A Novel Wayfinding System Based on Geo-coded QR Codes for Individuals with Cognitive Impairments

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ABSTRACT
In this paper, we present a wayfinding prototype system based geo-coded QR codes for individuals with cognitive impairments. The design draws upon the cognitive models of spatial navigation and consists of wayfinding devices and a tracking system. Compared to the sensor network approach, it is easy to deploy because of low cost and short time frame. The prototype is tested with routes on a campus where a rehabilitation trained job coach oversees the process. The results show the prototype is user friendly and promising with high reliability.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces–*Evaluation/methodology, User-centered design, Prototyping, Screen design*; K.4.2 [**Computers and Society**]: Social Issues–*Assistive technologies for persons with disabilities*

General Terms
Design, Experiment, Human Factors

Keywords
Cognitive disability, navigation system, ubiquitous computing, user interface, QR code.

1. INTRODUCTION
The growing recognition that assistive technology can be developed for cognitive as well as physical impairments has led several research groups to prototype wayfinding systems. Researchers at the University of Colorado have designed an architecture for delivering just-in-time transit directions to a PDA carried by bus users, using GPS and wireless technology installed University of Washington has developed artificial intelligence on the buses [1].

The Assisted Cognition Project at the University of Washington has developed artificial intelligence models that learn a user behavior to assist the user who needs help [2]. Later a feasibility study [3] of user interface was carried by the same team, who found photos are a preferred medium type for giving directions to cognitively impaired persons in comparison with speech and text.

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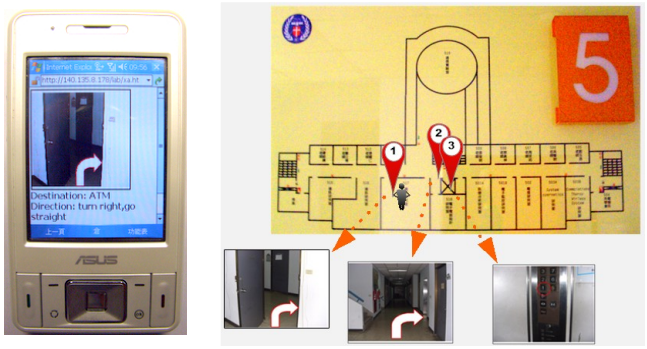
However, they used a manual approach to decide when to send photos based on location information uploaded by the shadow support team. Our research on deploying and displaying visual tags for navigation/direction provision via camera-ready handhelds is one step forward beyond their pioneering work in [3].



(a) **(b)**

Figure 1: (a) A just-in-time direction is shown on the wayfinding PDA. (b) Floor plan and the wayfinding photos used in one of the experiments.

A QR Code is a two-dimensional bar code created by Japanese corporation Denso-Wave in 1994. QR Codes can store URLs which may link to multimedia intended for specific users. We propose a novel personal guidance system based on geo-coded QR codes for individuals with cognitive impairments. Such a personal guidance system will help them safely and effectively with personal wayfinding and, thus improving the quality of life without the great cost and inconvenience of special assistive services. Based on psychological models of spatial navigation, an individual carrying a handheld is instructed by a photo showing directions when she reaches a position on a planned trip. Every such photo (Fig 1a) is triggered by the QR code displayed at important positions, such as street intersections, exits, elevator doorways, and entrances to stairways, thus called geo-coded (Fig. 1b). Furthermore, to increase the sense of security and help with precautionary measures, a tracking interface is included in the system for authorized personnel to observe an individual's trajectory while the handheld device is being used. The tracking functions by recording the person ID, timestamping the visited position, elapsed time after leaving the last position, and expected arrival time to the next position. In case anomalies occur, such as individuals failing to reach a position en route or prolonged

elapsed time between two adjacent positions, actions can be taken by the support team or family members to make sure things are all right.

