Natch : A Watch-like Display for Less Distracting Pedestrian Navigation

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Abstract

Modern Smartphones have enabled navigation system developers to provide their solutions to pedestrians. However, interacting with mobile devices can result in distraction and fragmented attention. We therefore investigated how the navigation systems' information presentation can be designed in a less distracting way. We propose a prototype called Natch (short for navigation watch): on a wrist-mounted display a reduced set of navigation information is displayed (direction, distance to next decision point and street name). In addition, a vibration motor sewn into the watchstrap is used to alert the user when reaching a decision point. In a field study we investigated if this design distracts the user less than a commercial Smartphone-based navigation system. Nine participants navigated through a city centre with both devices. The results show that Natch users made less navigation errors, felt less visible, and were less distracted by the device.

1 Introduction

Not at least with TomTom© for Smartphones, the Nokia Navigator series, or Google Navigation, navigation systems for pedestrians have reached the end consumer market. They promise the convenience of guiding us to places we do not know similar to the well-known car navigation systems. While initially navigation systems for pedestrians were just car navigation systems installed on mobile devices with a "pedestrian route mode", it is starting to get recognised that pedestrians require a different kind of system. For example, Google Navigation's satellite view or the street view can help pedestrians to find the right corner.

Nevertheless, the interaction is still visual and presents plenty of information via rather small displays. This can be an issue for several reasons. Bad environmental conditions, such as reflecting sunlight, darkness or rain can make it inconvenient to read a mobile device's display. Interacting with mobile devices easily results into fragmented attention and frequent distraction (Oulasvirta et al. 2005). Furthermore, field studies have shown that pedestrians often spent an enormous amount of their navigation time looking onto the map. This means they are distracted and may easily run into a dangerous situation (Pielot & Boll 2010). Another often overlooked problem is that such navigation systems require interacting with precious and potentially expensive mobile devices in public. But many people do not like to stand out as "strangers" and for pick-pockets this may represent favourable opportunities.

We therefore investigated the approach of radically reducing the displayed navigation information and presenting it via an everyday device: the watch. In a user-centred design process we designed Natch, a navigation watch that uses a wrist-mounted display to present the turning directions and the distance to the next decision point. Realised as a Wizard-of-Oz prototype, we evaluated the underlying concept in a field study. We experimentally compared Natch against a TomTom© application. Nine people had to navigate to two destinations with one of the devices each. We observed a significantly better navigation performance and a significantly reduced distraction by Natch. We conclude that wrist-mounted displays may be a good add-on to existing navigation systems.

2 Related Work

The interaction with pedestrian navigation systems has been subject to research for several years. According to Tscheligi and Sefelin (2006) one of the most important aspects that has to be considered is the context of use. For drivers, driving and navigating are usually the primary tasks. For pedestrians, in contrast, navigation is often only a secondary task. Still, most state-of-the-art navigation systems for pedestrians use the same maps and turning instructions we know from car navigation systems.

Field studies repeatedly showed that this kind of information presentation is not yet optimal for pedestrians. For example, Rukzio et al. (2009) tested several navigation aids, including a navigation system and a paper map, and found that the paper map was preferred. Ishikawa et al. (2008) compared maps and turn-by-turn navigation systems and found that maps were more efficient in some aspects of the navigation.

One problem is that the interaction with the tiny display causes distractions. Oulasvirta et al. (2005) showed that pedestrians interact in short bursts only with mobile devices, which leads to a significant fragmentation of the users attention.

As a potential solution, Tscheligi and Sefelin name the use of wearable computers. In particular, the use of tactile information presentation is discussed as an alternative means. Van Erp et al. (2005) proposed a tactile belt for waypoint navigation. Several vibrating elements are sewn into a belt. When worn, the tactile belt allows generating stimuli all around the torso. A front vibration would then correspond to the waypoint bearing straight ahead. However, a recent study by Pielot & Boll (2010) shows that this kind of information presentation might need further research. Although it can reduce the distraction, the users still performed better with the commercial pedestrian navigation system used as baseline.

