

NFC BASED APPLICATIONS FOR VISUALLY IMPAIRED PEOPLE - A REVIEW

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ABSTRACT

Recent technological developments provide technical assistance that enables supporting people with visual disabilities in their everyday tasks and improve their quality of life. Considering that about 90% of the world visually impaired people live in developing countries, particularly in the local context, in Saudi Arabia, there is a lack of assistive tools and adapted environment supporting people with visual disabilities. To overcome this problem, a wide variety of relatively inexpensive applications adapt Near Field Communications (NFC) tagging technology in the development of assistive tools for people with visual disabilities. In this article, we will systematically review the current adaptation of NFC technology for visually disabled people and introduce NFC practical applications to help them overcome challenging tasks that they may encounter every day.

Index Terms— assistive technologies, visually impairment, NFC tagging, object identification, indoor navigation.

1. INTRODUCTION

Visual impairment is defined as the decrease in the volume of information collected by the eye from the environment, diminishing the amount of experiences that individuals might receive from their surroundings, and it may range from low vision to total blindness. Total blindness is the complete inability to see, while visual impairment or low vision is a severe reduction in vision that cannot be corrected with spectacles or contact lenses [1]. According to the World Health organization, number of people with visual disabilities reached around 285 million in June 2012, in which 39 million are blind. And about 90% of the world visually impaired people live in developing countries [14].

Recent technological developments can provide technical assistance that are able to support patients in their everyday tasks, improve their quality of life and allow such large population to perfectly integrate in society. Assistive

technologies are relatively new and they are used by individuals with disabilities in order to perform functions that might otherwise be difficult or impossible, including hardware and software that assist people with disabilities [2]. Nonetheless, there are not many applications or tools for people with visual disabilities, possibly due to the high cost for instrumentation and limited capabilities [10]. Particularly in the local context, in Saudi Arabia, there is a lack of assistive tool and adapted environment supporting people with visual disabilities. Hence, the focus in this paper is on assistive technologies, which are relatively inexpensive for both the blind and the businesses, to support visually impaired people so that they could integrate in society.

One of the relatively recent technologies in the communication field is the Near Field Communication (NFC) technology. There has been a fast growing progress in mobile devices and the number of new generation smartphones equipped with NFC readers is increasing nowadays as shown in Figure 1.

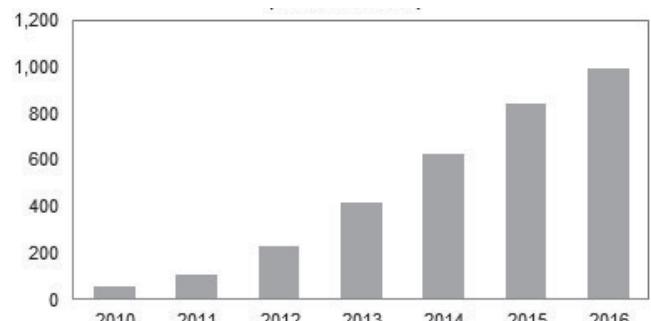


Fig 1: Global Forecast of Cellphones Integrating NFC Chips (Millions of Units). [Source: IHS iSuppli September 2012].

NFC is actually a subset of RFID with a shorter communication range for security purposes. It is a fast, easy-to-use and short range wireless communication technology that combines a contactless identification and interconnection technologies which enables secure communications between electronic devices, such as mobile phones, PDAs, computers or payment terminals. It is one of

the most important emerging technologies for the upcoming years [4] thanks to its simplicity, reliability and security. In the interaction process the user just has to touch the RFID-tagged object to get a piece of information. It is considered as a passive low-cost technology and the number of mobile phones equipped with NFC readers is remarkably increasing. A wide variety of applications have been subsequently developed over the past few years. Next section reviews the current applications using NFC technology for visually disabled people. Then, in Section 3, we report the research challenges and some recommendations that should be considered in developing systems using this technology for blinds.

2. NFC FOR VISUALLY IMPAIRED PEOPLE

Considering the features of NFC technology mentioned above, a plethora of publications were found in the literature that discussed the employment of NFC technology in the development of assistive tools for people with visual disabilities. Using NFC tags has been proposed in earlier works for object identification in specific contexts as well as for indoor navigation assistance.

