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Easing the integration: A feasible indoor wayfinding system for cognitive impaired people

Juan C. Torrado *, Germán Montoro, Javier Gomez

Escuela Politécnica Superior, Computer Engineering Department, Universidad Autónoma de Madrid, Madrid, 28016, Spain

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ABSTRACT

People with cognitive disabilities have to acquire several skills in order to achieve autonomy and self-development. One of these is indoor navigation through new and complex environments such as their school or work center. We propose a smartphone application that helps them to get from one place to any other in a modeled environment, following a trail of clues. It is based on location through QR codes, which makes it inexpensive, straightforward to implement and reusable. We conducted an experiment on 14 users with several cognitive disabilities in an unfamiliar environment. The results validated both the system and the approach.

1. Introduction

One of the main problems faced by people with cognitive disabilities during their lives is personal autonomy [1]. This is true even in those with minor cognitive impairment, who are expected to achieve a level of autonomy similar to non-disabled people. The difficulty of getting and keeping a job becomes a barrier to their level of autonomy since, in people with cognitive impairment, full autonomy implies labor insertion [2]. There are a lot of issues concerning this matter, such as productivity, enforceability, performance or planning abilities. Some of these problems can be solved through the use of Assistive Technologies (AT), which are defined as "any product (including devices, equipment, instruments and software) specially produced or generally available that is used by or for disabled people to protect, support, train, measure or substitute for body functions or structures and activities, and to prevent impairments, activity limitations or participation restrictions" [3]. Specifically, getting a job involves the development of several skills, such as social skills, frustration tolerance, performance of various job-related tasks, and outdoor and indoor wayfinding.

This paper focuses on indoor wayfinding, which is a major challenge for these individuals since at first, they are not used to their new workplace and need constant guidance until they have assimilated its structure and learned how to go from one place to another. Caregivers and labor trainers usually undertake this tutelage, but it is expensive and time-consuming [4].

Due to this problem [5], researchers started to introduce technology-based aids in order to reduce costs and facilitate this learning process. The first issue to solve was how to locate the user: if we use technology to guide an individual, the technology used must know where the user is at any given time. One idea is to install beacons along circulation paths at the job facility, as proposed by Chang et al. [6], and perform guidance through wireless sensing, prompting multimedia instructions. However, installing beacons is still expensive and requires an intrusive process in the work center.

Another more subtle way to locate users indoors is to make them notify the system indirectly of their position in the building. We propose to do this by leaving a trail of clues along the route: when users find a clue, the system knows which

* Corresponding author.
E-mail addresses: juan.torrado@uam.es (J.C. Torrado), german.montoro@uam.es (G. Montoro), jg.escribano@uam.es (J. Gomez).

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clue has been found and where it was placed, and therefore can pinpoint the user's location. These clues are presented as QR tags, which are inexpensive, straightforward, and easy to place throughout the workplace. QR tags can easily be scanned with any modern smartphone, which have become widespread devices among people with cognitive disabilities too. Our proposal, therefore, consists of a system based on two popular and accessible technologies: smartphones and QR codes.

2. Related work

2.1. Indoor positioning methods

Much work has been done recently in the field of indoor positioning and indoor navigation. Before the popularization of smartphones, indoor location and navigation relied on infrastructures such as beacon systems (see the aforementioned work by Chang et al. [6]) or signal detection through devices developed ad hoc. But smartphones provide the user with a handheld set of sensors and actuators, and have proved extremely useful in this area. However, systems combining smartphones and indoor movement have always been problematic, either in terms of the need for infrastructure or in terms of performing complex calculations on the device, both of which can lead to high expenses and slow or battery-demanding systems. The system developed by Elloumi [13] uses smartphone cameras to detect the location of the user through computer-vision algorithms. When successful, location is extremely precise, but requires the device to be fixed at chest height with the camera working constantly. The battery consumption is relatively high (both camera and real-time algorithms in operation), and the mobile phone cannot be used during navigation time. Ciurana et al. [7] performed positioning through the user's Wi-Fi and GPRS connection. Despite being widespread technologies, however, this system would not work in many indoor environments lacking network coverage or Wi-Fi equipment. In the proposal by Qian et al. [8], the calculation of the user's inertia is performed on the smartphone, deriving the user's movement and location. This approach is straightforward and inexpensive for normal users with standard movement patterns, but in the case of people with cognitive disabilities, relying on user movement to calculate their location does not seem to work so well in practice. Other studies have combined signal infrastructure and mobile devices, as in the case of Kumakura [9], which is very precise when it comes to locating the user, but the high cost remains a problem, and such extreme precision, locating the user to within centimeters, is unnecessary. Anwar et al. [10] took a very interesting approach, using special labels in the environment. These labels were structured so that the device could calculate the distance and angle from the label when its picture was taken. This scheme involves low costs and high precision location, but the tags are quite large and the algorithm requires a certain level of computational power in the device. What we wanted for our system was very simple: quick, straightforward actions to locate the user with cognitive disabilities (taking photos of tags with the smartphone is very suitable) and less intrusive tags, containing fewer data for the device to process. Thus, we chose QR Codes as tags and the size of the printed tags as precision guarantee (the smaller the printed tag, the closer the user has get to scan it and obtain the data).

2.2. Presentation of routes

There has been recent research contributing to the issue of how instructions are given to these individuals. For example, Benson [11] indicated that people with Down syndrome, among other types of cognitive impairments, show more difficulties in receiving instructions relating to spatial navigation, having a higher error rate and navigation time. Lemoncello et al. [12] evaluated three different types of written directions: landmarks, cardinal directions and street names. They concluded that landmarks yield better results. In another remarkable research study, Fickas et al. [23] considered the best way to assist a user who gets lost along the way. They evaluated two groups of individuals with and without cognitive disabilities who required assistance because they had intentionally been given erroneous directions. They concluded that individuals with cognitive disabilities have greater difficulty when it comes to describing their position to an assistant who is supposed to get them back on route. Furthermore, they require more directions in order to return to the correct route, in addition to constant verifications and more frequent interventions.

Regarding the way in which information is given, we must consider the research by Liu et al. [14] and Chang and Wang [6]. Their works studied the specific design of visual interfaces for people with cognitive impairment. They found that each individual has their own preferences regarding picture, audio or text based instructions. Liu et al. [15] discussed several elements to be included in a mobility application. For example, instead of using the actual names of places when giving directions, they studied using composite instructions. They also discussed route personalization.

Another interesting indoor navigation system is WADER (Wayfinding System with Deviation Recovery), proposed by Tsai [16], an application for indoor wayfinding with PDAs and QR codes to build the routes. This system began using popular technologies (not as popular as smartphones nowadays) to assist users, such as QR codes, which we have adopted too due to their low cost, error tolerance and reusability.

3. Prototype description

Based on the ideas mentioned above, we developed our system, called AssisT-In, which consists of an Android smartphone application supported by QR codes. The indoor environment must be tagged with QR codes, preferably at places where

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