3 Natch

The aim of this work was to investigate how navigation information can be presented more suitable to the context of use, by using potentially widely available devices. We therefore designed the concept of a watch-based display presenting a reduced set of information only, as watches are still widely worn and interactive, programmable devices are nowadays emerging. In this section we describe the design and the realisation of our display.

3.1 Requirements

We made a survey and test run with TomTom©, a commercial navigation system, in order to find out what kind of needs the potential users have. 117 people took part in our online survey: 60% men and 40% women. With our questions we aimed to find out the preferences related to the information presentation. During our test run we asked our participants about problems they had while using the navigation system and their wishes for such a kind of device.

93% of participants preferred displays for information presentation. The display has to be small enough to be easily handled and the information on the display has to be large enough to be readable. They pointed out that the voice output was annoying and drew off the user's attention. 18.7% of participants said that the voice output called attention of other pedestrians to them, other 18.7% pointed out that the voice output distract them from their environment. Vibration patterns, according to 44.3% of participants, were too difficult for them to memorise, but the actual problem might be the lack of experience with such patterns.

The participants stated that they *did not want to attract attention of other people* by holding the device in their hand. They found it annoying that other people looked at them and it kept them from doing other things during the test run. Thus they voted for a device that *does not distract from the environment*. A short notification about route changes was preferred by 73.8% of participants. They *do not want to be strictly guided* and to *have permanent eye contact* with the device. The majority of the participants wished *to have less information* about the route in order to avoid confusion, but they *did not want to abandon arrows* as a concept of guidance.

3.2 Design

In order to overcome the found issues we decided to provide only drastically reduced navigation information. We assumed that a reduced set of information is processed and memorised faster, being more suitable for interaction with fragmented attention.

As essential navigation information, we identified the distance and direction to the next decision point, the direction to turn to at a decision point and as additional information, providing confirmation to the user, the name of the street to enter.

Due to the high acceptance of displays, we chose to use a display to present these minimized waypoint information. Many participants of our survey stated, that they want arrows showing the direction. We incorporated this wish in our design, using large and thick arrows, which are easy to read. Turns are represented by bend arrows, applying the turn's angle directly on the arrow. Right-angled turns will result in an arrow bend by 90°, while larger or smaller angles will result in a less or more bend arrow.

Participants of the survey stated that standing out because of using a navigation system is annoying. In order to reduce the visibility of users for their environment, we came to the conclusion of carrying the device on the wrist, incorporating the idea of wearable computers. This enables pedestrians to use both hands, while reading the information would be performed with the natural and familiar gesture of reading a watch.

Navigation systems like TomTom© have the ability to notify a user via audio messages about e.g. approaching a decision point. However, many participants of our survey stated that using audio messages attracts their environment's attention as well and that not all of the available voices are pleasant, but sometimes misleading or annoying. Therefore we used a short vibration pulse to discretely notify the user 10-15m in front of a decision point, interrupting other tasks only if necessary and drawing less or no attention of the environment.

3.3 Realisation

Using low budget materials, the Natch prototype was build using mainly non-electronic components. The prototype can be seen in Figure 1.

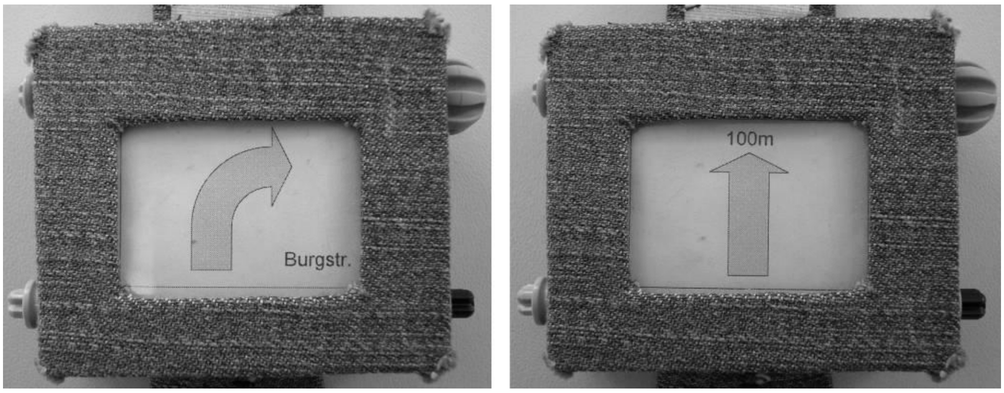

Figure 1: Screen layout of Natch, showing information presentation 5-10m in front of a decision point (left) and after encountering a decision point (right).

