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Pointing for non-visual orientation and navigation

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ABSTRACT
People who have visual impairments may have difficulties navigating freely and without personal assistance, and some are even afraid to go out alone. Current navigation devices with non-visual feedback are quite expensive, few, and are in general focused on routing and target finding. We have developed a test prototype application running on the Android platform in which a user may scan for map information using the mobile phone as a pointing device to orient herself and to choose targets for navigation and be guided to them. It has previously been shown in proof of concept studies that scanning and pointing to get information about different locations, or to use it to be guided to a point, can be useful. In the present study we describe the design of PointNav, a prototype navigational application, and report initial results from a recent test with visually impaired and sighted users.

Author Keywords
Non-visual, interaction, navigation, GPS, compass, audio-haptic, augmented reality.

ACM Classification Keywords
H5.2: Auditory (non-speech) feedback, H5.2:Haptic I/O, H5.2: Prototyping, H.5.1: Artificial, augmented and virtual realities.

INTRODUCTION
The use of navigation devices based on GPS information increased with 100% between the years 2006 and 2009 [5]. Nowadays (2010) many mobile and smart phones are delivered with pre-installed navigation applications. By combining GPS data with the information from an electronic compass (magnetometer), directional information can be displayed to a user when a device is aimed in the direction of a point of interest (POI). So far the bulk of this work focuses on adding visual information on the screen of the mobile device, of which Layar is one example (layar.com). However, there is also recent research showing how to make use of non-visual feedback, for example [1], [2], [4], [6], [7].

The soundcrumbs application [2] demonstrated that the non-visual feedback received when pointing with the device and scanning with it in different directions provided sufficient information to the user about the direction to a target. The SoundCrumbs application was an application mainly for creating trails (hence the "crumbs") and following them, and was therefore independent of map data. The display of map data in a completely non-visual use case becomes increasingly complicated with increasing numbers of map features to display. Still, pointing and scanning with a navigation device could potentially augment the reality to aid users who have limited eyesight and give them a means for obtaining an overview and orienting themselves as well as a means for navigating in unknown places. We have developed the PointNav prototype in order to explore how such an application should be designed.

THE POINTNAV PROTOTYPE
PointNav is a test application implemented on the Android platform which can provide speech and vibratory feedback. The application allows the loading of point of interest lists (via .gpx files).

Figure 1. The touch screen interaction design.

The main functionality from the user's perspective is the non-visual touch-screen interaction, the environment scanning by pointing, and the guiding to a selected target.

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The touch screen contains nine buttons as shown in figure 1. You get a short vibration as you move from one button to the next. This allows you to feel the borders between the different buttons. If you rest your finger on a button the speech feedback will provide you with the name of the button. You select a button by releasing your finger from the screen (just as you do for mouse button selection in the standard windows interfaces). This design allows the user to slide her finger over the screen to find the right button without accidentally selecting something unwanted. In contrast to the accessibility design used in the Apple iPhone or in [9] this type of screen interaction requires no double tapping or special multi touch gestures.

In the scanning mode, the user points the device in the desired direction, and if the device points at a POI within a certain distance range she will get a short vibration followed by the POI name and distance (by speech feedback). The scanning angle (see figure 2) is currently 30º, and if several POIs fall into a sector, the one closest to the 0º bearing will be displayed. The last POI reported is stored and the user can select it by pressing the "Add" button and also ask for more information about it. In the real world there are often very many POIs and the user can filter these points by selecting to scan for near points (0-50 m), intermediate points (50-200 m) and far points (200-500 m).

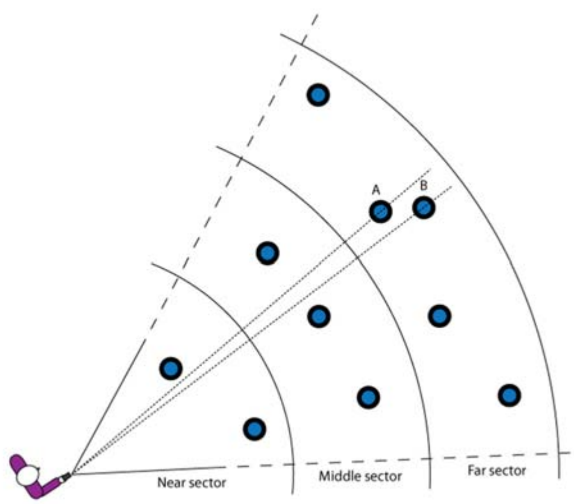

Figure 2. Scanning angle and sector ranges. The points signify POIs, and the POIs A and B in the same sector are close to each other in angle.

