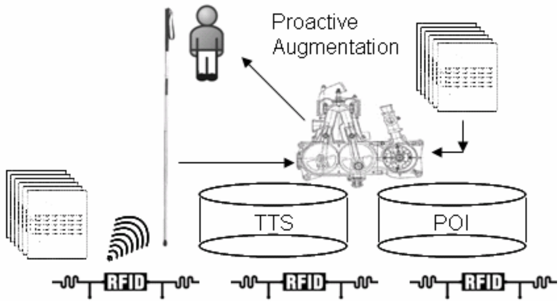

Fig. 1. Proposed architecture

Thanks to the established urban RFID/NFC GRID infrastructure, visually impaired pedestrians would gain the chance to participate in mobility activities with reduced need of an external assistance. An urban GRID infrastructure enables some proactive behavior because of the embedded situational awareness and precise localization.

We have designed, engineered and implemented an RFID-based augmenting system with the HF 13,5 Mhz RFID reader integrated into the walking cane in a particular way to improve the readability of tags the directional traditional antenna cannot achieve, making us to discard low frequency tags. The initial prototype is shown on Fig. 2 and the final one on the Fig. 3. We have used a wireless (Bluetooth) connection to the handheld device, which is the modern 3G smart phone equipped with GPS. The augmenting is released through the vocal feedback based on the TTS technology.

Fig. 2. Initial prototype

Fig. 3. Re-engineered design

An important consideration was accounted then: many blind people appear reluctant to use any assistive devices revealing their disability. Similar finding appears valid for visually-impaired users accepting their status and avoiding devices designed for blinds. Being motivated by these factors, we propose the differentiated augmentative devices for the above-mentioned categories: hi-tech sticks for blind and handheld-based alternative devices by visually impaired. This leads to the combination of two technologies: RFID tags embedded into sidewalks and NFC tags in urban infrastructures (at a given quota). The near-cooperation using a labeling is exploited also in [7].

An emphasis on the system architecture, ergonomics, energy savings, design and proactivity allow an integrated pervasive augmentation with minimal flows to the outside. Our system follows statements described in the patent [4].

The use case scenario showing the arrival in the Turin's ophthalmic hospital presented by Fig. 4 exemplifies the use by heavily impaired visually. This trial has validated the usability issue: our device is almost identical to the traditional stick in terms of the geometry and weight, while the in-tactile path's tags readability appears satisfactory.

Fig. 4. Reaching the Ophthalmic hospital.

We use a wireless communication to link in-pocket smart phone with the RFID-enhanced stick, cooperative with the urban GRID, and correlating GPS location with relevant context. The personal navigator offers some augmentation, because of the context awareness, is not invasive because releasing few and short messages, but the behavior remains reactive, releasing the message with some delay after the context-related tag was read. To improve the situation we propose serializing tags preceding the annotated object (Fig. 5). The directional vector is GPS-generated and refined by tag's reading. The hypothesis about the junction might be refined using two tags, releasing the guidance before passing over the "next" tag. The stick-less setup reading NFC tags on-demand basis remains reactive being impossible pushing preventive events.

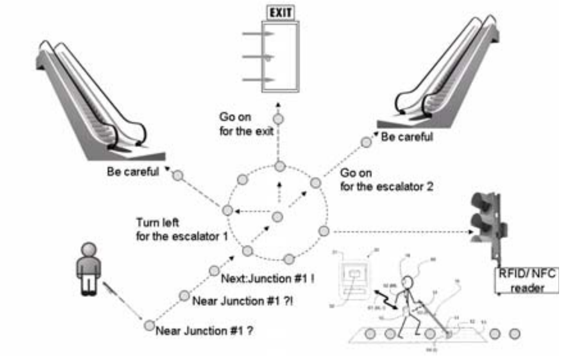

Fig. 5. Strategy

We are currently working on extending the setup to achieve the better proactive behavior, e.g. the ability to anticipate events and provide the assisted with continuous seamless guidance, investigating on the pattern-matching techniques. A situation shown on the Fig. 6 is representative of the "recurrent mobility" pattern, in which we may envisage the most probable "next" occurrence anticipating the help provision. This makes manageable the Fuzziness.

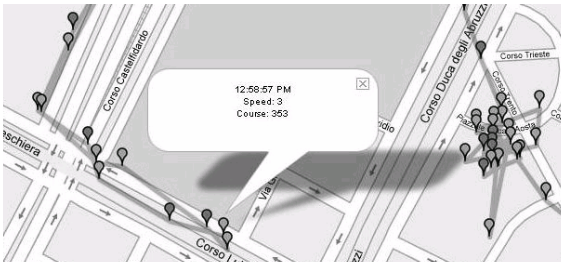

Fig. 6. Recurrent mobility pattern tracked

Lacking the possibility to calculate behavioral patterns on computationally low powered handheld devices, we consider modifying the architecture by sending the GPS tracking information to the remote server for the further elaboration and pattern-matching. The intelligent remote "Travel Agent" would elaborate the flow of events and might push back the needed reaction addressing the assisted directly or its caregiver, translating the setup in another domain. It permits detecting and accounting the cognitive disabilities (dementia) related behavioral patterns, where feedback delivery to the caregiver/ parent might activate further processes.

In order to achieve the reliable feedback or the reliable and synchronized delivery of the updated information about the local topology and mobility, the digital radio/TV technology appears beneficiary leading to the embedded dvb-h use on handheld devices. The broadcast or group-cast of an adapted geo- or RFID GRID- related information might replace the proposed option of preventive programming of RFID/NFC tags delivering the up-to-date database describing the local topology.

4 Conclusions and future work

We have prototyped the RFID-enhanced sensorial device equipped with the voice interface capable to interact with urban infrastructures refining the GPS geo-localization. Two embodiments are experimented, a handheld with the RFID-enhanced stick for blind users and the stick-less setup for those visually impaired. Intelligent algorithms and pattern-matching techniques add some value enabling the better proactive behavior. However the smart real-life applications present some difficulties.

A prototype of the system was implemented and some experiments were carried out validating the initial design concept, suggesting considering the NFC-enhanced cooperative setup for visually impaired users.

The future work will be focused on context awareness and pattern-matching, so the extension towards an extended cooperation.

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References

1 Stockham, T.G. (1972), Image Processing in the Context of a Visual Model, *Proceedings of the IEEE*, Vol. 60, pp. 828-842

2 Coughlan, J., Manduchi, R., Shen, H. (2006), Cell phone-based wayfinding for the visually impaired, in *The 1st International Workshop on Mobile Vision*, Graz, Austria

3 Bohonos, S., Lee, A., Malik, A. (2007), Universal Real-Time Navigational Assistance (URNA): An Urban Bluetooth Beacon for the Blind. *1st International Workshop on Systems and Networking Support for Healthcare and Assisted Living Environments* (HealthNet 2007)

4 Borsic, A., Belforte, G., Di Sora, E. (2007), System for exploiting information selected on the basis of the position of a user, in particular a visually impaired user, method and computer program product therefrom, *European Patent WO2007099416*, publication date 2007-09-07

5 Finkenzeller, K.(Ed.). (2003). *RFID Handbook*, John Wiley & Sons, Inc.

6 Shin, B.S., Lim, C.S. (2007), Obstacle Detection and Avoidance System for Visually Impaired People, in *Haptic and Audio Interaction Design*, Springer Berlin, pp. 78-85

7 Coughlan J., Manduchi, R. (2007), Color targets: fiducials to help visually impaired people find their way by camera phone, *Journal on Image and Video Processing*, 2007(2), 10-20