Distance Encoding in Vibro-tactile Guidance Cues

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Abstract

To navigate in unfamiliar places is, for obvious reasons, particularly difficult for blind people. In this research we used vibro-tactile guidance cues with the goal of allowing users to reach their destination with the most efficiency. Our hypothesis was that adding distance information should improve walking speed and accuracy, however, similar results were obtained with and without distance information.

Keywords: *Tactograms, Vibro-tactile guidance cues, Distance encoding, Space awareness.*

1. Introduction

Recently, vibro-tactile displays in human-computer interfaces gained more and more attention, especially the task of navigation using vibro-tactile guidance cues is topic of several publications [1]. [2] and [3] described systems tracking the current position of its users via GPS and guiding them from waypoint to waypoint with the help of vibro-tactile waist belts. The main aim of these papers was to help soldiers navigating from one waypoint to the next, where they had to find their own way while traversing several kilometers. In contrast to that, we focused on a more accurate navigation, using an indoor laboratory setting with a highly precise position tracking system and dynamically calculating the cues to guide the user to the desired point.

For healthy people vibro-tactile guidance could be a good addition to what they already use: maps, visual cues (signs) or memories from past visits. The benefit for blind people would obviously be much higher. Considering that, we evaluated different cues to see how such a navigation system could guide (blind) people regarding high speed and precision.

2. Experimental Design

We used the 6-DOF wireless ultrasonic positioning system Intersense IS-900[1] and a vibro-tactile waist belt composed of 8 C2-tactors from Engineering Acoustics Inc.[2] for our studies. The laboratory where these experiments have been processed is $7.3m$ by $7.45m$ in size. Positional information was retrieved from the IS-900 system exact to the centimeter which allowed us to create very short test courses. Due to the fact that after every waypoint participants needed to reorientate, differences should be clearly visible in the results. In the first series of experiments (A) routes had 13 equidistant ($1.5m$) waypoints, in the second series (B) routes had 10 waypoints with distances of 1.0, 1.5, and $2.0m$ and an overall length of $13.5m$. Within these two sets of experiments the routes had the same total of changes in direction.

Notification Methods

Latency (as used in this paper) is the time between the user being at a specific position of the room and the vibration pattern based thereupon reaching the participant. To guarantee unimodal feedback we masked the noise generated by vibrating tactor elements with music. In series A the two tactors closest to the next waypoint were activated, in B it was only one tactor. We used the following parameters for vibro-tactile guidance cues: position (which of the 8 tactors around the belly is activated), frequency, intensity and pattern (turn vibration on/off). Experiments A1 and B1 are used as baseline for reviewing the impact of distance encoding.

When a waypoint was reached, all tactor elements were activated in a $100ms$ on - $100ms$ off pattern for 1 second.

1. http://www.intersense.com/IS-900_Systems.aspx
2. http://www.eaiinfo.com/TactorProducts.htm

Digital Object Identifier: 10.4108/ICST.MOBIQUITOUS2009.6938
http://dx.doi.org/10.4108/ICST.MOBIQUITOUS2009.6938

Experiment A1 and B1: Fixed Frequency and Intensity. In these baseline experiments, tactors constantly vibrated at $250Hz$[3] and with highest possible intensity. Latency was around $750ms$ in A1 and, due to improvements in the setup, around $250ms$ in B1.

Experiment A2: Varying Frequency and Intensity. The distance from a test person to the next waypoint was mapped linearly to vibration frequency and intensity. Frequency varied between $200Hz$ (distances of $1.9m$ or more) and $300Hz$ (at the waypoint), the intensity was highest on the waypoint and $24dB$ less if the user was $1.9m$ away. Latency was approx. $750ms$.

Experiment B2: Varying Frequency and Pattern. Activation frequency and pattern were linearly mapped between "$100ms$ on - $200ms$ off" with $250Hz$ ($1.9m$ away) and "$200ms$ on - $100ms$ off" with $320Hz$ (at the waypoint). The frequency range was changed according to the user feedback from series A.

In B1 vibrations of the tactor above the navel signalized that the waypoint was ahead within 45^o ($360^o/8$ tactors). To further improve precision, we added two slightly different cues so that participants were guided more precisely. (i) a $50ms$ pulse was included when the waypoint was within 12^o (i.e. "$100ms$ on - $100ms$ off - $50ms$ on - $50ms$ off", (ii) for a deviation between 30^o and 45^o, one of the tactors next to the tactor above the navel was also activated for $30ms$ to hint a minimal change in direction. Latency was approximately $350ms$.

3. Results

Both A2 and B2 may be influenced by learning effects, because immediately before these experiments a similar one to each of the subjects was conducted.

Performance in experiment A2 was clearly worse than in A1, which came unexpectedly, since adding distance information should have led to improvements. Feedback from participants revealed that the combination of low intensity ($-24dB$ from maximum) and low frequency ($200Hz$) led to situations where they could not feel the tactors anymore.

We used these outcomes to design series B, where variations in intensity were dismissed and replaced by variations in pattern. Also the minimum and maximum frequency were raised. Results show that performance in B1 and B2 were almost identical, which is already better than in A, but unfortunately we could not (yet) design a distance encoding scheme that improves navigation performance.

3. As stated in [4] $250Hz$ can be perceived best by humans.

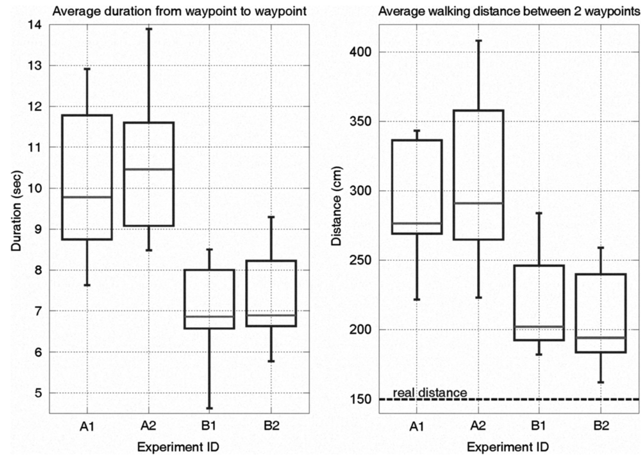

Figure 1. Results for both series of experiments

4. Outlook and Acknowledgements

Our results do not motivate the encoding of distance information in vibro-tactile guidance cues, nevertheless, participants were able to follow the waypoints quite well, especially in B due to lower system latency compared with A. We still believe that distance information is important – especially for blind people who can not see their destinations.

The next step in our research will be the implementation of a system for the guidance of blind people on our campus.

This work is supported under the FP7 ICT FET programme of the European Commission under grant agreement No 231288 (SOCIONICAL).

References

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