Gentleguide: an exploration of haptic output for pedestrian guidance

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GentleGuide: An exploration of haptic output for indoors pedestrian guidance

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This paper describes an investigation into how haptic output can be used to deliver guidance to pedestrians, who do not have any particular disability, to find their way to a particular destination indoors, e.g., a room in a hospital. A prototype device called GentleGuide was designed iteratively, resolving several design issues for the use of haptic output. GentleGuide has been assessed experimentally. Our conclusion is that haptic output offers significant promise both in improving performance and in reducing the disruptiveness of technology. A negative aspect of exclusively relying on a device like GentleGuide is the reduced location and orientation awareness by some participants.

1. Introduction

The haptic modality is relatively unexplored in the domain of mobile human computer interaction. Existing work often focuses on people with a severe visual impairment, e.g., the wearable navigation system by Ertan et al. [2]. This paper presents an application of haptic output to provide guidance to people without any particular disability walking inside buildings, e.g., to help first time visitors and patients find their way through large hospital or office complexes. Contrary to drivers or pilots, pedestrians can travel in jagged trajectories, can make shortcuts, can pause and turn back to easily to correct errors. Way finding is the task of determining how to get to a destination and directing the activities needed to get there [3]. Way finding requires simultaneous processing of several sources of information: monitoring the environment, architectural patterns, other people, obstacles, etc. The visual modality is often used to display maps or text instructions. However, graphical visual displays usually require users to operate the device 'head down', thus disrupting their primary tasks. As a recent evaluation showed, the limited screen space of mobile devices, make maps and text instructions difficult to use on the move [1].

Three output techniques for providing guidance to blind pedestrians outdoors are compared in [5]: binaural audio beacons, speech advice and haptic guidance in the form of shoulder tapping. Their empirical results show a clear advantage of the haptic modality, both in objective performance and subjective preference. Notably, some of their subjects commented that it didn't compete for their attention, as audio information does. A prototype of a haptic device for way finding in complex indoor com-

plexes is described in [6]. The advantage of their device is that it can easily be ignored or consulted at will.
A range of design options that must be addressed for designing haptic output are discussed in section 2, in the context of the iterative development of GentleGuide. We then describe the implementation of the prototype, its experimental assessment and conclude with some preliminary conclusions from this research.
Although this work focuses on pedestrian navigation, in essence the Gentle Guide adds an extra modality to navigation feedback in a broader sense.

2. The design of GentleGuide

The original concept for the GentleGuide was of a wearable haptic device that would provide the analogue of a little nudge one gives to a disoriented companion to gently guide them in the correct direction. Pressure seems the obvious way of realizing the concept of the friendly nudge (see, e.g., [5]). However, mild pressure, tends to be ignored after the initial stimulus, is hard to convey through clothing and may be confounded by forces from the environment. Vibration output was eventually selected, not least because it easy to produce, as tiny vibration alarms are commercially available (e.g., those used inside mobile telephones). GentleGuide was developed iteratively, by several prototype and test cycles, which concluded on the following points:

- Using a single output device on one wrist is confusing. Two devices, one on each wrist is more appropriate.
- Vibrations are interpreted by users as a beacon to follow, rather than as a corrective nudge for one's direction.
- Direction is better encoded in the duration of pulse trains rather than in intensity.
- Vibrations should simply indicate left, right and stop, rather than more refined directions, e.g., 45 degrees to the left or proportional to the change of direction.
- A signal on both wrists, proved very intuitive as a stop signal.

We note that the first two design decisions, contrast the design of [5] for a very important reasons: contrary to their target users, our users are not visually impaired and are able to maintain straight line trajectories; i.e., even when lost, the non visually impaired users will not have the problem of veering.
Eventually, after repeated trials, we settled on the following conventions: 0,7 sec. right (left) receiver: go to your right (left), 0,7 seconds on both receivers: destination reached and 1,5 sec. both receivers: wrong direction. The final GentleGuide prototype is shown in fig. 1. The central box generates the navigation signals. The wrist devices contain a receiver, a decoder used to identify the signal and a battery fed vibration alarm. If the received pulse train is coded for the wrist device, the vibration alarm will be switched on as long as the pulse train is received. The prototype devices are housed in a plastic box. This box serves as a resonator for the vibration alarm. The prototypes are typically technical prototypes: focus was on functionality. Currently we are working on miniaturizing the devices and to improve their aesthetic appeal.

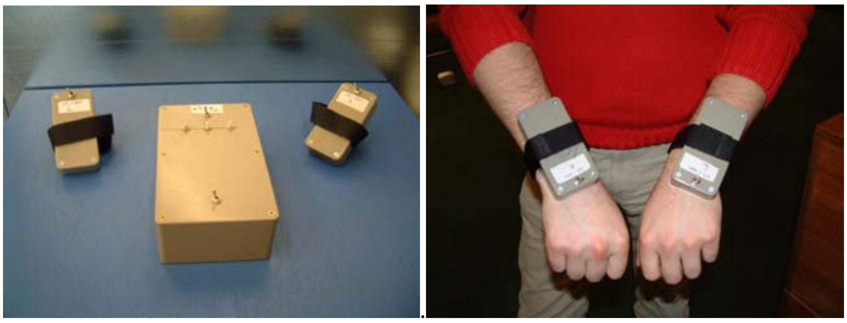

Fig. 1. (a) GentleGuide control unit and wrist devices (b) GentleGuide worn by a participant

3 Evaluation of GentleGuide

An experiment was conducted to assess the potential of GentleGuide for supporting way finding by pedestrians indoors. GentleGuide was compared to signage, which is how way finding inside buildings is currently supported. Because of familiarity with signage, this puts novel systems at a disadvantage, but improvements upon this ‘benchmark’ are necessary for providing added value to the non-blind user who can read. The experiment was conducted inside campus buildings that have a complexity in layout not uncommon for large buildings.

