Touch Your Way: Haptic Sight for Visually Impaired People to Walk with Independence

Ji-Won Song
Dept. of Industrial Design.
Korea Advanced Institute of
Science and Technology.
335 Gwahangno,
Yusong-gu, Daejeon, Korea
Jiwon.song@kaist.ac.kr

Sung-Ho Yang
College of Design.
Inje University.
607 Obang-Dong,
Gimhae, Gyongnam, Korea
deyangsh@inje.ac.kr
and Graduate school of Techno
Design, Kookmin University.

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Abstract
Haptic Sight is a new interface idea providing immediate spatial information to visually impaired people in order to assist independent walking. The interface idea stems from a thorough investigation in which we studied visually impaired people's indoor walking behavior, decision making process, their unique concept of space, and information needs. The aim of this study is to identify an interface design and investigate an appropriate means of spatial information delivery.

Keywords
Visually impaired, independent walking, assistive technology

ACM Classification Keywords
H5.2. User Interface: Haptic I/O, H5.2. User Interface: User-centered design

General Terms
Design

Introduction

In spite of recent technological and sociological improvements, visually impaired people still face major barriers in their everyday lives. Independent walking is one of the most frequent and difficult problems they face, restricting their physical and social opportunities. In order to assist visually impaired people's walking with independence, various technologies and devices have been developed, including ultrasonic [1], RFID [2,3], GPS [4,5], infrared [6], and barcode[7] technologies. However, compared to technological research, research on information required by visually impaired people in real walking conditions and means of communicating this information are currently insufficient. As a result, state-of-the-art technologies have not been able to provide enough assistance suited to blind people's needs, and still they suffer from restrictions when walking.

Therefore, our research proposes a new interface idea providing appropriate assistance for visually impaired people's independent walking in real situations. The study has two main goals:

- To understand visually impaired people's indoor walking behavior and information needs for walking without the help of person or animal.
- To suggest a new interface by which to communicate appropriate information in a suitable manner for visually impaired people, ensuring effective assistance in independent walking.

Currently, our study is in the process of verifying a design prototype of the interface idea and investigating the best possible means of information delivery based on our thorough investigation of visually impaired people's indoor walking behavior.

In-door walking behavior

From a Focus Group Interview (FGI) study and two separate observation and interview studies, we investigated the indoor walking behavior of Korea's visually impaired citizens, including cane usage, decision making process, and information requirements for independent walking, as the study subjects walked independently along routes both familiar and unfamiliar inside a building. Eight blind people participated in the three studies. The participant group included people with total blindness and those whose limited vision allows them to see flashes of light. The time span since participants had lost their sight varied from 11 to 75 years.

Cane usage

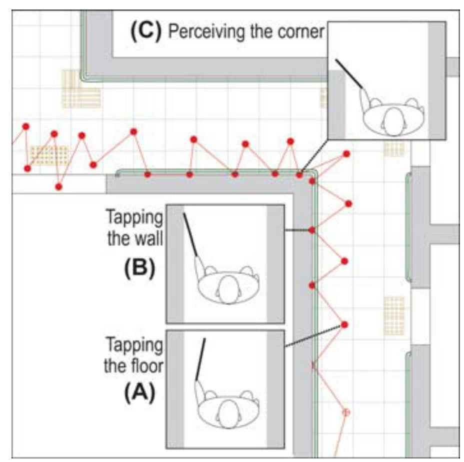

figure 1. A typical cane movement.

Except one, all participants used canes while walking, with independent walking being limited generally to very familiar routes that are passed daily. Figure 1 is the recorded cane movement of a participant in a familiar route, which is close to the typical cane usage participants described and showed. When a visually impaired person walks independently without assistance, except a cane, she moves along a wall; tapping the floor (A in figure 1), to reveal any humps or obstacles, and the wall (B in figure 1), in turn. The changes in the wall sensed by visually impaired people through use of a cane, such as doors and edges of buildings, provide cues for understanding location and deciding movement (C in figure 1).

