Assistive Platforms for the Visual Impaired: Bridging the Gap with the General Public

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Abstract. The visual impaired are a specific minority group that can benefit from specific assistive systems in order to mitigate their mobility and accessibility constrains. In the last decade, our research group has been integrating and developing assistive technologies, focused in human-computer interaction, artificial vision, assisted navigation, pervasive computing, among others. Several projects and prototypes have been developed with the main objective of improving the blind's autonomy, mobility, and quality of life. Currently the technology has reached a maturation point that allows the development of systems based on video capturing, image recognition and location referencing, which are key for providing features of artificial vision, assisted navigation and spatial perception. The miniaturization of electronics can be used to create devices such as electronic canes that equipped with sensors can provide so much more contextual information to a blind user. The adoption of these systems is dependent of an information catalogue regarding points of interest and their physical location reference. In this paper we describe the current work on assistive systems for the blind and propose a new perspective on using the base information of those systems to provide new services to the general public. By bridging the gap between the two groups, we expect to further advance the development of the current systems and contribute to their economic sustainability.

Keywords: Assistive technologies · Blind users · Navigation · 3D mapping · NFC

1 Introduction

Currently there are 285 million people with visual impairments worldwide [1], of which 39 million are blind and 246 million suffer from reduced vision, to whom the lack of vision may cause suffering as well as a reduction of their personal autonomy. The World Health Organization (WHO) defines four levels of visual function: normal vision, moderate visual impairment, severe visual impairment and blindness [2], in which these visual impaired individuals are classified.

This group of disabled people is highly vulnerable in regard to physical accessibility and consequently in their ability to develop work and personal activities and relations. About half of the visual impaired individuals (48%) experience a considerable degree of detachment, from other people and from their surrounding environment, which can be classified as "moderately detached" or "totally detached".

Á. Rocha et al. (eds.), *Recent Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 570, DOI 10.1007/978-3-319-56538-5_61

The visual disability introduces several types of constraints in the individual's life and one of the most relevant, directly related to most of the individual life aspects, is the reduced mobility.

Most of these individuals have a strong willpower and are highly motivated to deal with their disability. They are receptive to new technologies as long as they consider them useful.

Some important advancements in computer science algorithms and hardware have created a fertile environment for the maturation of computer vision systems capable of being used to build new applications to assist blind people [3].

Three important contributions are those related to:

1. Artificial vision;
2. Assisted navigation;
3. Detailed spatial perception.

Artificial vision has become a very interesting application as an assistive technology, currently developed based on text and object recognition, which has been made possible by the developments in mobile devices and data processing services on the cloud. In this context, users can have thin devices, e.g. mobile phone, to acquire images and videos, which are instantly processed on the cloud, resorting to powerful algorithms, using deep learning and other weak artificial intelligence technologies.

Assisted navigation has been evolving to an augmented navigation concept. An example translates in an augmented cane, in which several systems are being developed to augment the conventional white cane used by blind people to sense the surrounding environment. These electronic canes have built in electronics that can have several types of sensors, e.g., RFID, NFC, sonar, GPS, gyroscope, video, etc. and provide audio feedback to the user, regarding the composition of the physical space surrounding the user [4, 5].

Detailed spatial perception is a general concept for the acquisition of detailed information about geometry and composition of a scene or object. Several approaches have been proposed that can be classified in this general concept. A promising approach is the Integrated System for Enhancing the Autonomy of the Blind (ISEABlind) [6].

These assistive proposals are specific to the blind people group and rely on special digital information, services and hardware, which are expensive and requires proper maintenance. This paper reports on a proposal to use the blind people assistive systems as a framework for other services to serve the general public. It is a different approach in the sense that the classical approach advocates the addition of elements to the general public regular systems in order to make them accessible and useful to specific impaired public, which are the blind people in the current case. This proposal features the specific blind people systems as the baseline and researches other features that can be added for the general public.

A good example of the combination of detailed spatial perception with navigation is provided by a project of the University of Buffalo, in which a tactile model is used to provide spatial perception and navigation information to blind users [7]. The University of Buffalo, together with the companies Tactile Graphics and Touch Graphics have developed a technology of 3D mapping and used it to build a 3D mapping system with a tactile sensing interface. The system features a flat map equipped with wire sensors and a processing unit (a computer) that reads the user's touch and voices the name of the locations and their related paths, as in Fig. 1.

