ShopTalk: Toward Independent Shopping by People with Visual Impairments

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ABSTRACT

ShopTalk, a proof-of-concept system designed to assist individuals with visual impairments with finding shelved products in grocery stores, is built on the assumption that simple verbal route directions and layout descriptions can be used to leverage the O&M skills of independent visually impaired travelers to enable them to navigate the store and retrieve shelved products. This paper introduces ShopTalk and summarizes experiments performed in a real-world supermarket.

Categories and Subject Descriptors

K.4 [**Computers and Society**]: Social Issues—*Assistive technologies for persons with disabilities*

General Terms

Experimentation, Human Factors, Design

1. INTRODUCTION

Shopping complexes top the list of the most functionally challenging environments for visually impaired (VI) individuals [7]. A typical modern supermarket stocks an average of 45,000 products, and has a median store size of 48,750 square feet [1]. One can distinguish two types of grocery shopping. In small-scale shopping, the shopper buys only a few items that can be carried by hand or in a hand basket; large-scale shopping necessitates the use a shopping cart [4]. The scope of this paper is limited to finding the desired grocery items in a supermarket when small-scale shopping for products stocked on the aisle shelves.

We view the process of shopping as a shopper moving through space, initially defined as a spatial dichotomy [4], but since extended to a trichotomy [3]. In the locomotor space, the shopper travels from her current location to the general area, somewhere in an aisle, of the *target product*, i.e. the next product on the shopping list. Next, the shopper shifts to the search space where a small amount of locomotion may be required to place the shopper directly within reach of the target product. When the target product is within reach, the product is considered to be in the shopper's haptic space which requires no locomotion, because the shopper can now physically grasp the target product.

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2. SOFTWARE AND HARDWARE

ShopTalk guides VI shoppers through a store to specific products, requiring no additional hardware instrumentation beyond what is already installed in the store. ShopTalk uses the assumption that simple verbal route directions and store layout descriptions can be used to leverage the orientation and mobility (O&M) skills of independent VI travelers enabling them to navigate the store and retrieve products.

Two data structures represent the store environment. A topological map models the locomotor space using nodes to represent decision points and edges to store movement instructions. The topological map is the only software instrumentation requirement for ShopTalk and is built by walking through the store, noting decision points of interest, and then representing them in a graph. The other structure, barcode connectivity matrix (BCM), takes advantage of the inventory systems used by many grocery stores. These systems place barcodes labels on the shelves immediately beneath every product. The BCM associates each shelf barcode with five types of location information: 1) the aisle, 2) the side of the aisle, 3) the shelf section, 4) the shelf, and 5) the relative position of the product on the shelf.

ShopTalk's hardware (see Fig. 1) consists of a computational unit, a small headphone, a numeric keypad, a wireless barcode scanner and its base station, and a USB hub connecting all components. The user wears a small backpack to help carry the components. The barcode scanner, carried in a shopping basket and retrieved when needed, has stabilizers attached to take advantage of the fact that many stores have shelves that curl down with a small lip at the bottom. The stabilizers rest on the shelf lips when a shopper is scanning barcodes, making it easier for the shopper to align the scanner with shelf barcodes.

ShopTalk issues route instructions in two modes: location unaware mode (LUM) and location aware mode (LAM). LUM instructions, used in the locomotor space, are generated using the topological map. LUM is location-unaware because there are no sensors to detect the shopper's current location. Instead, the shopper detects environmental cues to make sense of the verbal instructions. There is some research

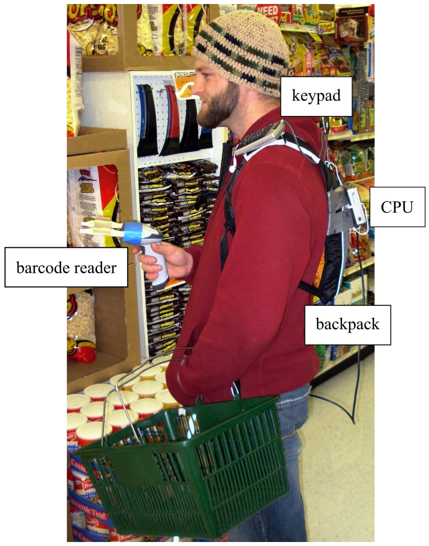

Figure 1: The ShopTalk hardware.

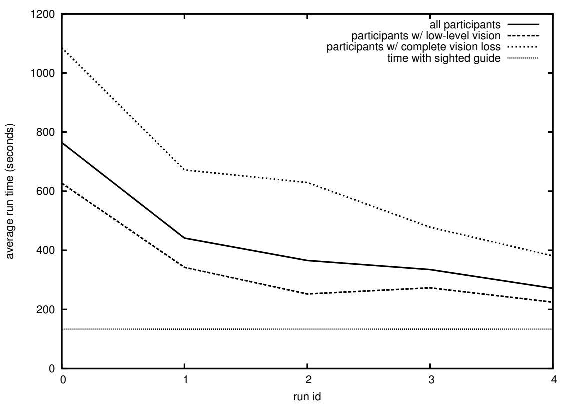

Figure 2: The average total run time for each run.

evidence [2, 6] that people with visual impairments share route descriptions and guide each other over cell phones. Following LUM instructions is conceptually no different from being guided on a cell phone.

A barcode scan switches the mode of instruction from LUM to LAM which is reserved for the search and haptic spaces. When a barcode is scanned, the exact location of the shopper is known, and ShopTalk issues location aware instructions on how to proceed to the target product. In the search space, barcode scans use the BCM to guide the shopper through the search space to the haptic space. In the haptic space, the process of scanning guides the shopper to the target product's exact location on the shelf.

3. EXPERIMENTS AND RESULTS

Ten participants were recruited from the local area. Three reported total vision loss, the remaining seven reported partial vision. With the cooperation of a local supermarket, the locations of shelf barcodes were recorded for three aisles (9, 10, and 11), a total of 4,297 products. One product was randomly chosen from each aisle for a total of three products. The experiment, performed during regular business hours, had each participant shop for the three products five times. The 117 meter route began at the store entrance, went to each of the three products, and ended at a cashier lane.

The experiment was designed to test five hypotheses. Hypothesis 1 (H_1) was that using only LUM route directions, VI shoppers can successfully navigate the locomotor space in a store. Hypotheses 2 (H_2) was that verbal LAM instructions based on the BCM are sufficient to guide VI shoppers to target products in the search and haptic spaces. The remaining three hypotheses were that as participants repeatedly perform a shopping task, the total distance (H_3) and the total time (H_4) needed to find the products approaches the those of a VI shopper guided by a sighted person, and the number of barcode scans needed to find the products decreases (H_5).

The product retrieval success rate was 100%. All ten participants were able to find all three products in every run providing evidence in support of H_1 and H_2. ANOVA analysis for the collected data found statistical significance in decreases in distance, time, and number of barcode scans supporting H_3, H_4, and H_5. Figure 2 shows how the average total time fell over repeated runs; similar results were seen for distance and barcode scans. Fuller data analysis can be found in [5].

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