2. IMPLEMENTATIONS AND EXPERIMENTAL RESULTS

The wayfinding handheld is a PDA equipped with a screen size 320*240, Wi-Fi 802.11g, GPRS, and a mega pixel CMOS camera. The server is an Intel-based PC server. The connectivity is provided via Wi-Fi on a venue which is a campus for reasons of safety. In places where Wi-Fi is not available, GPRS is used instead. The architecture is shown in Figure 2.

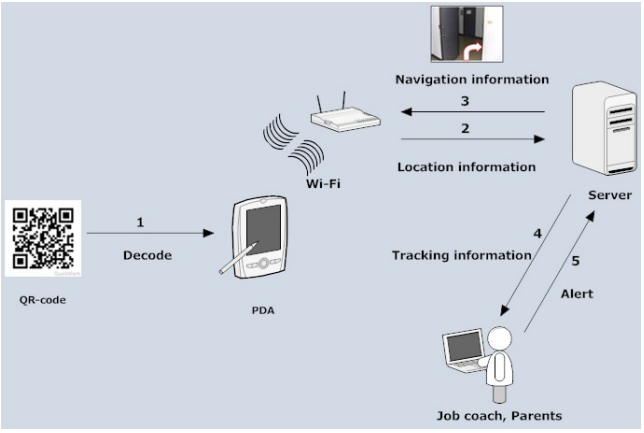


Figure 2: Architecture and system interaction of the wayfinding prototype. By shooting at a QR code (1), the user PDA provides location information (2) sent over wi-fi, followed by the navigation server uses that location information to decide which photos to send (3). The user then follows the direction or prompt displayed on device. The navigation server records the positions, time, and user ID for the tracking purpose. A user interface is provided for job coaches or family members to retrieve the tracking information (4) which is then displayed on a map.

Experiments are designed to test the implemented prototype. A domain expert, called job coach with rehabilitation training, oversees the process. Four routes in different combinations of stairways, elevators, and turns have been planned in the study. Route 1 involves no floor changes, while Route 2 is outdoors, Route 3 involves taking the stairs down one flight, and Route 4 involves using an elevator and taking the stairs down one flight. In Table 1, we summarize the experimental outcomes based on the observations of the prototype design team. In the 96 trips made by 12 cognitively-impaired participants taking the four routes, twice on each route, respectively, the ratio of participants deviating from the set routes is 7.30%. Note the ratio can depend on the extent to which participants suffer from mental disabilities, the complexity of routes, the degree of received training and self-practices, and the distractions the participants may encounter.

Table 1: Experiments of twelve cognitively-impaired participants taking the four routes, twice on each route

Partici-pant	Gen-der	Arrived /Lost	Using PDA first time (Yes/No)	Capability of navigation (1~5, poor to good)	Quality of information provided by images (1~5)
1 (SC)	F	8/0	Y	3	3
2 (SC)	M	7/1	Y	3	3
3 (SC)	M	8/0	Y	4	4
4 (SC)	F	7/1	Y	4	4
5 (SC)	M	8/0	N	3	4
6 (SC)	F	7/1	Y	3	5
7 (MR)	M	7/1	Y	2	4
8 (MR)	M	7/1	Y	4	4
9 (DN)	M	7/1	Y	4	4
10 (DN)	F	8/0	Y	4	4
11 (DN)	M	7/1	Y	4	5
12 (DN)	F	8/0	Y	4	4

SC: Schizophrenia MR: Mental Retardation DN: Down Syndromes

In terms of experimental methodology, at first a baseline will be appropriate for comparison. However, it is finally ruled out in our study. For example, individuals with Down Syndromes do not read directions, either on a traditional map or navigation handheld for non-cognitively impaired individuals, say TomTom or Garmin GPS navigator. On the other hand, travelers with no support are uncommon, except for trivial routes.

In case people deviate, automatic alerts will be issued by the tracking server and show on the consoles or send to PDAs or cellular phones of authorized personnel, depending on the preferences set ahead of time.

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