The frame of Natch consists of LEGO® and contains the route-information as a paper printout on a reel. The display dimensions are 33mm width and 24mm height, while Natch itself is 57mm x 48mm. The user utilises a small wheel to change the display content manually by sliding the paper printout in the display area to the next screen. Natch is worn around the wrist by a cloth band and is adjustable by a hook-and-loop fastener. Sewn into the wristband is the vibration motor of a mobile phone. The battery and switch for the vibration motor are external and connected by a cable of two meter length, giving a remote control method to trigger events without distracting the user. In front of a decision point the screen shows an arrow bend in the direction to turn to and the name of the street to enter. After a turn an arrow will point in the walking direction and the distance to the next decision point is given in meter.

We used the Wizard-of-Oz method to simulate the GPS and way-finding algorithms. The user is followed by the *Wizard*, who knows the route, and is informed about new information 10-15 meters in front of and after each decision point via a short vibration impulse of about one second, triggered by the *Wizard's* remote control. To read the new information, the user has to use the wheel to slide to the next instruction screen.

4 Evaluation

In order to investigate our concept of displaying reduced navigation information via a wrist-worn display, we compared our Natch prototype to the commercial navigation system TomTom©. Our hypotheses were:

- (H1) Natch needs less attention and is not as distracting as TomTom© because of its plain and simple presentation of information.
- (H2) The navigation performance with Natch is as good as with TomTom©.
- (H3) The wrist-based concept of Natch is natural and attracts less attention of other people compared to TomTom©.

4.1 Method

We conducted a field study to test our hypotheses. During the experiment the participants had to navigate through a city centre with Natch and TomTom©.

4.1.1 Material

For the evaluation we used two routes with similar length and difficulty. Each route is about one kilometre long. The first route has seven turns, while the second route includes six turns. To simulate a natural situation, the first route leads through the pedestrian zone of Oldenburg and ends at a church as a point of interest for tourists. The second route starts at this point and leads to the railroad station of Oldenburg. Both routes lead to their destinations on an indirect way, to prolong the route and add turns.