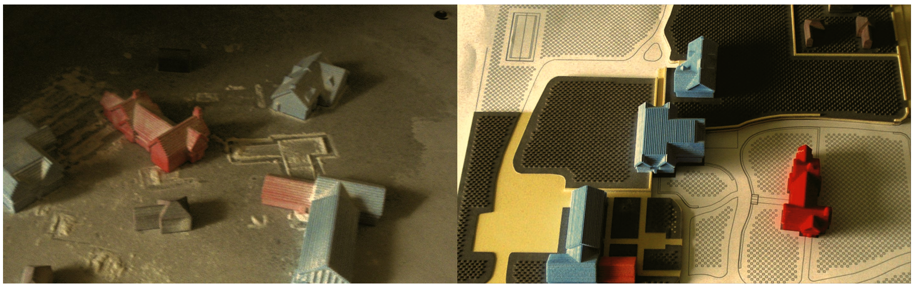

Fig. 1. 3D map from tactile graphics, touch graphics and the University of Buffalo [7].

2 The ISEABlind Model

The ISEABlind features a demonstration scenario developed in the SmartVision (PTDC/EIA/73633/2006), Blavigator (RIPD/ADA/109690/2009) and CE4Blind (UTAP-EXPL/EEI-SII/0043/2014) projects [4, 6, 8–11]. In our previous work, we developed a model using detailed spatial perception for navigation by combining the technologies of 3D mapping and NFC tagging. The 3D mapping is used to provide detailed spatial perception of the scene through tactile stimulus and NFC tagging is used to trigger a sound message related to the tag's specific location within the 3D map. This model aims to enhance the blinds' spatial perception by combing tactile and audio stimulation.

2.1 The Sculpture Maps

The 3D mapping is intended to give the user the opportunity to create a mental map and have spatial perception of the surrounding environment, previous to the actual navigation. The implementation of the sculpture map is based on existing plans and blueprints, which are modelled using a 3D software tool. In Fig. 2 are displayed some prototype models containing several elements [8].

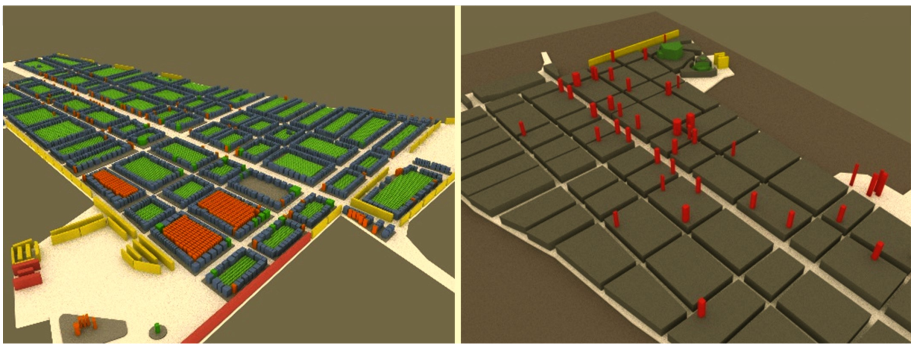

Fig. 2. (i) First version model of 3D maps and (ii) simplified model.

These sculpture maps are built mainly for easy and fast tactile interpretation by a blind user, so the different height of the various locations and points of interest, as well as the different textures of the elements, are very important for an easy memorization and usability of the map. The sculpture map creation is a two phase process, beginning with the removal of the unnecessary elements from the 3D map in order to highlight the relevant areas, according to a predefined level of detail. This scene simplification is important in order to not confuse the blind user with too much detail. Several techniques are used for the simplification, e.g., joining similar elements in groups, redesign complex elements, etc. On a second phase, the 3D model is resized and the solid faces are created, and subsequently extruded with different values for each element group (Fig. 3). Finally, the sculpture map is created and the NFC tags are placed in the proper points of the map.

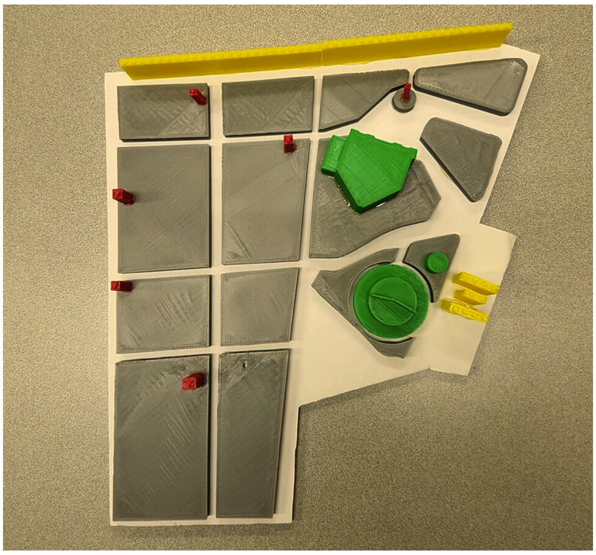

Fig. 3. Final sculpture map.