2.1. Objects Identification

Joe Whitworth [4] has discussed various applications of NFC technology for providing audio information for users in general. The authors intentionally focused on the field of identifying everyday items, where items like food packages and medical bottles are equipped with NFC tags to provide some useful information. This information can be audibly spoken or it can be directly downloaded and posted to a blog or web page. NFC tags could also serve as an access point for digital services like directing to a specific web page or downloading a specific application.

Garrido et al. [5] presented a realistic model for object identification by labeling context-awareness scenarios where both visually impaired and healthy people can interact with the labeled objects through their NFC-equipped mobile devices. This labeling allows the creation of different augmented scenarios that offers tailored services to the users which allows for a customized interaction based on a set of rules defined by those users. Their solution was tested in a real environment; the Baena Olive-Grove and Olive Oil Museum, and has received good acceptance.

Bae et al. [8] presented a Ubiquitous Library for the Blind and Physically Handicapped through the use of NFC-enabled mobile phones. The project was conducted at the LG Sangnam Library. The Library adopted NFC technology to automatically proceed with user identification in connection with the network. NFC technology is utilised to sense and track personally identifiable information of the user; and allows them to easily gain access to the network and download the Digital Talking Books via activated Bluetooth communication.

Sánchez et al. [9] proposed the utilization of the NFC technology in the medical field for helping blind users through the (PharmaFabula) project to recognize medicines and report about the patient information and other useful data in audio format. This project employs NFC technology and RFID tags in providing useful audible-formatted information about the patient case and other useful medical information like dosage and treatment duration, simply by incorporating the RFID inside the medicament box.

Kathryn Ringland [28] designed a collection of tagging systems prototypes that can be used in helping visually impaired users when making clothing decisions. Several prototypes were developed including adapting different shapes of buttons to inform about the visual data of a clothing article. Other prototypes involve Braille ID Tags, QR codes and washable RFID/NFC tags. Washable RFID/NFC tags were sewn directly into the hem or collar of an item of clothing. These NFC tags allow the user to only aim in the general area of the clothing instead of directly at the tag like in QR code. For this prototype, a RFID handheld device was built that plugs into the computer. When it reads the tag, it sends the ID number to the computer, which can be interfaced with a database.

Recently, Samsung has introduced new accessories for its Galaxy Core Advance NFC smartphone, including an NFC-enabled voice label [25] to assist users in identifying objects allowing them to record notes or any other additional information. According to Samsung, this voice labels may be used for recording instructions on how to use a specific electronic device, for instance.

Table 1 summarizes the proposed applications for NFC in the scope of object identification for the visually impaired.

Table 1: A summary of the NFC applications for object identification for the visually impaired.

NFC main application	NFC sub application	Publication/s
Object Identification	Works as access points.	Joe Whitworth [4] (to access digital services such as web page) Bae et al. [8] (to access a library network)
	Identify food packages, medical bottles and other items.	Joe Whitworth [4] Sánchez et al. [9] Samsung [25]
	Obtain information about museum exhibits with user-tailored services.	Garrido et al. [5]
	Report about patient medical case, dosages and treatment duration.	Sánchez et al. [9]
	Report about the visual data of a clothing article	Kathryn Ringland [28]
	Report about instructions on how to use a specific devices	Samsung [25]

2.2. Indoor Navigation

One of the most challenging problems facing people with visual disabilities in their daily activities is to move in an unfamiliar place and to plan a safe path to reach the desired destination. Lack of independent and safe mobility is ranked as the most significant barrier depriving individuals with visual impairment of a normal living experience [6]. The problem of navigation assistance in general has been widely addressed in the literature. Particularly for outdoor navigation, several commercial navigation applications provide users with directions from one place to another using GPS technology offered by smartphones [15, 20]. Some of these products are designed for people with visual impairments [16, 17, 18, 19].

However, for indoor navigation, GPS performance has fundamental limitations that result in much larger position estimation errors. A variety of alternatives to GPS have been proposed for indoor navigation including WIFI [23], Infra-Red transmitters [21], Image matching and processing [12] and RFID tagging [10, 11, 13]. The methods used in indoor localization can be classified into two main approaches as shown in Figure 2:

2.2.1. Locating in relative coordinates

The most straightforward method to estimate the position of the user is to determine whether it is within the coverage of some reference station. The accuracy of positioning with this approach strongly depends on the range of reference transmitters. The systems usually calculate the position of the mobile subject using the signal strength at reception time, expressed by Received Signal Strength Indication (RSSI). Distance estimation techniques involving radio wave propagation modeling are widely used

in positioning systems. However, due to the high complexity of indoor radio wave propagation environment, it is often hard to unambiguously relate measured signal parameter value to a distance from the transmitter.