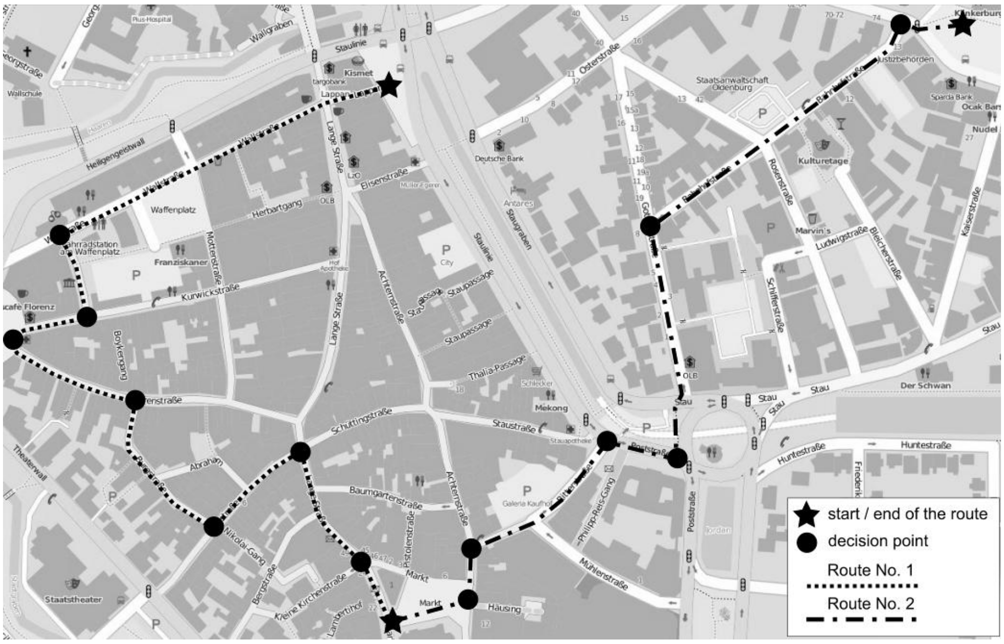

Figure 2: Map of the used routes in Oldenburg

The used systems were on the one hand Natch, described in Section 3, and on the other hand a HTC P3600 Smartphone device with internal GPS and the navigation software TomTom© v6.030. The routes were programmed and set to pedestrian mode by the experimenter, so that the participant did not have to know the input mechanism.

4.1.2 Design

The navigation system served as independent variable. Natch is the experimental condition while TomTom© is used as control condition. The study used a within-subjects design. Thus, all participants contributed to both conditions. The order of conditions was counter-balanced to avoid sequence effects. The following dependent variables were measured.

Distraction: We measured distraction by self report, asking the participants how much of their attention the navigation system drew. The subjective distraction was rated on a Likert-Scale from one (low distraction) to five (high distraction).

Visual usage count: In order to collect information on the distraction of the participant from his or her environment, we observed the participant and noted each of his or her eye contacts with the device's display.

Navigation errors: Evaluating the navigation performance of Natch and TomTom©, every wrong turn or leaving the planned route was registered as a navigation error.

Visibility: We measured the participant's feeling of visibility by self report, asking how standing out or visible they felt while using the navigation system. The visibility was measured on a Likert-Scale from one (not visible) to five (very visible).

Manual usage time: In order to evaluate the participant's visibility for his or her environment, we measured the duration of holding the device in front of the body. The device had to be clearly visible by the observing experimenter and the time was measured whether or not the participant was currently looking at the device. The time for sliding Natch to its next screen was included.

4.1.3 Participants

Nine participants (five women and four men) took part in the field study. The mean age of the participants was 29 ranging from 21 to 50 years. 66% of the participants were students. All participants rated their experience with navigation systems as average. Almost all participants came from *Oldenburg* and were familiar with the city. All volunteered and received no payment.

4.1.4 Procedure

The experiment consisted of three phases and took place in the city centre of *Oldenburg* in the last week of January 2010.

At first we welcomed the participants and explained their tasks. We told them that the aim of our study was to compare the prototype to a commercial system and explained that they are supposed to go through the city using Natch and TomTom© as navigation help. The participants could ask for help if they encountered problems with the devices. We also demonstrated how both systems work and let the participants test them. We pointed out that they may stop the experiment at any time without giving reasons.

The navigation from the start to destination point was the second phase of our experiment. A participant navigated using one of two systems and three experimenters followed him or her. Two of the experimenters noted the duration of eye contact with the devices and the duration of carrying it in front of the body with the help of stopwatches. They also noted navigation errors and either the reaction of a participant on the environment or the reaction of other pedestrians on the participant. If the participant was about to leave the predestined route, a experimenter approached him or her and pointed out the right direction to keep consistency with the planned route.

Arriving at the destination of the first route the participants answered our questions by means of the questionnaire. Afterwards we repeated these steps for the second system and route. All nine participants were able to conduct the experiment on two consecutive weekends, using both types of navigation systems, and were exposed to similar weather and light conditions.

4.2 Results

Table 1 summarizes the descriptive results. The total number of visual contacts with the Natch amounts to only about 56% of that from the TomTom© device. In addition, the total time spent on actually using the device is almost 98% lower in case of the Natch and much more constant. Navigation errors have been reduced by more than 25%. The subjective impression of distraction caused by device usage has been rated less than half as high compared to the TomTom© device, as has also been stated for the feeling of visibility. In all cases, the standard deviation is much lower as well, making the values more reliable. To test the for significant differences we used a dependent, two-tailed t-test.

