Tacticycle – A Tactile Display for Supporting Tourists on a Bicycle Trip

Benjamin Poppinga, Martin Pielot
OFFIS Institute for Information Technology
Oldenburg, Germany
{poppinga|pielot}@offis.de

Susanne Boll
University of Oldenburg
Oldenburg, Germany
boll@informatik.uni-oldenburg.de

ABSTRACT

Cycling is a common leisure time sports in touristic regions. For us it was the question how tourists actually find their paths in the area and what kind of navigation aids might be helpful to them. In a requirements study on a touristic island we learned that tourists rather explore the environment spontaneously than efficiently navigating from on place to another such as the beach or the light house, and just cycle on without much map or navigation aid. While exploring the area, the cyclists however, sometimes lose their orientation which they compensate for by accepting detours. We designed and developed an orientation aid, Tacticycle that does not influence the cycling experience but improve the orientation and awareness of the overall direction. In order to ensure the cyclists' safety two vibrotactile actuators are used to indicate directions and announce the presence of interesting places. In two field studies we showed that despite the accuracy of the indicated direction being rather coarse, the tactile user interface allows cyclists to reach a presented destination easily. The visitor of the demo can experience a virtual cycling tour supported by the Tacticycle demonstrator.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Haptic I/O; I.3.6 [**Methodology and Techniques**]: Interaction techniques

General Terms

Human Factors, Experimentation

Keywords

tactile display, tourists, exploration, bicycle

1. BACKGROUND AND MOTIVATION

Going on a bicycle trip is a common leisure activity, not only on vacation. These trips often have an explorative character in which the cyclists try to find out something about the area and have enough time and interest to one or another detour. A navigation system might contradict the desire to explore and experience the environment, as these systems might disengage the user from the environment [4] and impede the geographical understanding of the environment [1].

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In contrast to visual displays, tactile displays do not compete with the visual attention, and have successfully been used in different navigation and orientation applications. Ross and Blasch [6] employed a shoulder tapping metaphor to guide blind people safely while crossing a road. Van Erp et al. [7] integrated tactile actuators into the seat of a car to indicate course changes and the distance to the next waypoint. Bosman et al. [2] used two tactors attached to the wrists to provide route instructions for wayfinding in indoor environments. Ho et al. [3] found out that tactile cues can direct the visual attention of drivers. If tactile cues came from the direction where a critical situation was happening, the participants reacted significantly faster. The findings of the related work encourages the use of tactile information and tactilve feedback for conveying directional information and direct attention to locations. However, to our knowledge, there has been no investigation of tactile feedback for bicycles used in touristic trips.

Figure 1: A group of tourists on a bicycle trip on an island.

In order to understand the information needs of tourists on a bicycle trip in more detail, we conducted a survey and a field study on a touristic island (see Figure 1). The two studies revealed that rather few and hint-like information is sufficient to support the tourists cycling experience. Building on the results, we designed the *Tacticycle*: a simple exploration support system optimised for bicycle usage. Instead of efficient navigation from one place to another it just conveys the general direction of a landmark as an orientation help. Instead of detailed information about the environment the system just highlights the presence of points-of-interest in the vicinity of the rider.

For the design of the Tacticycle, we focused on how to convey the spatial information in a way that would not divert the rider's attention from the primary task of riding. We designed a tactile display, as they have successfully been used in different navigation and orientation applications. Similar to the layout used by Bosman et al. we integrated two vibrotactile actuators in the steering rod. They are used to encode the direction of a landmark as well as alert the user nearby points-of-interests. In our studies we showed that users are able to coarsely interpret the directions presented by the tactile display, which is, however, sufficient to enable riders to reach their destinations without any other navigation aid.

2. REQUIREMENTS STUDY

The design of the Tacticycle is based on a requirements study we conducted in summer 2008 [5]. In this study, we aimed at understanding the tourists' goals, their primary information needs, and issues arising due to the situational context. The investigation took place at the North Sea island Borkum. In a bike rental outlet we distributed questionnaires to tourists renting a bike, which asked about the goals and experiences of a bicycle trip. In addition, we conducted an ethnographically informed field study, where a different set of tourists was observed during parts of their actual trips.