2.2.2. Locating at choke points

The sensors can be located at fixed points and return values from the predefined node in the network. In this approach, the location is determined using the location indexing for tagged objects with known identification and location coordinates of the tags. Hence, when a predefined node in the network and the receiver are within communication range, an assumption about their mutual distance and location can be done. The position of the user may be determined by the position of visual markers and a mobile phone with photo-camera.

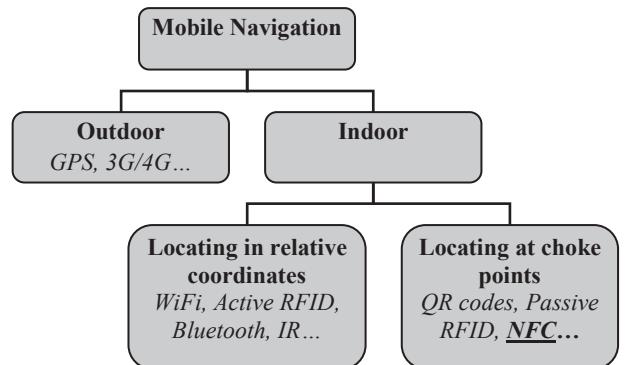


Fig 2. A classification of number of technologies depending on their application for Mobile Navigation.

As example, [30] describes a low cost system that recognizes the Quick Response (QR) markers. The main

challenge is in locating the visual tag by the blind and navigating to its position.

BlindAid [10] uses RFID tags to set up the user's location and utilize this localization data to generate vocal directions to reach a destination. The system encompasses an RFID reader carried by the user, and a network of inexpensive RFID tags in the building to be navigated. In the proposed system, an RFID reader (IDBlue) was required to communicate with the mobile phone.

Rosen S. Ivanov [7], proposed the development of a low-cost indoor navigation system that relies on the NFC technology. The proposed system helps the user imagining the map of the rooms through information stored in NFC tags. This imagining is done through two types of tags - navigation (current position; navigational information to reach selected reference point) and audio (name of reached reference point, room dimensions, names of the reference points in the room). The system was evaluated in hospital settings, as shown in Figure 3, where RFID tags placed on the doors of all rooms to which visitors have access, and the doctors promoted to leave messages for their patients in audio tags. However, the proposed solution faced many obstacles when buildings have very long corridors.

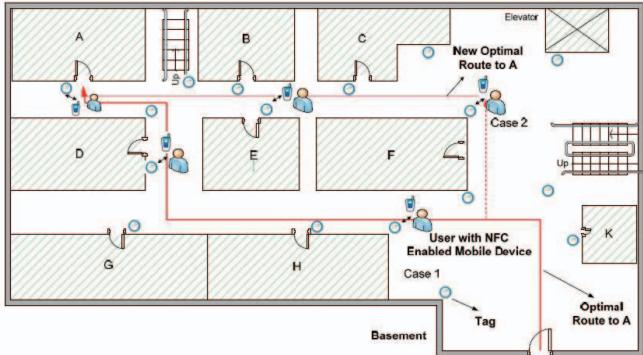


Fig 3. NFC tags are placed on the points of interest around a building. With each tap the app calculates a new optimal route to the destination [27].

Ganz et al. [29] proposed an indoor navigation system for the blind called PERCEPT. The system uses passive RFID tags deployed in the environment, a custom-designed glove, smartphone carried by the user and a backend server for handling information. When the user, equipped with glove and a Smartphone, enters the building, he scans the destination at a kiosk located at the building entrance then the system directs the user to the destination using landmarks (e.g., rooms, elevator, etc.). Proximity of 2-3 cm is required for reading tags. Experiments on the system were performed with 24 visually impaired users in a multistory building. Each subject was asked to navigate to ten different destinations. The ratio between the length of

Actual Path Traveled and the length of the PERCEPT Path was measured and the average was 0.90. This was interpreted as an indication of the very high efficiency of the navigation instructions.