	Natch		**TomTom©**		
Dependant Variable	**Mean**	**S.D.**	**Mean**	**S.D.**	**p-value**
Distraction	1.67	0.87	3.56	1.13	0.00
Visual usage count	17.11	1.58	30.33	13.56	0.01
Navigation errors	0.33	0.5	1.22	0.67	0.01
Visibility	1.33	0.5	3.11	0.78	0.00
Manual usage time	6.4s	2.6s	292.0s	368.4s	0.05

Table 1: Results given as mean, standard deviation and p-value of the t-test.

During the experiment TomTom© repeatedly showed a routing issue at one position of the second route. Approaching a traffic circle, TomTom© tried to guide the participant straight through the traffic circle instead of the planned way around it across pedestrian lights. This contributed to most of the navigation errors with TomTom©. However, the distance announcement of TomTom© also caused irritation. For instance, being 10m in front of a turn. TomTom©'s audio message announced a turn in 30m, followed by a 'Turn left/right' message after five more meters.

Seven participants used the display as primary interface, while two relied on audio output, only using the display when the audio message was not clear or the environment to loud. We observed that the audio output of TomTom© interrupted some participants while talking. The participants stopped talking until the audio message ended. Some participants were irritated by the audio messages with wrong distance information.

Three participants encountered problems using the wheel of Natch, caused by thick gloves, and three other had to familiarise with wearing Natch for some minutes. They said they were afraid of damaging the prototype.

4.3 Discussion

In summary, Natch could successfully guide our participants to the given destinations. Natch users made significantly less navigation errors, looked less often at the device and spent less time holding it visibly in hand. The participants reported to be less distracted and standing out with Natch. Taking our hypotheses into consideration, we come to the following results:

H1 (Natch is less distracting in comparison to TomTom©) is supported. The subjective distraction as well as the time spent looking at the device was significantly reduced with Natch. We believe that the reduced amount of information enabled the participant to comprehend the displayed navigation information at a glance. Since only short glances were needed we conclude that the interaction is more suited for the short interaction bursts described by Oulasvirta et al. (2005).

H2 (Natch has equal navigation performance) is supported. Natch users even made significantly less navigation errors. However, we assume the cause was not the information presentation but in TomTom©'s way-finding algorithm. Most of the observed navigation errors occurred at the traffic circle where TomTom© gave false routing information. Our observation tried to distinguish a system's navigation error from a participant's error. Taking this into consideration, Natch performed at least equal to TomTom©, but may not have superior navigation performance.

H3 (Natch attracts less attention) is supported, since our participants interacted less often visibly with the device and subjectively felt attracting less attention. However, the difficulty of measuring environmental attention has to be taken into account. We tried to accommodate this by the personal impression of our participants and an objective measuring of the manual usage time. Our results show that the participants felt less standing out and that using Natch is less visible, but it can be questioned if holding a navigation system attracts the attention of the environment.

The Wizard of Oz low-budget prototype lead to certain disadvantages: the rather short cable connection may have increased the test person's impression of standing out and the need to manually obtain the next instruction added to the overall interaction time. Despite these circumstances, our tests yielded significant findings and Natch still achieved better results.

5 Conclusions

In this paper we investigated how information presentation on navigation systems could be designed to be less distracting and to let users of a navigation system feel less standing out. We therefore propose Natch, a watch-like display providing reduced navigation information only. In a field study we could show that this type of information presentation can reduce the users' distraction and attract less attention by bystanders while not decreasing the navigation performance.

Altogether the study showed that presenting reduced navigation information through a wrist-worn display leads to an improved navigation experience. At the same time, the navigation performance is on a par with systems like TomTom©, as in most situations complex information is not needed. Thus, we advocate for thinking about how the complexity of the presented navigation information can be reduced to the essentials instead of providing more and more information crammed into a tiny display.

In order to be used in everyday navigation systems the idea has to be advanced further. Since many survey participants mentioned that they felt less safe without a map, but also did not want too much information on the display. Natch could be used together with a Smartphone-based device, providing computing power, input interfaces and a larger display for detail information. Natch itself could therefore be designed slim and lightweight, discretely providing necessary information, while the main device could stay in a pocket.

6 Acknowledgements

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