Guiding Tourists through Haptic Interaction: Vibration Feedback in the Lund Time Machine

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Guiding tourists through haptic interaction: vibration feedback in the Lund Time Machine

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Abstract. This paper describes the vibrationnal feedback that was chosen for the guiding interaction part of the Lund Time Machine application. This tourist guide provides information on points of interests along a trail, and guides the user along it. The interface uses audio and tactile modalities to be accessible in situations where the visual channel is not available. To navigate to the next goal, the user scans around and feels the phone vibrating in the correct direction. The distance coding was embedded in the directional feedback by making the bursts more frequent when getting closer to the goal. The design was first evaluated in a controlled study and then validated as usable and non-obtrusive within an evaluation in the real context of use.

1 Introduction

In mobile situations, looking at the screen is not always feasible. Providing an interaction relying on audio and tactile modalities enables the pedestrian to continue the interaction "on the go", when vision is required to attend to the rest of the environment. It also gives a more accessible solution for people with visual impairments. The Lund Time Machine is an application that guides tourists along a historical trail, while letting them experience sounds from the past. This paper reports the choice of vibration feedback for the guiding interaction.

2 State of the art

2.1 Non-visual guiding

Current navigation systems in mobile phones are based on screen interaction. The user is usually expected to look at the map to find where to go (e.g. Google Maps). The interest in non-visual modalities to guide navigation is increasing in the research community, explained in part by the need to reduce the load on visual attention in mobile situations [9]. Several systems have been devised using sound as guidance. An early attempt was the Audio GPS [2]. The Swan project [19] gives auditory feedback about routes and contexts aimed at visually impaired people. The ONTRACK [3] system uses 3D audio and music to guide the user, while Soundcrumbs [5] uses chosen audio tracks of varying volume according to the user's phone bearing. Audio Bubbles [8] gives auditory feedback about nearby landmarks. Others have explored vibrations to convey information. Sweep-Shake [12] for example uses vibration feedback instead to let users get information on points of interest close-by. It was then evolved to support users' navigation as described in "I did it my way" [13]. The Tactile Wayfinder [10] explores the use of a vibrating belt to give directional information. PointNav [4] gives both orientation and navigation support through vibrations and speech feedback. For more exploratory navigation, different kinds of soundscapes have been created by communities or artists. The Urban Sound Garden [18] and the Tactical Sound Garden [14] are two examples.

2.2 Distance coding

In our design we wanted to be able to code not only direction, but also distance into the vibration feedback in an intuitive way. Using a vibration motor one basically has two parameters that can be manipulated: pulse length and off time. In [7], a constant pulse length of 50ms is used, and the distance coding has shorter off times for closer distance. The work in [7] is focused on discrimination – the assumption that shorter off time maps to short distance is not tested. The same assumption is made in [16,17] where it is assumed that shorter pulses should be given nearer the goal (although it is also recognized that when one is far away and needs to select a new direction it is important to get pulses often enough). Furthermore, these studies test walking speed, and not intuitiveness. In [11], rhythm based, duration based and intensity based encodings are explored. For the rhythm based coding the number of pulses indicates distance – more pulses mean further away. In the duration based coding, stimulus duration is coded so that longer stimuli map to longer distances, while in the intensity based coding, stronger stimuli are mapped to closer distances. This study reports on the perceived simplicity of judging the distance for the different mappings, but participants were able to learn the patterns so first impressions on intuitiveness were not recorded. In [1], rhythm, intensity and duration are again investigated. The study designs were based on a pilot study with one participant who indicated that she got stronger sensations with fewer pulses (opposite to the designs in e.g. [7]). Thus all designs in [1] have few pulses at close distance. Since we wanted to include the distance in the feedback given to the user and there seems to be no clear recommendation for what is intuitive, we decided to do a simple test where we included both the mapping we thought intuitive as well as the opposite.

3 Description of the Lund Time Machine interaction

The "Lund Time Machine" (LTM) is a tourist guide application developed for Android 2.2. It uses GPS positioning and compass orientation to guide a tourist along a trail by tactile guiding (vibrations), and displays relevant information at the points of interest. The spoken information played when arriving within 15 meters of those points is of the kind a human tourist guide could tell about interesting locations in the city. An image and the spoken text are also displayed onscreen. Questions about the point of interest can also be displayed and answered at some points of interests. During navigation, medieval sounds are played to enhance the experience around chosen locations, such as animal sounds at the medieval market place or bells at the place where a church once existed. The guidance in itself is based on a scanning interaction. When the tourist points the phone in the direction of the next goal, it vibrates. The angle within which the succession of 3 short bursts are played around the target direction is 60 degrees, as recommended in [6]. The distance as well as the list of points and a map were displayed onscreen during the navigation, but we also wanted to embed some distance information in the vibration feedback pattern.