López-de-Ipiña et al. [30,31] proposed an RFID and QR-code based mobile solution for helping blind people achieve an autonomous shopping in a supermarket. Their proposed solution named "BlindShopping" provides two main components: 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. Using the cane, a user can follow a specific lane, composed by RFID labels, on the floor of a supermarket. A basic usability evaluation with a blind person has been carried out where the user was requested to navigate through different sections of an emulated supermarket surface. User's feedback comments were positive regarding the navigation tasks she performed.

Tomitsch et al. [6] pointed out the problem of accessibility of real-world tagging for users with visual disabilities in that they cannot get benefit of RFID tags because they are simply not aware of the presence of these tags. To propagate the existence, location, and functionality of these tags, authors introduced the concept of Audio-tactile Location Markers (ALMs) as a solution to this problem. This solution is a combined approach of audible signals and tactile identification; where the audible signals makes users aware of the presence of a real-world tag, the tactile exploration allows them to identify the tag's purpose. Participants experienced no problems locating the ALM based on the audible signal, but they required assistance with touching the tag.

3. RESEARCH CHALLENGES AND RECOMMENDATIONS

Several studies proposed to utilize NFC technology for assisting visually impaired and blind people in indoor navigation and identification of daily life objects. However, there are few user studies addressing the problem of the effectiveness and the accessibility of this technology [24, 6]. Thus, we believe that there are many challenges that need to be considered in designing assistive tools especially for visually impaired people. Hence, we propose some recommendations that might help to overcome the following challenges:

1. **Usability:** Using NFC tags generate new forms of interaction. Studies about the application of new interaction concepts in real contexts often raise usability problems that had not been considered before. In fact, exposing real users to such new forms of interactions in real-world scenarios might raise further research challenges.

Usability issues can be addressed by increasing the level of user involvement into every stage of the system development process. Further, prototyping should be done in several iterations to examine the usability of NFC tags.

2. Accessibility: An inherent problem of NFC tagging technologies is their lack of affordances for user interaction (transmission of data over very short distances: <10cm). This is even more problematic when designing accessible applications for blind users, who require assistance in locating and identifying the tags.

Accessibility issues can be handled by utilizing the solution proposed in [6] which suggests using Audio-tactile Location Markers (ALMs). Especially for indoor navigation, we suggest to combine the use of NFC with another type of sensors which is easier to access and with higher range than NFC. Actually, we are working on integrating Estimote Beacons sensors [26] built on Bluetooth 4.0 chip, also called a BLE (Bluetooth low energy), with the NFC tags in an indoor navigation system.

3. Accuracy: The model must count on quite accurate information about the user's movement and location. The information accuracy must allow the system to support the navigation of blind people in a safe way.

Accuracy issues can be mitigated by examining different path finding optimization algorithms to find out the safest and most accurate one. Prototyping the system can also help in increasing its accuracy.

4. User-centric: When creating applications for people with visual disabilities, the choice of the user interface is of particular importance. The User Centered Design (UCD) must be used in which a selected group of users might be involved at the different stages in the process of application design. Investigating the opportunities of finding eligible volunteers in the local context was also a must to face UCD challenge.

Difficulties of applying user-centric method can be reduced by studying the key characteristics of the people with visual disabilities and reviewing similar work in literature and the lessons learned. In the local context of Saudi Arabia, we are also working closely with Kafeef Society which is a charity association offering rehabilitation and educational support for visually impaired people in Riyadh.

4. CONCLUSION

By exploiting NFC technology and the power of modern mobile devices (including various capabilities such as sound, video, data processing, etc.) users can interact with the real environment just by touching tangible objects previously augmented by NFC tags. Adapted to the visually impaired people's requirements, it allows them to perform

tasks such as navigating through different rooms in buildings or receiving useful guiding information regarding objects merely via mobile devices equipped with NFC technology.

For object identification, NFC tagging seems to be very promising and robust approach. However, creating a useful indoor navigation application for disabled people should enable users to get detailed information to identify the different locations and then clearly understand how to follow the resulting path to their destination. Based on the literature survey, safety, usability and accessibility concerns were not given much attention in the previous work despite their criticality. An inherent problem of NFC tagging technologies is their lack of affordances for user interaction (transmission of data over very short distances: <10cm). Therefore we believe that there are many challenges that still need to be overcome mainly for applications targeting visually impaired people.

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