Since speech information about a POI takes time to display there is, in this respect, the question about how to handle the speech queuing in the case of several POIs with small angle differences (like A and B in figure 2). In PointNav the TTS is allowed to finish speaking POI names. This might result in feedback given at the wrong location, but having the speech interrupted by new speech requests can result in incomprehensible stutter due to compass and GPS jitter. We do, as yet, not employ any signal filtering strategy since filtering has been observed to result in a lag in the compass bearing which has been observed to be problematic for the scanning interaction. It is still possible that some filtering strategy might need to be adopted at a later stage.

In the guiding mode the user is guided to the previously selected point. The guiding does not make use of any routing, instead the application provides the user with information about if the device is pointing towards the target point or not. The figure 3 illustrates the guiding design.

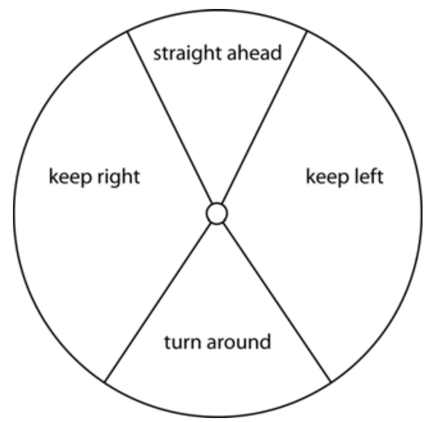

Figure 3. Guiding design. The "straight ahead" angle is 46º (to avoid decimals), the "turn around" angle is 60º and the "keep right/left" anlges are 124º.

For the design of the angle intervals we have been guided by the recommendations in [3]. In contrast with the design used in the soundcrumbs application [2] this design does not only provide information about how close the device is to the 0º bearing, but also about which direction to turn in order to point more straight at it. The speech feedback says the name of the goal, the distance to it and the text indicated in figure 3; "keep straight", "keep right/left" and "turn around". The corresponding vibration feedback used a design inspired by the PocketNavigator [8] and used a long and a short vibration for the "keep right/left" sectors (long-short for keep right and short-long for keep left). The forward direction was indicated by a pattern of three short vibration pulses and the turn back was shown as indicated by a sequence of long vibrations. The guiding stops when you are 15 m or closer to the target and the speech feedback says "arriving at <POI name>. No more guiding". In addition you get a sequence of five short vibration pulses. The 15 m distance is to some extent determined by the jitter/jumps in the GPS signal and for the test location (a park with many trees) we had observed that the 10 m used in [2] occasionally placed locations in places that were hard to reach or dangerous while 15 m appeared to work better. For all the vibration patterns described above a short vibration is 50 ms and a long vibration is 150 ms.

The start button in figure 1 was to keep the application inactive before the test, and the mute button allowed the user to silence the guiding speech information.

TEST DESIGN

The above described application was tested with five visually impaired users and one sighted user. The test was semi-informal/qualitative and was done in a park (figure 4).

Figure 4. POIs in the test area. The POIs used in the test are indicated by arrows.

Of our visually impaired users three were completely blind while two had some residual vision. We tested with 3 men and 3 women. We tested with young, middle aged and old users – the age of the test users was 14, 16, 44, 44, 52 and 80. The sighted user was the youngest of these – we wanted to test also with a sighted teenager to compare how this kind of user would react to an application like this.

To allow the users to familiarize themselves with the application the test started with a tutorial where we showed them how to find the test starting point (the topmost of the points indicated in figure 4). Once at the test starting point the user was asked to locate the fictional place "Beachstock" (at middle distance, rightmost of the points in figure 4) and go there using the guiding functionality of the application. Once at "Beachstock" the user was asked to locate "Neverhood" (at long distance, leftmost in figure 4) and then to go there. The user was not told in which distance interval the points could be found. The use of fictional POIs was motivated by a wish to avoid having users making use of previous knowledge of this park. After having found "Neverhood", the test leader guided the users to a spot near a fountain placed centrally in the park (the centrally placed white circle in figure 4) and asked the user to tell him how many POIs that could be found nearby. The users were video filmed during the test, and the test concluded with a short semi structured interview around the experience and the application. The whole test took between thirty minutes and one hour.