The survey indicated that destinations were often imprecise and not always reached, and despite using maps, disorientation events occurred. The field study showed that the nature of navigation was mostly undirected and spontaneous, while mostly no navigation aids were used. Regarding the usage of navigation aids, the results of the survey and the field study were rather conflicting. According to the survey, most of the informants used a paper map for navigation, however, we observed only two groups regular using their paper map in the field study. Both, the survey and the field study indicated that the informants often lost orientation. Surprisingly, that did not seem to be an issue for the informants. One survey participant commented a case where he lost orientation with the words: *"One time, I chose the wrong way, but it did not matter to me. I am on vacation!"*. Reaching specific destinations turned out to be not of high priority. About half of the survey participants did not reach their chosen destination. The field study confirmed that assumption, as people were frequently discussing how to continue and which destination to reach next.

From the requirements study we derived four design implications for a system that is aimed at supporting the experience of tourists on a bicycle trip: The seven reported and many observed disorientation events suggested that such a trip companion should **provide orientation help**. The spontaneous nature that was observed indicates that preplanning of trips is not desired by the user. Instead, **planning trips on-the-fly** should be supported. Since destinations were rather denoted by large areas and actually reaching those goals seemed mostly optional, a **drift towards the destination** should be supported rather than providing detailed route instructions. The field study also showed that people are open to spontaneous deviations from their current goals. In order to improve this explorative experience, a travel companion should therefore **highlight interesting spots** nearby and encourage the tourists to visit them as well.

3. THE TACTICYCLE

The design process of the Tacticycle regards possible issues about public and individual safety, attention distraction and usability in a mobile context. Based on the design implications we describe the chosen input and output capabilities and illustrate the overall user interaction.

3.1 System components

To convey the direction of a destination, two main inputs are needed: a positioning system and a system obtaining the user's spatial orientation. Since the Tacticycle is designed to be used exclusively outdoor, the well known Global Positioning System (GPS) is suitable to determine the user's position. Being accurate enough for car navigation, the user's orientation cannot be determined adequately for cyclists via GPS. A separate digital compass can fit the requirements of supplying precise user orientation.

To receive information about the direction to the destination or about the immediate surroundings, a user interface is needed. Since the environment should not be harmed in any way, acoustic information transfer is unsuitable. Furthermore, because the user is already busy maintaining the primary task, namely driving and exploring, a combined visual-tactile information transfer method is chosen. The tactile information enrichment disengages the user with the secondary task, navigating and orientating. Therefore two tactile actuators and a visual display are needed, both mounted directly to the steering rod (see Figure 2).

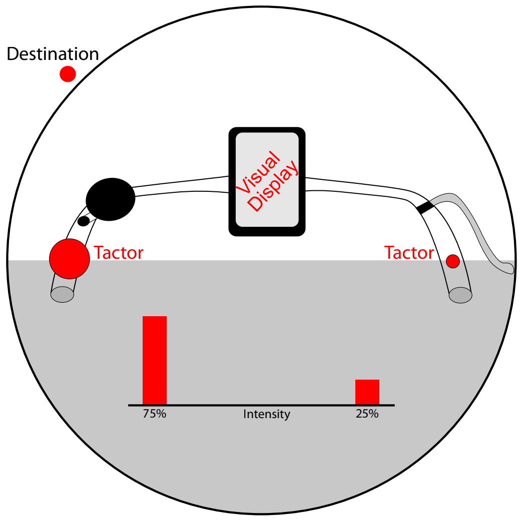

Figure 2: The tactile actuators have different vibration intensities to show towards the destination.

3.2 Information presentation design

Given this input and output capabilities and with consideration of the design implications, the following presentation methods has been found: To **provide an overview of POIs in the immediate surroundings**, we use a radar like, egocentric, visual user interface, which only allows and requires interaction if the cycle is not in motion (see Figure 3). To **select and convey the direction of a destination** via tactile feedback the user has to click on a POI. The routing information is encoded by the two tactors, using a signal interpolation according to Figure 2. Instead of using a continuous vibration, we decided to use interrupted, subsequent vibrations. The visual and tactile presentation changes, if the user changes the steering wheel orientation, detected using the digital compass. To **indicate the presence of POIs in the immediate vinvity** we alter the vibration interval to short, directed tactile bursts, using the same model of interpolation as the described destination encoding. In case that the Tacticycle already shows towards a destination, the tactile presentation can be overwritten shortly in the case the cycle passes a point-of-interest.