Process of indoor walking

Although there were slight differences in cane movement and walking, stemming from varying levels of vision impairment among participants, the general process visually impaired indoor walking can be described as follows:

- First, a visually impaired person needs to know in which direction to head to reach a destination.
- Next, a visually impaired person finds the nearest wall. If he cannot find a wall, he keeps searching with a cane until a wall is found.
- If a wall is found, he moves along the wall tapping the cane continuously until he perceives a change in the wall.
- When he finds a change, such as varied depth or material on the wall (a door), or stopped or interrupted wall (a crossed or corner location of a corridor), he guesses the location on the basis of his prior memory and makes a decision. If he senses a first door through change in sound or touch, he guesses the door is A's office so he needs to keep going two doors further to the corner at which he needs to turn.
- He keeps going until he thinks he has arrived at the position at which to turn or change his movement, such as a corner, stairs, door, or hall. If he arrives at a corner, he changes direction and repeats the same process until he arrives at his final destination.

But a successful process happens only when his cane doesn't miss any information from the wall; even on a very familiar path. In the study, when a participant couldn't count a door on a path he travels everyday, he lost his way because the information he absorbed through the cane conflicted with his existing knowledge. So, it is essential to gather spatial cues carefully and not to miss any, because visually impaired people make decisions on where they are and how to move based on these cues.

Linear concept of a space

One interesting finding from the interview was that some participants described a space as a linear concept combining a number of steps and directions to the left and right. A participant in his seventies, whom lost his sight at 5 years old, said he hasn't a concept of space or area. It seems that this is because blind people who lose their sight at a very young age haven't memories of visual space; they have experienced only movement. This is related to Jung's finding in his research [8], that some visually impaired students drew a space using continuous lines, while some drew a space using rectangles to express area just as unimpaired people do.

It is also interesting that visually impaired people describe length in steps, while unimpaired Koreans use meters. They preferred information expressed as number of steps and building features, like the third door, the second crossed corridor, or five steps from the corner, when asking information from other people.

Our findings from the user study are summarized as follows. For independent and successful walking, a visually impaired person needs to know:

- Where she is and which directions she is heading
- Which direction she needs to head for
- Path information to the destination

A small piece of missed cue information in a space can destroy a visually impaired person's understanding of where she is. To make successful independent walking, it is essential that a visually impaired person gets continuous and concise information about her surroundings.

Haptic Sight for Indoor walking

In order to assist a visually impaired person's independent walking, a natural and effective interface is required to provide continuous spatial information from which he can decide where he is and how he moves. We suggest an interface idea a visually impaired person can touch that provides information about 15 steps ahead of a person (figure 2). Haptic Sight has 30x50 small blocks that move into two layers. It uses double-acting cylinders and direction control valves, as seen in figure 3, which are operated by electrical signals created from information received through Ultrasonic or infrared sensors wirelessly. The tiny raised blocks create a touchable outline of building layout information. Through Haptic Sight, a visually impaired person can sense his surroundings just as an unimpaired person watches the space visually to know his location. He touches Haptic Sight with one hand while the other hand holds a cane which is already familiar and an essential aid to blind people's walking.