RESULTS

All users were able to complete all test tasks. The visually impaired users particularly liked the possibility to orient themselves using the scan mode. The guiding was also quite well liked by four of the five users with vision problems, while one user did not like it since the GPS precision is not good enough (this user had previous gps experience and thus knew the imprecision you sometimes get – "you want to get to the ATM and you end up at 7-11"). The touch screen interaction worked quite well – all users were able to learn it quite quickly, and the main problem was actually to remember which functions there were and what they should be used for. Given the short duration of the initial familiarization, users were allowed to ask for help with the touch screen interface, and everyone except the sighted user needed reminders like "the top left button" initially. All users were able to handle the final task without support indicating that they had mastered the interaction fully.

Compass jitter made it hard to select the "Neverhood" POI (the speech feedback would jump between the two nearby points), causing selection errors and forcing the users to try several times before they succeeded. In response to this, two of the users developed the strategy of turning the phone to a vertical position as soon as they heard the right name (the scanning updates only while the phone is held horizontally).

In general users kept the phone pointing forwards during guiding and followed the speech instructions. One user also developed the alternative strategy of keeping the phone pointing towards the goal even when walking in another direction (when walking around obstacles or having to follow paths that did not lead straight towards the goal).

All users had to be told about the vibration patterns. They spontaneously noticed that there was vibration, but unless told so they did not notice the different patterns. One of our blind users had used the application before during pilot tests, and this user preferred to turn off the speech feedback for the guiding. The other users were quite happy about listening to the speech, although some commented that once you got more used to the vibrations you might want to turn the speech off. One user who had tested an earlier application that made use of a Geiger counter type of vibration feedback to indicate direction commented that such a design might be more intuitive than the one we had implemented in PointNav.

The users were offered to use earphones. Four of them preferred to use these, while two preferred to listen to the phone loudspeaker. This may in part be due to the test design – since the test leader was walking nearby it is possible that some users felt it more natural to share the sound compared to if they had been on their own.

We had included one elderly user in the test. This user had no central vision, and no longer used a mobile phone. Before the onset of the vision problems this person had used one, but it was described as the "old" kind. Thus this user had no experience of touch screens, and needed longer time to learn how to use the touch screen interface (although also this user was able to complete the final task without assistance). The pointing and scanning on the other hand caused very few problems.

We were also interested in how the PointNav application (which was designed to be accessible) would be perceived by a sighted teenager and we included one such person among our test users. Teenagers can be considered mobile phone expert users, and much marketing is targeted towards this group. Since we only tested with one user from this group we can make no general statements, but at least this person reacted very positively to the application and thought something like this would be really useful. It was also interesting to see how little the application interfered with the walk – the user looked around and also talked quite a lot with the test team. Even when interacting with the screen in bright sunlight, the device was held in a relaxed position at waist height. This can be contrasted with the "hold the device in front of the face" type of interaction that tends to result from the standard touch screen interaction.

DISCUSSION AND CONCLUSION

This paper describes the design of the PointNav application and reports initial results from a user test involving five visually impaired users (ages 16-80) and one sighted teenager (aged 14). PointNav includes a combination of augmented reality scanning and guiding while earlier studies have focused on either augmenting the reality [4, 6] or guiding [1-3], [7], [8]. In contrast with [1], [4], [6] and [7] we have also tested with visually impaired users. The test reported in [2] involved only one visually impaired user, and was (as was stated above) directed solely at guiding. Our test results are encouraging – the scanning and guiding interaction is intuitive and easy to use, and also the touch screen interface worked well although users needed some time to learn the button layout. The select on release design caused no problems, and the users quickly understood how the interaction worked.

Our visually impaired users particularly appreciated the scanning mode since it provided overview and helped with orientation. The guiding allowed all test users to find the goals we had assigned, but this may to some extent be part of the test design. The kind of POIs we used (not closely tied to a physical object) and the kind of environment we were in (a park) is less sensitive to GPS inaccuracies. Judging from the user comments the orientation one gets from the scanning may be more important – in fact one user explicitly stated that GPS guiding was not good enough for his needs. Still, guiding was appreciated by several users and in fact two of our visually impaired users spontaneously expressed that they felt safe using it (one of these was the elderly test person).

Another problem we partially avoided by using a park was the kind of situations where objects in the environment block the path to the goal (an extreme example would be a cul-de-sac forcing the user to take a detour). It is clear that routing will improve the guiding in an environment where such problems are more common – but at the same time we see that for more open environments the kind of interaction described in this article (as well as in [1-3] and [6-8]) works well both for sighted and visually impaired users. It should be noted that the park was not completely open – there was one place where a ridge barred the way and our users were still able to handle this by walking around it. Still, we feel it should be the subject of future studies how these guiding designs can be combined in a good way.

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