Chapter 9
A Mobile Navigation System Based on Visual Cues for Pedestrians with Cognitive Disabilities

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ABSTRACT

The authors present a prototype of a mobile navigation system designed for pedestrians with cognitive disabilities. The system first determines the shortest route from current location to a desired predefined destination from a set of candidate routes obtained from Bing Maps and Google Maps. Then the system extracts intermediate targets (decision points) from the route according to street crossings. The guidance to the next intermediate target is provided in the form of atomic textual and auditory instructions, together with visual cues extracted automatically from Google Street View. The experimental evaluation of the application is carried out via a field study with two subjects with Down syndrome in authentic urban setting. The chapter concludes with a reflection on the design of the system and the findings of the field study.

INTRODUCTION

Modern smart phones equipped with GPS receivers, navigation applications, and detailed maps and POI (point of interest) databases have made it easy to find a route from the user's current place to some other location. Navigation applications are typically able to adapt their interface and functionality according to various context attributes, such as the mean of transportation (car, walking, public transport or bike), current traffic conditions, ambient lighting (different color palettes for day and night), and user preferences (e.g. 2D/3D view, optional speech output). Nevertheless, navigation instructions are typically presented for all users in the same way that requires particular cogni-

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tive abilities. People with cognitive disabilities may not be able to understand detailed maps and complex textual instructions of standard navigation applications, such as "take the second exit on the left after the roundabout". Further, such people often suffer also from some other disabilities, e.g. dyslexia, aphasia and vision problems that should be taken into consideration in the design of assistive applications (Montello & Sas, 2006).

We present a prototype of a mobile phone application that is designed to assist pedestrians with cognitive disabilities in their navigation around a city center. Cognitive disabilities may result from a genetic disorder, birth defect or acquired as a brain injury due to a trauma or a stroke, for example. Special needs of such individuals may be vastly different, depending on their clinical profiles. Therefore, in order to constrain the problem in hand, we restrict our study to assisting young adults of about 20 years in age with Down syndrome in their independent pedestrian navigation around a city. Around that age they often start to go out alone to nearby and known places or even to some new places. Thus, they are in position to benefit from the proposed application that seeks to promote their independence, autonomy and self-confidence. The application also supports caregivers by allowing them to locate the user of the application at any time. We evaluated the prototype in a field study with two subjects with Down syndrome in authentic city environment. Given the experimental results, we reflect upon the design of the application.

RELATED WORK

The ISO has defined Assistive Technologies (AT) as "any device, equipment, instrument or software produced to prevent, compensate, monitor, calm or neutralize disabilities in the body structures or their functionalities, restrictions in activities or social participation" (International Standards Organization, 2011). Similarly, the 1998 U.S. Assistive Technology Act (ATA, 1998) defined the AT as "product, device, or equipment, whether acquired commercially, modified or customized, that is used to maintain, increase, or improve the functional capabilities of individuals with disabilities".

Braddock, Rizzolo, Thompson and Bell (2004) discussed how ATs have been designed for people with various disabilities, such as robotic prosthesis for motor control (Hochberg et al., 2012) or augmented and alternative communication devices (Ganz et al., 2012). A number of systems for assisting people with cognitive disabilities in their daily lives have been proposed in the past, for example GUIDE (O'Neill & Gillespie, 2008), COACH (Mihailidis, Fernie & Cleghorn, 2000), Archipel (Bauchet, 2009), ePAD (Mihailidis et al., 2010) and 2D-Tasks (Caballero-Hernández et al., 2012).

However, systems for assisting people with cognitive disabilities in mobile navigation are less common.

It is a challenging application domain, as cognitive disabilities usually relate to limitations on spatial navigation skills, which in turn makes guidance difficult (Carmien, 2010). Carmien (2003, 2006) proposed the MAPS-LifeLine system that comprised of two coupled prototypes. The Memory Aiding Prompting System (MAPS) was a mobile wireless context-aware prompting system running on a PDA. The LifeLine was a remote monitoring and intervention system that caregivers could use to supervise and support their clients in common living and working tasks. Beeharee and Steed (2006) evaluated a photograph-based navigation system based on actual geo-tagged photographs, observing that photographs may help users to observe whether they are in the correct place or not. They elaborated on the (un) availability of photographs and the need of taking them that has since then been solved by new services such as the Google Street View where it is available.