
Requirements of Navigation Support Systems for People with Visual Impairments

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Abstract

Tactile patterns are a means to convey general direction information to pedestrians (for example when turning right) and specific navigation instructions (for example when approaching the stairs). Tactile patterns are especially helpful for people with visual impairments in navigation scenarios and can also be used to deliver general notifications. This workshop paper is supposed to spark a discussion within the workshop about correctly identifying requirements and other needs of the visually impaired population in order to create a useful guidance tool to eventually replace the white cane as a primary navigation tool for the visually impaired.

ACM Classification Keywords

H.5.2. [Information Interfaces and Presentation]: User Interfaces – haptic I/O, input devices and strategies

Author Keywords

tactile, guidance, navigation, accessibility, visually impaired

Introduction

In previous work we presented *HapticHead* [6], a vibrotactile display around the head consisting of a bathing cap with a chin strap and a total of 24 vibrotactile actuators (see Fig. 1). We showed that our prototype can be used in immersive games as well as in 3D guidance and localization

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Figure 1: HapticHead prototype with 24 actuators around the head and high-density areas on the forehead and chin. Left: Raw prototype; right: integrated into a beanie. Built after the concept of Kaul et al. [6].

scenarios in both virtual (VR) and augmented reality (AR) with relatively high precision and low task completion times. This workshop paper builds upon this scenario and introduces research questions and a discussion about making this technology available to the visually impaired by identifying requirements and special needs.

Related Work - Guidance via Tactile Feedback

We only consider related work on tactile feedback for the navigation of visually impaired users due to space constraints. Csapó et al. [3] neatly summarize developments of assistive technologies for the visually impaired that are based on audio and tactile feedback until the year 2014. There are two kinds of assistive tactile technologies in navigation scenarios: (a) vision substitution systems that map a depth-image from an RGBD camera to a high-density tactile grid placed on the back [2] or forehead [5] and (b) tactile feedback systems that directly map

orientation information onto a low-density actuator arrangement (usually a ring configuration) and mostly placed on the head [4] or waist [9]. The system presented in this work (previously used in [6]) is most closely related to these waist belts, as it basically takes three actuator ring configurations and puts them on the head in different orientations to provide 3D guidance instead of the 2D guidance that other systems offer. While 3D guidance is not always necessary, the increased actuator count compared to the usual actuator configurations and their spatial distribution around the head allow for more detailed vibrotactile patterns that are easier to interpret due to the given spatial relations. Therefore, we hypothesize that there is less of a chance to misinterpret a tactile pattern in a stressful or mission critical situation, such as when approaching a down-leading staircase at a train station.

Prototype

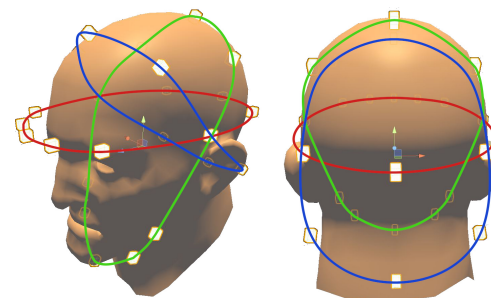


Figure 2: The prototype modeled with all 24 actuator positions. Notice that all actuators are part of one of three rings around the head and the higher density areas on the forehead and chin.

Our prototype consists of a bathing cap with 19 vibration actuators (Precision Microdrives 312-101, 12 mm coin type) attached on the outside and distributed on the whole surface. The stretchable chinstrap hosts an additional five

vibration actuators on the inside and can be adjusted to different head sizes using a Velcro fastener (see Fig. 1 and Fig. 2). This prototype may optionally be integrated into a beanie due to questionable aesthetics of the naked prototype. The vibration actuators are controlled by software PWM signals at a frequency of 20 kHz using the pigpio library [1] on a Raspberry Pi 3 connected to a custom actuator driver board. This prototype was first presented in [6], in which its concept is explained in greater detail.

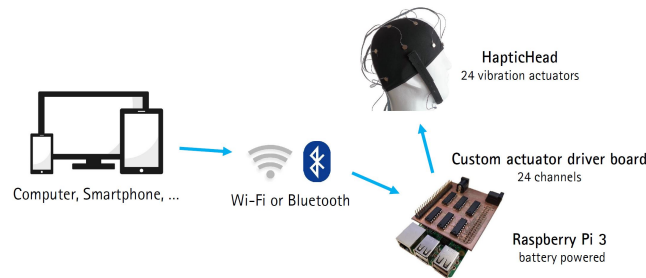


Figure 3: System overview of the HapticHead tactile around-the-head feedback system.

On the software side, a PC or smart device takes care of playing specifically designed vibrotactile patterns by sending actuator commands wirelessly to the Raspberry Pi 3 through Bluetooth or Wi-Fi at a variable update rate of up to 90 Hz. Fig. 3 depicts the system components.

Discussion and Conclusion

When designing systems for people with special needs, researchers need to work together with the group in question and identify requirements in order to come up with a system that the users actually like and want to use in daily life. In order to gather requirements and feature requests from the group of visually impaired people, we interviewed the staff of the Educational Center for the Blind located in

Hannover, Germany. Furthermore, we interviewed a visually impaired couple who took part in one of our user experiments guidance on user guidance for visually impaired people. We asked them about their thoughts on the HapticHead system. While we got some valuable input from these conversations we still feel that we did not yet fully reveal the full set of requirements that need to be met to successfully design guidance systems for people with visual impairments.

Due to our conversation with the staff of the Educational Center for the Blind, we identified four fundamental navigational instructions for people with visual impairments. These are, apart from the general direction: “start,” “stop,” “walk up,” and “walk down.” The latter is relevant for staircases. However, this set of fundamental navigational instructions may not be complete for real-life applications. In one of our experiments we decided to add another instruction: “attention”, which tells the user to focus on the navigational instructions as they tended to drift off the course when thinking about something else.

A promising way to reduce the audible noise from the actuators may be sophisticated voice coil actuators such as Lofelt’s “LoSound” engine [7] to generate a low-frequency signal of around 20–50 Hz while increasing the amplitude of the signal to still be able to feel it as humans can feel signals of around 150–250 Hz best, which is also the operating frequency of most commercial vibration actuators (e.g., for smartphones). When lowering the frequency, the amplitude has to become increasingly stronger to still provide the same sensation strength. Myles and Kalb recommend the vibration frequency on the head to be around 32–150 Hz anyway due to discomfort above that threshold [8].

The questionable aesthetics of a head-worn tactile device can partially be hidden under a beanie or hat by fully