Participants. 16 paid persons (9 male and 7 female) without any disabilities took part in this study. All subjects are undergraduate students, who were screened so that they would not be familiar with the buildings where the experiment took place and would not be involved or familiar in any way with the experiment. They were all familiar with the signage conventions of the test environment to make the benchmark harder to match.

Design of the experiment: A mixed design was followed. The within subjects condition was the use of GentleGuide or signage. The between subjects condition was the specific route concerned. Each subject had to walk 4 different routes, 2 with the GentleGuide and 2 with signage in mixed order. 8 subjects using the GentleGuide and 8 different subjects using signage attempted each of our 4 routes. The actual locations had been selected with pilot testing to ensure that the signage was adequate.

Independent Variables: The use of signage or GentleGuide.

Procedure. All way-finding tasks involved finding a room in an office building, without walking out of the building or going up or down a floor. Subjects were instructed to walk at their normal pace; they were introduced to GentleGuide by a brief written explanation and a 30 sec practice session. The experimenters would walk 5-6m behind the subjects issuing guidance instructions from the remote control console. Through pilot testing the appropriate position for issuing the instruction for the turn had been set to 2 meters before the turn. If subjects would take the wrong turn, they would be issued a command to stop. If they would ignore this command for more than 5 sec, the task would be declared a failure. Subjects were instructed to follow instructions, until they would be given a signal that they have arrived. In the visual condition, the subjects were allowed to find their way freely. They were stopped if they walked out of the building. The task then was declared a failure.

Dependent Variables. By counting how many of the tasks were completed successfully the effectiveness of GentleGuide was assessed. The time G it takes to get to the destination was measured. As a baseline measure, subjects were asked to return to the starting point at the same pace as they had just walked to get to the destination. This time, the evaluators would walk 1m behind the participant, telling them well in advance of approaching turns which way to go. We assume the time back B approximates the time needed by someone who knows the way. We added these measures for the two routes where a subject used GentleGuide and the two where signage was used. The dependent variable relative delay of getting to somewhere unknown was calculated as follows $\tau = (G-B)/B$.

The number of errors was counted for the two conditions. An error was simply defined as a subject not making the right decision at a junction point (a point where they have to turn). In order to distinguish from a momentary hesitation/confusion, a margin distance of 2 meters at the wrong direction was allowed. When subjects without GentleGuide would make an error they had to rectify it with help of signage (as is normally the case when no advice is sought by passers by). No new errors were counted till the subject would get back on the right track. Following the tests, subjects answered several questions to help us assess their subjective experience of the system.

Results. All GentleGuide users got to their destination on all occasions. One subject got lost when relying on signage. Only on one occasion did a subject make an error following the GentleGuide while 4 errors were made following the signage.

The average relative delay was 0.08 for the GentleGuide (i.e., subjects were 8% slower with GentleGuide than when walking back) and 0.40 with the signage. A one-tailed related t-Test, showed the difference to be significant (a=0.05). As not all test-trajectories consisted of 90 degrees turns to the left or right or binary choices, but more complex patterns were involved, this result suggests that participants easily interpret haptic guidance in combination with their perception of the space around them, their destination and their trajectory.

The experience of using GentleGuide was reported as positive. Interpretation was found intuitive and no further training was needed than the 30 seconds. Following signage seemed to help subjects feel they knew where they were more than when they used GentleGuide (a 2-tailed Wilkoxon signed ranks test showed this to be significant at a=0.05). This is partly because in the haptic condition subjects were not told their destination to avoid contamination of the haptic experiments with visual input. Further, continuous, turn-by-turn instructions make it unnecessary for users to actively plan their path and orientate themselves. In contrast, signage supports subjects to build a mental map of their path. Ratings of subjects on 5-point Likert scales, as to whether they felt confident they were walking the right way, showed a significant preference for Gentle Guide over signage, (2-tailed Wilkoxon signed ranks test at a=0.01). Further, the subjective reports by participants seem, in large, to support our belief that GentleGuide is understandable, pleasant, discrete, efficient, easy to use and easy to get used to. Mostly it was found helpful. Most ambivalent responses concerned the intuitiveness of the system, with one subject feeling and acting like a robot following instructions.

4. Conclusion

Vibration pulses delivered by two wrist-mounted devices are a practical way to deliver guidance information for pedestrians indoors. This approach works quite efficiently and reliably. Low-resolution guidance was reliably and effectively interpreted from the duration of pulses (just 4 types of directions). Vibrations are more intuitive when they indicate the direction where the person should go to at junction points, rather than corrective advice. A device like the GentleGuide is arguably a non-disruptive, easily learnable means to support way finding in complex indoors environments. We plan to extend this study to include more complex routes, e.g., including multiple floors and open spaces, as well as outdoors tasks where guidance information is more commonly needed and signage more often absent. Particularly where outdoor applications are concerned, an important limitation of continuous guidance seems to be the loss of orientation by the user. The combination of haptic output with graphical displays seems to be a promising approach to address this problem.

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