Show me the direction – how accurate does it have to be?

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ABSTRACT
One factor which can be expected to influence performance in applications where the user is expected to point a device in some direction to obtain information is the angle interval in which the user gets feedback. The present study was performed in order to get a better understanding of the influence of this angle interval on navigation performance. Results indicate that users are able to handle quite a wide range of angle intervals, although very narrow and very wide are less suitable.

Categories and Subject Descriptors  

General Terms
Design, Human Factors.

Keywords
Gesture, audio, navigation, pointing, angle, non-visual.

1. INTRODUCTION
The introduction of compasses in more and more hand held devices has opened the way for applications making use of pointing gestures to provide information about objects or locations in the real world. A device with a location-aware and direction-aware application (based on e.g. GPS and an electronic compass) can display geo-tagged information to the user when the user points in the direction of a point of interest. So far the bulk of work focuses on adding visual information on the screen of the mobile device (cf. http://layar.com), although there is recent research showing how to make use of the non-visual channels. The roaring navigator [1], ONTRACK [2], AudioBubbles [3], SoundCrumbs [4], Sweep-Shake [5], and SocialGravity [6] are all examples of applications displaying geo-tagged information with audio-haptic feedback.

In addition GPS and compass\(^1\) information can be used for navigation. The GPS device knows your position and together with the compass it is also possible to provide a pedestrian user with information about which direction he or she should go.

As was illustrated by the SoundCrumbs [4] application pointing the device in different directions and getting non-visual feedback when on target, is a way of both providing information about a target as well as giving information about in which direction the user should be walking.

One basic question for this type of interaction is the angle interval in which the user gets feedback. In [7] we report the results of an outdoor study. The present paper compares the results of this outdoor study with a computer simulation.

2. SIMULATION
The investigated interaction is illustrated in Figure 1. The application has a database of GPS locations and the user is guided towards the next location in the sequence by audio or vibratory feedback. Each GPS point is surrounded by a circle. As soon as the user is inside this circle the point is considered to be reached, and the user is guided towards the next point in the sequence.

Figure 1. The interaction principle.

In Figure 1 the track of GPS points is shown together with the circles around each point. The grey line indicates the path a user would follow if he or she walked in the direction pointing directly towards the points. The angle interval around this direction which will also generate positive feedback is indicated in front of the device.

Looking around to see what sights are available. A magnetic compass on the other hand (such as can currently be found in many smart phones) works also when kept stationary.

\(^1\) The GPS compass used in car applications relies on the movement of the device, while pedestrians have a tendency to stop when they are unsure where they should go or when they are
Inspired by [6] we decided to implement a simple computer simulation to gain a better understanding of the interaction. We had seen in [7] that two basic user strategies existed: 1) those who tried to find the center of the angle interval and 2) those who started walking as soon as they had a good signal. To get an overall simulation we simulated navigation towards a single point assuming the user will chose a random direction within the interval that produces positive feedback. To get a simulation of the kind of behavior resulting from walking as soon as you have a signal we also looked at the worst case scenario where the user walks in the least advantageous direction possible.

For the overall simulation we assumed a user walking in a random direction within the angle interval, changing direction only when the feedback stops. Although some users adjusted their direction while walking (by scanning during walking [7]), they did not in general change direction until the feedback indicated this was necessary.

The simulation was run 100 times in each condition. The proportions were selected to correspond to a distance between start and goal of 35 m with a step size of 0.5 m. To see the effect of the size of the goal circle we looked at goal radii of 1m and 10m. The result of the simulations can be seen in Figure 3.

The average number of steps it took to reach the goal can be seen in Figure 4, and the average number of turns is found in Figure 5.

As was expected the increase in goal circle size is comparatively more beneficial for the wider angles. We also see that there is little difference between the angles 10°, 30° and 60°. A small increase is seen for 90° and 120°, while 150° and 180° appear less suitable to use.

For the worst case scenario it is clear that if the angle interval is 180° and above the user will never reach the goal. At 180° the user will walk in a circle around the target and larger angles will produce an outwards spiral. Smaller angles will result in an inwards spiral ending at the target as is shown in Figure 6.
In the simulation we have used a finite step size, assuming that users do not adjust their direction “in stride” but only after a step. With this assumption the step size influences the trails – since we look at a worst case scenario the signal will be lost immediately and thus the simulated user actually takes the step outside the feedback angle. In the 180º case this results in a trail that is not a perfect circle, but rather a trail spiraling slowly outwards. For the 150º case in the picture the effect is that instead of spiraling in to the exact center, the trail will end in a small circle. Thus, for a wider angle, a large step size and a small goal area can result in a trail that circles the goal without ever reaching it.

The increase in the number of steps in the worst case scenario for a 1 m and 10 m goal circle is shown in Figure 7.

Even though the underlying strategy is quite different we see the same type of results for the more narrow angles: 10º, 30º and 60º produce similar results. The problem with the wider angles is more pronounced than before, although it can to some extent be mitigated by using a wider goal circle. It should be noted that the above described results apply to any navigation where the user keeps a fixed angle deviation with respect to the direction pointing straight at the target.

If we compare these results to the time to complete in the outdoor study in [7] given in figure 8, we see that for most angles except the smallest the simulated results are in agreement with the test results. In reality we expect heading fluctuations to impact heavily on the narrowest angles, resulting in longer completion times.
3. DISCUSSION

Both the computer simulations and the outdoor tests indicate that navigation performance should be fairly insensitive to the angle interval used. For small angles observations during the test lead us to believe GPS/compass fluctuations to influence the results heavily, while at the other end of the spectrum the very wide angle interval will cause many deviations and on the average leads the user to walk much longer than necessary that is problematic. This was confirmed by the simulation results.

Although the effect of heading fluctuations and GPS inaccuracies should be investigated in more detail, the presented simulated results together with the outdoor test performed gives a much stronger foundation for providing recommendations on suitable angle intervals:

- If it is important to get exact track following one should go for more narrow angles. This depends to some extent on the equipment at hand but we would recommend 30° to 60°.
- If you want a design that puts small cognitive load on the user it is better to use wider angles. We recommend 60° to 90° (or even 120°) for this purpose.
- In general people walk slower if the angle is too narrow. If you are targeting applications where the user wants to walk quickly or maybe even run (e.g. jogging applications) wider angles are preferable.

In this study we have looked at sound on or off as feedback since adding different sectors in the angle interval would introduce more factors that might influence the results and we wanted to focus on the basic influence the width of the interval. This does not mean that it is not a good idea to vary the feedback to give the user the advantage of having both a more precise direction combined with the advantages a wider angle provides. One example of such a design can be found in [4] where a central interval of 30° with 100% volume was followed by an interval out to 90° where the volume was 40%. Outside this the sound played at 20% level all the way up to 180°.

4. CONCLUSION

Both in the simulations and in real life we find that users are able to handle quite a wide range of angle intervals. The only intervals generating significantly slower completion times in the outdoor test were the 10° and 180° angle intervals. In the simulation we generating significantly slower completion times in the outdoor to handle quite a wide range of angle intervals. The only intervals used. For small angles observations during the test lead us to believe GPS/compass fluctuations to influence the results heavily, while at the other end of the spectrum the very wide angle interval will cause many deviations and on the average leads the user to walk much longer than necessary that is problematic. This was confirmed by the simulation results.

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6. REFERENCES


