BlindShopping: Enabling Accessible Shopping for Visually Impaired People through Mobile Technologies

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Abstract. BlindShopping is a mobile low-cost easily-deployable system devised to allow visually impaired people to do shopping autonomously within a supermarket. Its main contributions are: a) a user navigation component combining an RFID reader on the tip of a white cane and mobile technology, and b) a product recognition component that uses embossed QR codes placed on product shelves and an Android phone camera for their identification. Furthermore, it provides a web-based management component to easily configure the system, generating and binding barcode tags for product shelves and RFID tag markers attached to the supermarket floor.

Keywords: Blind, Navigation, Mobile Computing, QR codes, Web-Services.

1 Introduction

Accessibility describes the degree to which a device or environment is available for every person. Nowadays, this term is more and more present in our society, as it is considered a fundamental right. On the other hand, technology seems to be invading every aspect of our lives, but it is also moving away from or not giving service to those collectives which most need it.

The PIRAmIDE project[1] addresses this issue by taking advantage of smartphones potential to behave as disabled users' sensorial complement. Its aim is to enable the smartphone-mediated interaction of a user with the ecosystem of services populating an environment (e.g. home or supermarket). Thus, PIRAmIDE allows disabled people to perform daily life tasks autonomously and independently of their disability (e.g. blind, deaf or elderly people). Mobile devices are transformed into sense enhancers giving a 6^{th} sense to those who already enjoy their five functional senses, but more importantly, complementing those which have some sensorial impairment.

One of the concrete application domains targeted by PIRAmIDE is overcoming the difficulties blind people usually encounter whilst shopping in a supermarket without the help of someone else. This paper presents an inexpensive easily-deployable solution which makes use of off-the-shelf technology (mainly smartphones).

From our point of view, an accessible shopping solution has to fulfil the following requirements if a feasible and flexible wide deployment wants to be achieved:

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- *Conventional shopping behaviour should not be altered.* Many available solutions require the user to establish her shopping list before initiating the purchasing process (planned shopping). In most cases, such an approach is more efficient but it is less enjoyable since the user, in this case the blind person, cannot actually browse the products of the supermarket, discover new brands or new product types, i.e. carry out opportunistic shopping. In fact, what we actually wish to do is mixed shopping, i.e. something in between planned and opportunistic shopping.
- *Minimal additional off-the-shelf infrastructure should be introduced in supermarkets.* Supermarkets are reluctant to introduce complex changes in their internal information management systems. Furthermore, only simple low-cost easily maintainable physical instrumentation of their purchasing surface including aisles and shelves is acceptable. Any feasible solution should leave products as they are, i.e. such solution must be able of recognizing and deal with the standard UPC barcodes utilized in worldwide retail. It is a must that accessible shopping systems operate in actual supermarkets with all their restrictions.
- *Blind people should use their usual devices.* A blind person carries with her a white cane and a mobile phone. Therefore, if any, those are the elements that may be modified or enhanced in order to allow a blind person to safely and effectively carry out her shopping. Only inexpensive off-the-shelf already known technology by the blind should be considered to ensure wider acceptance.

2 The BlindShopping Platform

Our solution aims to offer eyes-free technological support for blind people to shop around as if they saw, without altering conventional shopping patterns. It is designed to avoid overloading the visually-impaired person with additional new gadgets and enforcing a supermarket to go through heavy and costly, both in price and time, installation and maintenance processes.

The assumptions taken by BlindShopping regarding a supermarket organization are as follows. First, it is considered that all products are grouped into different product categories (e.g. drinks), and these are divided into product types (e.g. drinks/cola) which again are divided into concrete brand products (e.g. Pepsi can). Apart from that, the supermarket is divided into cells of two main types: cells containing shelves and passageway cells. Thus, internally, BlindShopping maps the IDs of the RFID tags within a cell to navigation and product location information such as the type of a given cell, its neighbour cell types, and in case of being shelf type cells, the product category, types and concrete products located in that area.

BlindShopping offers infrastructural support for the whole purchasing process within a supermarket, understood as a four step cyclic process: *product category navigation/product search/product identification/product selection*. Such cycle is broken when the user decides to go to the cash till to pay for her purchases. Consequently, BlindShopping offers a *navigation* component driving the user through voice messages to the aisle where a product category previously dictated to her smartphone is located. Once there, BlindShopping also offers support for *product recognition* by either shelf section identification or product own identification by means of QR or UPC code scanning, respectively.

