Guiding Blind People with Haptic Feedback

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ABSTRACT

Maintaining orientation while traveling in complex or unknown environments is a challenging task for visually impaired (VI) pedestrians. In this paper, we propose a novel approach to assist blind people during navigation between waypoints (walk straight) with tactors on their wrists. Our main goal is to decrease the cognitive load needed by blind people to follow instructions in overloaded environments. Two issues are discussed, 1) the number of vibration motors used; 2) the type of vibration dimensions issued. Preliminary results from of an informal evaluation performed with two blind users showed that vibrations could help the users maintaining their straight path, however patterns were sometimes confusing. This reinforced that walking an unknown path is a demanding and stressful task and the cognitive load should be reduced to a minimum.

Categories and Subject Descriptors

H.5.2 [User Interfaces]: Haptic I/O; I.3.6 [Methodology and Techniques]: Interaction techniques

General Terms

Design, Human Factors.

Keywords

Blind, haptic feedback, mobile guide, wristband.

1. INTRODUCTION

In a navigation task, vision provides the pedestrian with landmarks and dynamic cues (e.g. optic flow) that are essential for updating position and orientation, as well as estimating distance to an endpoint. For a blind person, navigating in a familiar environment is not straightforward, and this becomes particularly complicated in unknown environments. Indeed, very basic (e.g. keeping a direction) actions as well as more demanding cognitive behaviors (e.g. way-finding) are weakened in the absence of visual feedback.

Electronic Orientation Aids (EOA) are designed to help blind people to orientate themselves in unknown environments. These devices comprise two important components: 1) the first step consists on computing a path

Figure 1 - A sample itinerary computed by EOA composed by waypoints and sections

between two geo-located points, a more technological component; and, 2) an interface to guide users to the destination, usually achieved through verbal instructions. The selected route can be presented as a list of geo-located waypoints; between two successive ones, a straight section is defined as illustrated in Figure 1. Thus, the guidance process consists in providing users with appropriate directional instructions to reach their goal through successive intermediate waypoints. In the absence of visual feedback, spoken instructions are normally used [10]. However, they have a high level of intrusion as the feedback delivery timing cannot be controlled. Furthermore, speech feedback is not an effective solution in noisy environments, such as public spaces or during a conversion [8]. An alternative approach has been widely investigated in recent years based on the usage of tactile feedback [1]. Nevertheless, there is still reduced knowledge on how to effectivelly deliver haptic feedback to blind pedestrians, either for simple actions such as maintaining a direction or more complex navigation tasks.

In this position paper, we propose a new haptic-based system and the design set within. Also, we focus on understanding the challenges of guiding blind people with vibrational feedback.

2. RELATED WORK

EOAs display interfaces rely on an auditory or somatosensory modality or a combination of those. However, spoken instructions could have a high level of intrusion and may not be received in noisy environments. Further, the imposed cognitive load may be inadequate as, for a blind person, environmental sounds are primordial to understand the environment.

On the other hand, the usage of tactile feedback for the provision of navigation information has been widely investigated and several projects have shown the feasibility of tactile displays for presenting directions by mapping them onto body locations.

Ross and Blasch [1] propose to use tapping contact speakers on the users back to indicate the direction of the next waypoint. The authors concluded that a combined tapping/speech interface would provide usability and flexibility to the greatest number of people under the widest range of environmental conditions. Erp et al. [2] proposed a display consisting in eight vibration motors arranged around the user's waist. The evaluation of this display showed that mapping waypoint direction on the user's waist is an effective coding scheme that does not require any training. All these approaches used more than one tactor and require specialized hardware. Azenkot and Ladner resort to just one tactor [3] to provide turn-by-turn walking instructions to people with visual impairments. Three methods have been evaluated for giving blind and low-vision people walking directions using a smartphone. Results demonstrate that one impulse is a viable means of communicating directional information without demanding the user's auditory attention or requiring special hardware.

Conversely, the somatosensory modality has been also investigated for sighted users to improve information presentation in the absence of visual support, namely, when situationally impaired. The PocketNavigator [4] presents a map-based pedestrian navigation system running on a smartphone and provides turn-by-turn instructions through different vibrations patterns. These patterns are performed with the vibration motors of common mobile phones with the device located in the user's pocket. A field study with 14 participants demonstrated that pedestrians can effectively feel and interpret several vibration patterns and use it for navigating between waypoints. The main argument behind this approach is that tactile stimulation can be perceived in a fashion that it is not obtrusive to the current user task, and that can be discreetly perceived (comparable to cellular phones that rest in vibration mode in our pockets). In PocketNavigator, direction and distance to waypoints are encoded using vibration patterns. In the same context, Naviradar technique [8] uses a radar metaphor in order to communicate the user's correct direction for crossings along a desired route.