figure 2. The concept of Haptic Sight

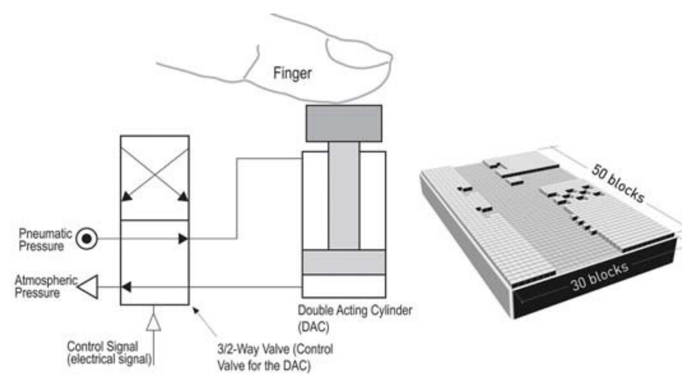

figure 3: Basic structure of Haptic Sight

Haptic Expression of a space

The two layers of the haptic interface must express spatial information naturally suitable to the space concept of the visually impaired. Based on prior user research, we designed four alternative expressions to describe a space, as shown in figure 4. A space where a visually impaired person is standing can be expressed with an upper layer and a lower layer. Alternatively, the walls or the path itself can be expressed with lines to reflect visually impaired people's linear concept of space. Haptic-cons are also designed to describe building entities, such as doors, humps, obstacles, elevators and stairs. Doors and stairs are designed in two alternatives (figure 5).

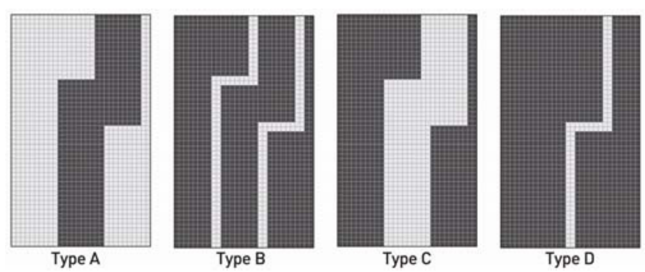

figure 4. Four alternatives to express space information (white blocks are the upper layer and gray blocks are the lower layer)

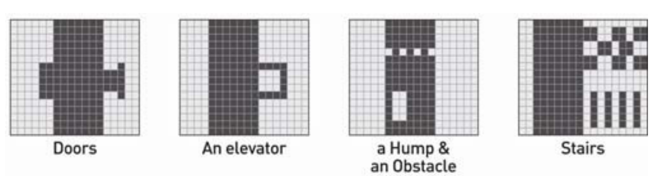

figure 5. Haptic-cons

The idea of Haptic Sight is shown in dummy prototypes, like figure 6, to verify the usefulness of the interface and to investigate appropriate means of information delivery and haptic-cons suited to blind people's concept of space. Four sets of prototypes have been prepared for four means of delivery. Each set consists of three pieces describing basic indoor space information.

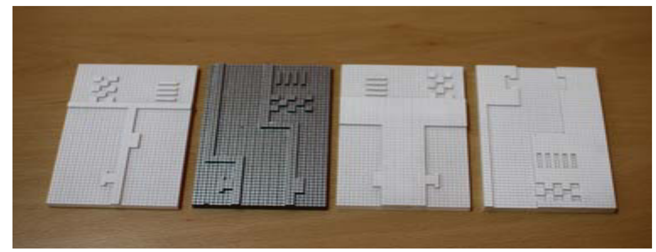

figure 6. Dummy prototypes

Conclusion and future work

Haptic sight is an interface idea providing space information on the surroundings of a visually impaired person, in order to assist independent indoor walking. It is suggested based on serious user study, in which we studied visually impaired people's walking behavior with a cane and their information needs. This study is not about developing a state-of-the-art technology, but rather, we propose an effective interface through which a visually impaired person can receive enough information to perform successful independent walking.

Currently, the study is in its early stages to verify the interface idea and means of information delivery. It requires further study to refine its design on the basis of visually impaired user opinions in a laboratory and in real walking situations, so that it can be developed as a useful and usable device interface. We are planning the following steps:

- An interview study with visually impaired people is planned to gather their opinions on the Haptic Sight interface in order to verify whether it fulfills enough of their information needs. An appropriate means of information delivery among four alternatives will be defined and refined.
- With a refined interface idea, an experimental prototype study in which visually impaired people walk through real situations with the assistance of prototypes would be conducted and examined for possible problems.
- Finally, we will design and develop an assistive device, which includes sensors and wireless technology.

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