Fig. 1. Navigation system (left), UPC code recognition (middle) and QR-code recognition

2.1 BlindShopping Architecture

The distributed component architecture of BlindShopping is composed of the following three components:

1. *Navigation system*. It is in charge of guiding the blind user inside the supermarket. It provides through a headphone connected to her smartphone simple verbal navigation instructions. It combines a white cane with a portable RFID reader attached to its tip, a set of road mark-like RFID tag lines distributed throughout the corridors of the supermarket (see left hand side of Fig. 1 and top part of Fig. 2, respectively) and a smartphone application processing the RFID readings received though Bluetooth and generating user navigation verbal commands as result.

Fig. 2. RFID tag marking (top), Motorola Milestone and HTC Desire Android devices (left), Baracoda's Pencil2 barcode recognizer and IDBlue RFID reader (middle), NFC 6131 NFC device (right) and QR-Code and standard UPC barcode (bottom centre)

2. *Product recognition*. Once the user reaches the target product section, she points with her camera phone (see Fig. 1) to an embossed QR [2] or UPC code attached to a shelf section or product. The smartphone camera recognizes that code and then informs verbally about the product main features. Note that a QR code can encode up-to 4296 alphanumeric characters, and its redundancy makes successful reading possible even when partial images of them are captured.
3. *System management*: BlindShopping includes a web front-end for BlindShopping RFID and QR code infrastructure management. It allows the registration of

the collection of RFID tags scattered though the supermarket floor and the QR-codes attached to products or shelf sections.

2.2 Implementation Details

A Nokia 6131 NFC was used, initially, for reading RFID tag floor markings and deliver them through a Java ME Bluetooth application to a user-carrying Android phone. An alternative implementation using the autonomous Baracoda Tagrunner[1] RFID Bluetooth reader has then been used.

The mobile application in an Android phone allows the blind person to choose an action through a gesture interface or by issuing a voice command. Concretely, the navigation system operation is requested by drawing an "L" or issuing the "Location" voice command (see Fig. 3). Drawing a "P" or issuing a "Product" voice command, the user will access the product recognition component that allows obtaining information about a product.

A backend server contains the system data and business logic of the BlindShopping platform. In a real deployment, this back-end should be integrated with the inventory management system of the supermarket.

Fig. 3. User drawing a "P" (left) on Motorola Milestone, Nokia 6131 NFC to read HF RFID tag for navigation and supermarket mock-up for testing (right)

3 Related Work

An exhaustive comparative study of existing accessible shopping systems for blind and visually impaired people was carried out by Kulyukin and Kutiyanawala [3] in 2010. ShopTalk [4] is a wearable solution that requires the user to carry a barcode scanner and a UMPC in a backpack. Verbal route instructions are issued through a headphone connected to the UMPC at the blind person's backpack. Although the supermarket does not need to install and maintain any hardware, the system requires access to the supermarket's inventory control system and binding of product barcodes into supermarket locations so that guiding can be accomplished. The advantage of BlindShopping is that it only demands a lightweight smartphone equipped with a camera to read QR Codes attached to shelf sections and the very blind person's white cane enhanced with an off-the-shelf RFID reader.

[1] http://www.baracoda.com/baracoda/product/ p_48_TagRunners.html

The Tinetra[5] project offers the possibility of detecting products via a barcode or RFID reader, and then it obtains related information via GPRS from the server. However, it does not include a guiding system as BlindShopping. Similarly to us they use Baracoda's Pencil2 to scan barcodes and IDBlue to scan RFID tags.

4 Conclusions and Further Work

A basic usability study with a blind person has been carried out. She was requested to navigate through different sections of our emulated supermarket surface by using her white cane with an attached BT RFID reader and an Android application on an HTC Desire. Her main comment was that navigation was very intuitive since locating the RFID tag markings was very easy and the navigation vocal commands very useful to reach the desired target. She was then requested to assess whether locating embossed UPC barcodes and using a Baracoda Pencil2 device to recognize them (see centre of Fig. 1) was easier or harder than using the Android phone camera to point to embossed QR codes located over products (see right hand side of Fig. 1). She judged that the latter was much more plausible. Besides, QR code recognition using a camera phone is much faster and reliable.

BlindShopping is a low-cost easily deployable solution which makes a supermarket accessible to visually-impaired people through two core components: a) an RFID and mobile phone based indoor navigation system and b) a mobile QR-code based product recognizer. Future work will undertake a fully fledge evaluation in a real supermarket.

Acknowledgments

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