3.1 Distance coding study

In order to test different ways of coding the distance using vibration patterns, we implemented a prototype on a Windows Mobile phone (Sony Ericsson Xperia) which allowed users to scan the area around them to locate two different objects. These areas were put at different distances, and the task was simply to tell the test leader which of the objects they intuitively thought was closest (the locations used were fixed using a fake GPS position and all test persons experienced the same position relative to the objects).

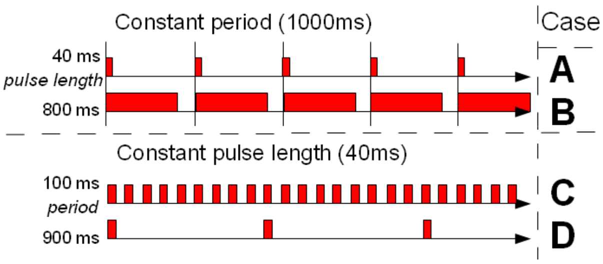

Fig. 1. Patterns used in the study for the vibrations' activation signal

In the first part of our study we tested a design where the period was kept constant and the pulse length varied (the short pulse was at 40ms and the long pulse at 800ms). Thirteen users performed this test (7 women and 6 men, ages: 14, 16, 27, 37, 42, 42, 43, 48, 50, 53, 54, 60, 65). Twelve of the 13 users thought the longer pulse (case B in fig. 1) corresponded to a closer object. The argument given spontaneously by many of these test people was that the longer pulses felt more intense and thus they were felt to correspond to a closer object. One user disagreed, and said the opposite with the motivation that the shorter pulses felt "blocked out" and thus the object had to be close to block out the pulses. In the second part of this study, the on time was kept constant (40ms) and the period varied (short period 100ms and long period 900ms). Twelve users performed this test (8 women and 4 men, ages 14, 20, 21, 38, 42, 43, 48, 50, 53, 53, 62, 78). All 12 users agreed that a shorter period (case C in fig. 1) corresponded to closer distances (the person who had disagreed with the majority in the first test also participated in the second test). These results are significant (t-test, $p<0.001$). We took care to include persons with and without a science/technical background in the study.

This study provides what we feel is a good indication for the mappings:

– Longer pulses (with a constant period) should be mapped to closer distances.
– Shorter periods (with constant pulse length) should be mapped to closer distances.

3.2 Lund Time Machine tourist guide evaluation

For the Lund Time Machine we decided to go with a design where the pulse length did not change with distance – and decided to vary the time between pulses (period) as the distance changed. This is shown in Figure 2. Three bursts are played when the phone is pointed in the direction of the next goal. As the user gets closer to the target, the pulse trains of 3 bursts are repeated more often. The pattern of 3 bursts is always played until its end, to avoid getting borderline effects when exiting the 60 degree target angle. The pattern starts anew when the user goes outside the target angle and then re-enters it. The calculations of the frequency of bursts is based on the actual distance to target, but also on a distance zone, so that the frequency increase in part becomes stepwise.

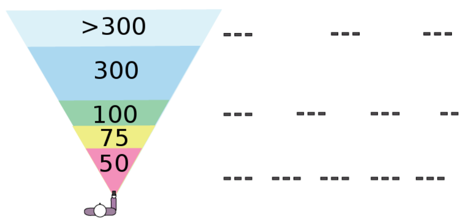

Fig. 2. Haptic patterns and distance zones

This design was used during the following global evaluation of the Lund Time Machine tourist guide involving 10 adults and 24 children. This evaluation is reported in more details in [15]. This evaluation highlighted the possibility of focusing on the city environment while being guided toward the points of interests. All users could reach the points using the guiding interaction proposed by the Lund Time Machine.

The distance coding received positive feedback. Most of the users noticed that the vibrations where more frequent when approaching a goal. One participant confirmed that the distance coding felt appropriate because it felt like "burning" when getting near the target.

4 Discussion and Conclusion

Our results agree with the designs used in [7,16], while they disagree with some of the mappings in [1,11]. In [11], shorter tactile stimuli are used at closer distances (opposite to our recommendation), while the recommendation for longer pulses agrees with two of the designs in [1]. In contrast, the recommendation for shorter periods closer to the object does not agree with the designs used in [1]. There is obviously room for more advanced designs with pulse trains for example, but if one wants intuitive designs these mappings should preferably not be mixed (as they would be if one has long pulses and periods at close distances and short pulses and periods at long distances [1]).

The design pattern presented here and choosen for use in the tourist guide consists of a vibration in three bursts that is more frequently repeated as the distance shortens. Embedded in the directional feedback, this design proved to be natural and non-obtrusive in the tourist guide context of use.

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