In the prototype, on a final sculpture map, as in Fig. 3, these values were width: 84 cm, length: 118 cm and height: 4 cm. The sculpture map was designed mainly for usage by blind people, but the parameters were chosen also to meet other general purposes, such as a model for touristic information.

2.2 Navigation with Support from NFC and RFID Tagging

For the navigation, the locations are physically tagged with RFID tags and the user carries an electronic cane, able to read the NFC tag information from the sculpture map and to provide guidance information leading to the desired location, physically tagged with an RFID tag. In the prototype setup, the location of the user is estimated from a set of possible inputs, e.g., Global Navigation Satellite System (GNSS) and the RFID tags.

A prototype of an electronic cane, similar to the previously described cane, was developed by the project Blavigator [9–11], which can sense NFC and RFID tags on specific points of interest, e.g., touristic locations, public services, etc. This points are arranged in a topology composed of connected lines and clusters, forming together a network of safe paths, connecting the interest points.

This cane uses the built-in NFC reader to obtain contextual information from the sculpture map, e.g., the points of interest, and provides the audio information stored on those NFC tags.

3 Extending ISEABlind Model to Other User Groups

The sculpture map may also be of great value for some other specific user groups or to the general public, as it contains a full catalogue of the points of interest of a scene and a physical representation of an area or object [11–13].

The previous mentioned projects are related to sculpture maps of large areas, in which the sculpture map is a small simplified object, representing a much larger area. This same concept can also be applied to common objects in which the object is a sculpture map of himself. This new perspective embraces a new technological challenge, as might not be possible or desirable to tag the object/sculpture map with NFC tags. An example is an art object, such as a painting or sculpture that might have specific points of interest but is not susceptible for the insertion of physical tags.

To extend the system, a solution would be the virtual tagging of the sculpture map by using image recognition. The NFC tag would then be replaced by a hieroglyph mark or even just by a digital feature description signature. That way, the recognition of the points of interest location would be accomplished by using image analysis technology instead of NFC reading.

With the base information (or catalogue) of a scene and its location reference on the sculpture map, an augmented reality technique can be used to combine the online image of the scene with the catalogue information, using the location reference to bound the two types of information on a single image. The user can then visualize the sculpture map while visualizing the information associated with the current sculpture map instant image. That would be a very interesting application for the visualization of touristic points of interest or object details that would provide semantic context to specific elements [14].

For the implementation of this concept we are working to develop an application for the current mobile devices (smartphones and tablet computers). The process of providing the augmented reality, as being developed: (i) the user points the device camera to a scene or sculpture map; (ii) the device acquires the image and checks for virtual tags; (iii) if it finds a virtual tag, will then alert the user and display the catalogue information directly above the original acquired image [15] (Fig. 4).

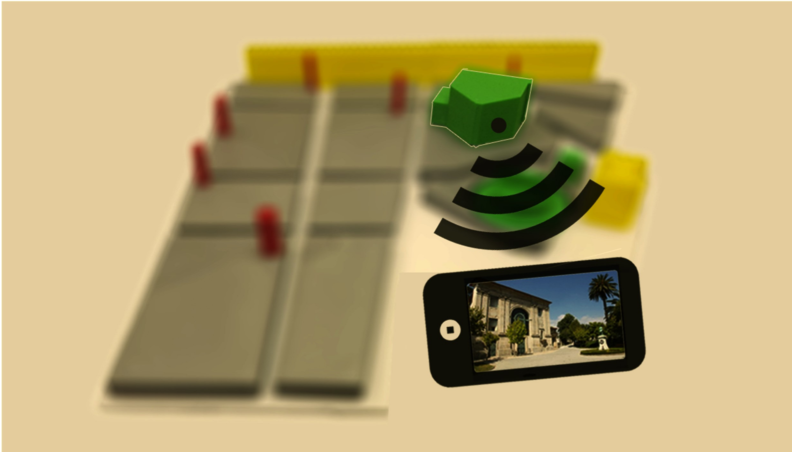

Fig. 4. Proposed model.

4 Conclusion

The assistive systems for the blind have been proved in several projects as scientifically and technologically feasible and sound. Unfortunately their adoption also requires the market test of economic feasibility and sustainability. This work provides a new perspective on bridging the gap, between the blinds minority group and the general consumers group, by using the same base information to support both types of systems.

It is our intention to further develop the current laboratory prototype in order to create a full scale production prototype that will be used to evaluate: the feasibly of the technology; its application on a real scenario; and its economic sustainability.

The long term objective is to mature the model and its implementation technologies in order to create a full scale product or line of products.

Acknowledgments. Part of this work is funded by the 2015 Digital Inclusion and Literacy Prize - Integrated System for Enhancing the Autonomy of the Blind, promoted by the Portuguese ICT and Society Network, granted by the Portuguese Foundation for Science and Technology (FCT).

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