3.3 Implementation

The Tacticycle consists of two subsystems: a common Personal Digital Assistant (PDA), running the software, and a low-level self-developed hardware platform. The PDA, type E-Ten X500+, includes a Global Positioning System (GPS) receiver to determine the current global position of the Tacticycle. The visual display of the PDA shows, without any underlying map, the current destination and POIs nearby. The hardware platform, based on an Atmel ATmega64 RISC CPU, receives the current user orientation from the attached Honeywell HMC6343 digital compass and has control over the two JinLong Machinery 6DL-1221H13.5 vibration actuators. The actuators are sticked on the steering rod handles directly, where the boxed hardware-board with the affixed compass is attached to the mid of the steering rod. Bluetooth links the hardware-platform to the PDA, which is also attached to the mid of the rod (see Figure 3).

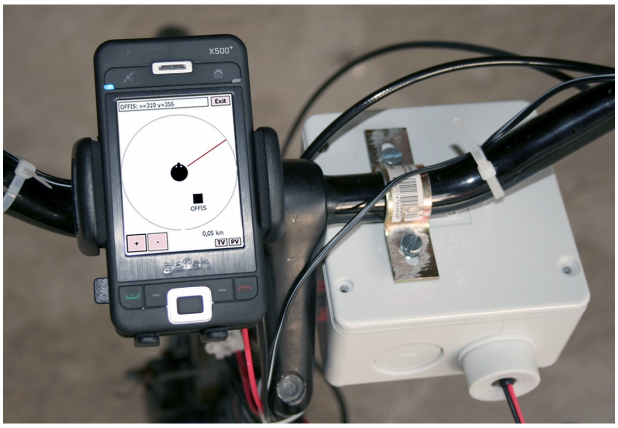

Figure 3: The PDA and the additional hardware attached to the steering rod.

3.4 Demonstrator

To resemble a realistic demonstration of the riders experience we'll present the whole Tacticycle at the demo session, simulating a virtual cycling trip through a residental area. To create a good sense of wellbeing while cycling and a good integration into the cycling trip, we place a 30-inch LCD screen in front of the Tacticycle, showing a pre-recorded video of a cycling tour through a residental area. Although the Tacticycle is fixed to the ground the information presentation to the participant feels like truly cycling within the environment, providing all the visual and tactile feedback as it would provide naturally. A participant of the demo doing a spin on the Tacticycle, could feel how the tactile feedback changes over time and space, encoding the direction to the supposed destination. Additionally the user have the visual feedback provided by the PDAs graphical user interface to obtain a general overview over the virtual environment.

Figure 4: The demo setup invites people to take part in a virtual cycle trip, providing real tactile feedback and visual impressions.

4. PILOT STUDY

To receive a quantitative and qualitative feedback on the Tacticycle we conducted a pilot study comprising two tasks. In the first task, tactile information should be interpreted, while in the second task, the participants should use the Tacticycle within an unexplored environment and state their user experiences. Both tasks were conducted outdoor. Six participants, three males and three females, aged between 20 and 26 years (average 23.33, SD 2.32) took part in the study. None of the participants had previous experiences with tactile displays.

4.1 Method

In the first task we tested if the information presented by the tactile display is interpreted correctly, without the availability of the visual display. The participants were asked to recognize presented directions and map them to a clock scale. 13 equidistant angles between 0° and 90° were generated prior to the study (0°, 7.5°, . . . , 90°). Those angles have been spread using a random sign to extend the range of perception. Thus we reached angles from the continuum of 270° over 0° to 90°. The participants were asked to drive along a straight route with a minimum speed of 3.7 km/h (2 kn). While driving, the direction of a hypothetical destination was indicated without considering the current user orientation. The participants had to indicate the perceived direction through the clock system, meaning that e.g. 12 o'clock would be straight ahead of them while 9 o'clock corresponded to left. Since we only indicated directions in front of the users, the possible answers were restricted to 9, 10, 11, 12, 1, 2, and 3 o'clock. Each response was stored together with the actually displayed angle.

