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Ebsar: Indoor guidance for the visually impaired

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ABSTRACT

The number of people experiencing vision loss has been increasing rapidly, leading to great interest in assistive technologies research. Together with the emergence of wearable devices equipped with cameras and sensors, these technologies integrate multiple hardware and software tools to help the blind. This paper describes *Ebsar*, an Arabic navigation aid with an optical head-mounted display that guides blind people indoors. The application constructs indoor maps by tracking the movements of a sighted person inside a building, generates and prints QR code location markers for points of interest, and then provides voice guidance in Arabic to blind users. A user acceptance study, in which 15 sighted people evaluated the map construction process and 9 blind users evaluated the guidance system's usability and effectiveness, demonstrated the ease of use of the Ebsar application.

1. Introduction

Vision is an essential sense for efficiently navigating spaces in daily activities. However, according to the World Health Organization, globally, the number of visually impaired people is approximately 285 million; this number includes 39 million blind people, 82% of whom are at least 50 years old. These statistics indicate that visual impairment constitutes a major worldwide health risk [1].

Research has shown that blind people reduce their outdoor and indoor mobility to avoid the risk of unintentional injuries [2]. In general, visually impaired people depend on their hands and their cane to touch objects and to identify their surroundings. These methods do not allow them to recognize the color of an object or identify written text [3]. Further, the coverage area of a cane is limited to a small area around the lower part of the blind person's body. Thus, a blind person may still be involved in a collision because a cane is useful only in the case of proximity to obstacles in this specific area [2]. Consequently, blind people often depend on sighted persons for descriptions of objects and assistance in navigation; hence, they face significant difficulty in living independently.

The field of computer vision has been used to help blind people in their daily lives. The development of smartphones, in particular, has been useful because of their integrated cameras and the various assistive navigation applications that have been developed to assist the visually impaired, as in [4] and [5]. These applications help blind people read signs, determine their location in the street, and find their way to their destinations [3]. For blind cane users, the advantages of smartphone applications include their affordable cost, lightweight, and low power consumption. However, the use of

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Fig. 1. Google Glass has a built in camera, microphone, speakers, touch pad, and numerous sensors [7].

smartphone applications poses certain challenges: e.g., the difficulty in knowing where to place the smartphone camera to obtain suitable images and the need to hold the smartphone in one hand while holding a cane in the other, thus making it difficult to open doors or press buttons [3]. Hence, a better solution is required.

Assistive technology for blind people is a key area in current research related to disabilities. This field focuses on wearable devices such as optical head-mounted displays (OHMD) like Google Glass [6]. Google Glass, shown in Fig. 1 [7], has a built-in camera and provides hands-free interaction. In addition to its affordable price and light weight, it has demonstrated great potential for assistive applications, as in [8] and [9]. Despite advances in technology, to the best of our knowledge, there is no existing application that helps blind Arab people to move easily inside buildings, such as schools, hospitals, and malls, without assistance. In order to address this limitation, we develop an Arabic system that uses Google Glass to guide vision-impaired users indoors. The main contributions of this research are:

1. a novel approach in constructing a building map based on tracking the movements of a sighted person using a mobile accelerometer and compass;
2. a system for producing camera detectable location markers, Quick Response (QR) Codes, that improve user guidance accuracy; and
3. an application that guides vision-impaired users in indoors spaces with the aid of Google Glass.

The remainder of this manuscript is organized as follows: In Section 2, recent literature in the field of assistive technology is discussed. The proposed system and its building blocks are described in Sections 3 and 4. In Section 5, the results of our user acceptance study are presented. Our conclusions are discussed in Section 6 and future work is described in Section 7.

2. Related work

Recent disability research has produced a number of studies that focus on wearable devices. In this section, we describe some of the solutions that have been developed to assist blind people. This section is organized in two parts: (1) we describe available indoor navigation systems; (2) we present some studies related to Google Glass.

2.1. Indoor positioning methods

Past research conducted in indoor navigation used infrastructures such as beacon systems or signal detection via a carried laptop or built-in-camera to navigate safely inside buildings. Recently though, attention paid to wearable technologies has increased and is fast becoming the main focus of indoor positioning research.

A significant number of studies have focused on complete systems for blind users. In one such study [2], researchers developed a complete system consisting of a mobile interface, glass-mounted RGB-D depth camera, navigation algorithm, and haptic feedback system. The camera captures images and sends them to the navigation algorithm. The navigation algorithm builds a location map based on ego-motion estimation and image mapping and delivers it to the user via haptic feedback. This system improves mobility but the setup is bulky. Although it assists visually impaired cane users, it requires that they connect to a laptop, camera, and mobile devices. In addition to a cane, this system requires blind users to travel with multiple heavy assistive devices. It is, understandably, better to provide blind users with a light, hands-free device for assistance in traversing an environment.

Another example of a complete system that helps guide blind users is presented in [10] and [11]. In [10], the authors illustrate some of the available indoor and outdoor systems for visually impaired people. For example, most outdoor systems use a Global Positioning System (GPS) based on geostationary satellite signals that has an accuracy of upto several meters. Indoor systems typically use a built-in camera to guide a blind person. Some indoor systems use an ultrasonic sensor system with synthetic speech to indicate the path a user should take; others use an embedded RFID unit and compass to guide visually impaired cane users. The authors highlighted the high cost, low accuracy, and limited usability of most current systems and recommended improving the usability of existing systems by reducing the number of sensors that a blind person must carry.

Similarly, in [11] the authors propose a robust indoor system, comprising an RGB-D camera, a laptop, and headphones, to help visually impaired people navigate. The proposed system combined the images from the RGB-D camera with color information to detect obstacles in the observed area. This approach improved on other systems because it increased the