Route Guidance with a Vibro-tactile Waist Belt

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Abstract. Navigation in unfamiliar places is difficult, even if signposts are available they are located at fixed points, may be overseen when the area is crowded, and are impossible to use by blind people. Visual navigation devices make guidance information available at any place but are neither hands-free nor a solution for blind people. In order to tackle all of these problems, we experimented with vibro-tactile guidance cues. First we created an indoor navigation system consisting of position tracking hardware and a vibro-tactile waist belt that guides a person from waypoint to waypoint of a predetermined course. For that we used the 6-DOF ultrasonic tracking system InterSense IS-900 and a waist belt composed of 8 C-2 tactor elements from Engineering Acoustics Inc. For the design of the vibro-tactile cues the following parameters have been used: (*i*) intensity (attenuation in dB), (*ii*) frequency, (*iii*) position (which tactor), (*iv*) vibro-tactile pattern. We started with a very simple notification pattern and then tried to improve walking speed and accuracy by adding distance information.

We showed that with a tracking system working at centimeter accuracy, vibro-tactile cues alone allow for precise walking with an estimated average distance to the test course of only $20cm$. Higher time-lag (around $750ms$ compared to $380ms$) lead to significantly worse results. Distance information did not yet lead to increases in precision, this may be due the subtle nature of the chosen encoding scheme. However, it is possible that after a longer learning period participants can estimate distance. More details about the experiment setup and the first part of the results can be found in [1][1].

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

Waistbelt (Torso) Displays

Recently, vibro-tactile displays in human-computer interfaces gained more and more attention and are used for different tasks including navigation, collision

[1] Unfortunately we did not respect the fact that InterSense only delivers new values around every $400ms$ in our calculations there, so the estimations of time-lag in this paper are the correct ones.

avoidance and raising users' attention. [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 waistbelts. Collision avoidance or obstacle detection in real or virtual worlds was the topic of [4] or [5]. Riener and Ferscha [6] presented a belt-like vibro-tactile notification system for assistance in raising users' attention.

Demonstration

We will show the vibro-tactile belt using simulated position tracking, since the InterSense 900 system is not mobile. A volunteer wears the tactor belt and can then experience different notification cues while the demonstrator simulates a person walking through the room with a mouse. Seeing the simulation and sensing vibrations will give volunteers a good impression on how the system works and the differences between the following three different notification cues:

(i) Continuous vibration at a fixed frequency of $250Hz$ and with maximum vibration amplitude.
(ii) Continuous vibration at variable frequency in the range between 200 and $300Hz$ and with variable attenuation of the vibration amplitude in the range -24 to $-0dB$.
(iii) Application of vibration patterns (*tactograms*) for distance encoding as shown in Fig. 1. Additionally a variable frequency in the range between 250 and $320Hz$ is used for distance estimation.

Conclusion and Future Work

Not surprisingly walking accuracy is worse for experiment setups with higher time lags for the cues. Therefore it is very important for a navigation system to work in realtime. We achieved quite good results for a lag of around $380ms$ and in a second series of experiments even $250ms$ whereas when time-lag was around $750ms$ participants tended to overshoot and circle around targets and walk in zig-zag lines due to overcompensating directional errors.

Even if our results do not directly support our hypothesis of distance information encoded into vibro-tactile cues improving navigation speed and precision, we think that creating a useful distance encoding schema is an important goal. If only directional information is transmitted, users will never be able to have situation awareness. When first confronted with cues with encoded distance around 50% of the participants noted, that they had a vague feeling for distance to the next waypoint. This did not result in better performance, but it is quite possible that long-time users of such a system would learn how to extract a distance estimation from the signal and therefore be able to achieve a certain amount of situation awareness.

Future experiments will use longer waypoint segments and more realistic routes. For the past experiments participants had to walk in circles in one room, the next series will feature a walk through a small part of a building.

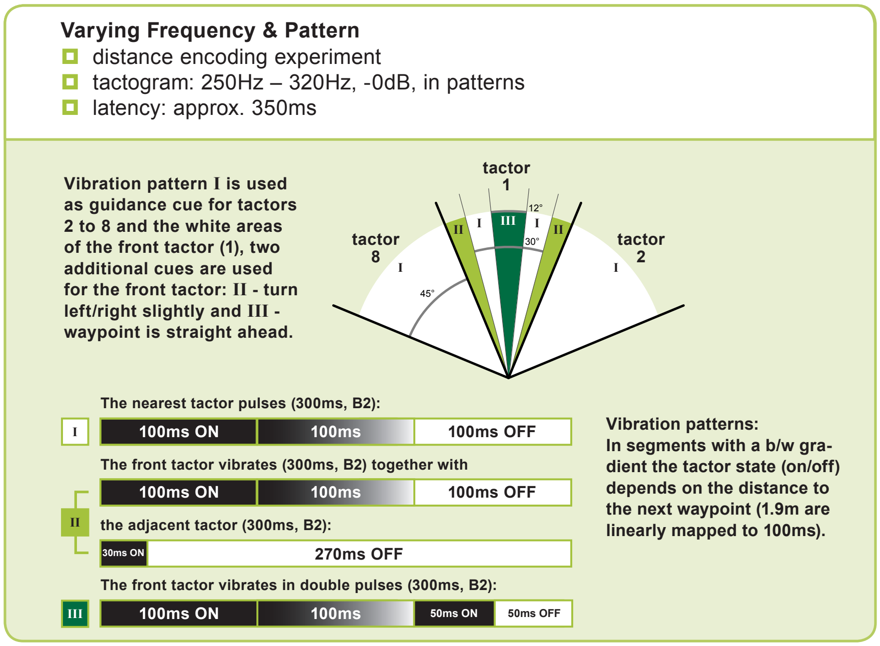

Fig. 1. Most complex vibration patterns.

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