In the second task, the participants were asked to reach a defined, but also unknown destination, only relying on the Tacticycle's visual and haptic feedback. As evaluation environment we used a calm city area with minor traffic occurrence, containing dead-end roads and exclusive cycle-and pedestrian paths. Beside the question to reach the destination, the participants has been asked to be attentive to cycling, vibrating and surrounding characteristics, without the mention of a specific change on the presentation methods. On every possible way to the destination there has been at least one point-of-interest (POI), triggering a change in the tactile and visual representation. The participants were followed by an experimenter who stayed in hearing distance. After the destination has been reached, a paper only showing the starting and destination point in a map-like way has been issued. Each participant was asked to fit in the layout of driven path. Then, possible changes in presentation should be correlated to a geographic location and meaning within the trace. Finally, the participants were asked to describe their experiences and impressions of the system.

4.2 Results

Since we used a randomly chosen algebraic sign in the first task and therefore had a symmetric system, we first matched the angles on the left back to the corresponding angles on the right (e.g. $352.5°$ has been matched to $7.5°$). The analysis of the stored data shows that the tactile signals corresponding to 12 o'clock can be classified accurate to 44.4%, while classification to 9/3 o'clock was 58.3% (see Figure 5). As a second quantitative value we conducted the average deviation of the angles classification to a specific time interval. For 12 o'clock the average deviation was $-35.8°$, for 11/1 o'clock $-18.1°$. We detected an average deviation of $-12.5°$ for 10/2 o'clock and $3.8°$ for 9/3 o'clock.

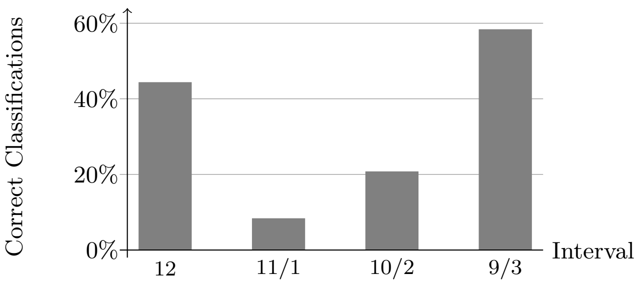

Figure 5: Achieved correct angle classifications obtained from the first task of the pilot study.

The observation of the participants during the second task shows that five of the participants mainly used the tactile display method, while one participant only used the visual feedback. Every person reached the destination, two of them did a $180°$ turn. Three persons were able to draw a trace of the cycled way. One of them was able to draw the highlighted POIs to the trace. Two others, who were not able to draw the trace, also mentioned a change within the representation methods. Every participant noticed at least one advantage of the system, mainly the increased environment awareness or the reduced need to explicitly gain orientation or spatial information.

4.3 Discussion

The quantitative results of the first task show that especially tactile directions towards the front or to the sides can be classified accurately. We think that the disabling of the fixed user orientation can increase the overall classifying accuracy. With every participant reaching the destination without using any additional guidance, we think that the Tacticycle is effective. Nevertheless the study shows that the POI highlighting should be redesigned to be more intrusive. The overall impressions of the qualitative and quantitative results are satisfying.

5. CONCLUSION

The observation of tourists in the wild was difficult. Triangulating the results of the survey and the fieldstudy helped us, to acquire the major needs of cyclists with touristic background. To work against the described problems, the Tacticycle has been build. The design of the Tacticycle uses visual and haptic modalities to convey spatial information about the destination and nearby points-of-interests. A conducted pilot study allowed us to obtain an early feedback on accuracy, efficiency and user satisfaction. The overall results look promising. Every participant was able to reach an unknown destination within an unexplored environment easily. However, we do not know if the Tacticycle is able to support tourists in an unexplored environment. We plan to further improve the Tacticycle to accomplish another evaluation with real tourists within an appropriate holiday environment.

6. ACKNOWLEDGMENTS

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