All presented work tries to help users in the absence of visual feedback by providing turning instructions or waypoint location. Herein, we propose a novel approach to assist blind people during navigation between waypoints (walk straight) with tactors on their wrists. One particular challenge is to decrease the cognitive load needed by blind people to understand instructions. Two main important decisions are discussed:

The number of vibration motors used;

The type of vibration dimensions issued;

In the next section, we present an informal evaluation performed to assess the feasibility of a haptic-based navigation approach for blind people. Then, we present the prototype developed and its challenges and opportunities.

3. PRELIMINARY STUDIES

To assess the feasibility and preliminary challenges of a haptic-based approach for guidance, we performed a preliminary evaluation with two blind people. This study was twofold: 1) first, an evaluation of vibration detection on different body sites (hand, wrist and pocket) while walking; 2) second, an evaluation to assess the ability to maintain the user in a straight path with two vibration patterns.

The first study suggested that the pocket-based approach is unfeasible as it highly depends on the type of clothes used. In our study, both participants were using large pockets and they were unable to feel more than 75% of the vibrations. As expected, both the hand and the wrist had near 100% detection rates.

In the second study, we asked participants to walk in a straight line towards an endpoint. They performed the task without any EOA (just with a white cane) and with a mobile device in their hand. In the latter, a wizard-of-Oz approach was applied: whenever the user deviated more than one meter from a predetermined walking corridor a vibration stimulus was issued by the evaluation monitor. Two different patterns were used (one for left and one for right) and they were employed within two different metaphors: 1) magnetic, where the stimulus meant that the user was required to shift to the indicated direction, and 2) corrective, where the stimulus indicated that the user was hitting a virtual barrier and should correct his path to the opposite direction. The patterns issued were similar as the ones reported by [4] each composed as two different length vibrations (one short followed by one long and vice-versa for right and left, respectively). Results suggested that vibrations could help the user maintain their path but patterns were sometimes confusing. This reinforced that walking an unknown path is a demanding and stressful task and the cognitive load should be reduced to a minimum. Concerning the meaning of vibration, the magnetic

Figure 2 – The guiding system: Two wrist bands with vibration actuators connected to a bluetooth Arduino card.

metaphor was preferred.

4. PROTOTYPE

Karuei et al. explore the potential and limitations of vibrotactile displays in practical wearable applications, by comparing users' detection rate and response time to stimuli applied across the body in varied conditions [9]. They concluded that wrists and spine are generally best for detecting vibrations, and are also the most preferred. To response to precedent questions, we propose two different designs set.

We developed an Arduino wearable prototype using two wrist bracelets each one equipped with a vibration actuator (Figure 2). This design enables the users to easily set up and use the haptic system to receive feedback on their route. The actuators enable us to control the frequency, duration and interval between stimuli.

The first design option comes with the numbers of bracelets used. This option reflects in other possible design solutions. A single bracelet design is feasible either by simplifying the stimulus meaning or by stressing other vibration dimension. As an example, the stimulus may just mean that you are going off-course. In this case, the load is placed on the user's side as he/she needs to correct his path without any information on how to do so. This solution is hardly applicable to present information about turns but usable in a scenario where the user has to keep his path (e.g., crossing a street). Other option is to resort to patterns to differentiate between directions; to distinguish between right and left instructions, different vibration patterns can be used. Previous work [5] has shown that pedestrian users are able to recognize different directions as they are communicated via different tactile patterns called tactons [6]. A possible pattern approach is the one presented by [4].

Another design option, going in line with the reduction of cognitive load, comprises the use of two wristbands. This solution enables the simplification of the stimulus as the side where the bracelet is used determines the direction. Further, in the single bracelet approach, the use of other dimensions was hardly applicable due to high cognitive load. Without the need for patterns to present direction, the vibration dimensions can be used to provide more clear and rich information. For example, information on distance can be offered through vibration duration or turn angle can be presented with vibration duration or frequency. Several combinations can be applied, enriching the scenarios where it can be used in.

5. DISCUSSION AND FUTURE WORK

In the last few years, several approaches have been presented to present non-visual guiding information. However, they can be seen as discrete contributions in an unexplored design space. Particularly, knowledge about the effectiveness of haptic feedback has been presented sparsely and without a comprehensive understanding of which dimensions are better applicable in a way-finding scenario. This is highly relevant for blind people as haptic feedback is one they can receive without reducing the auditory understanding of their environment.

Herein, we present a prototype to be used by blind people in way-finding scenarios. In this paper, we constringed our focus on the feedback and the possible types of feedback paying no attention to localization techniques, which is still a problematic to be considered. This wrist-based haptic prototype enables the deployment of different feedback approaches. Not only the number of bracelets can vary, as the type of feedback patterns and dimensions therein (frequency, duration, interval). To better understand how these dimensions can be used, a thorough evaluation needs to take place. Our plans include validating different designs within the haptic design space and deriving a set of guidelines for the usage of such haptic feedback for way-finding purposes.

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