
User responses to GPS positioning information on a digital map

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Abstract

Many navigation products for pedestrians present the user with a 2D plan-view map together with positioning information supplied by GPS. Typically, this is displayed as an icon overlaying the map. This paper presents evidence to suggest that, during the navigation task, this information is, at best, redundant and, at worst, confusing. It concludes by arguing for display formats that convey to the user the level of accuracy of the information.

Keywords

Mobile computing, positioning information, mobile guides

ACM Classification Keywords

H.5.2 Information interfaces and presentation (e.g., HCI): Interaction styles.

Introduction

With widespread mobile phone ownership and signs that mobile phone manufacturers are beginning to bundle navigation applications as standard features, digital navigation aids look set to become widely used within the near future.

While researchers have explored a range of display formats for digital navigation aids (e.g. 3D maps), most commercial products present the user with a 2D plan-view map (see for example Google Maps in the iPhone). Typically, the user is free to manipulate the map using pan and "zoom" controls.

A sub-group of these map-based applications incorporate GPS positioning information. Typically, this is displayed as a position icon overlaying the map; as the user moves through the environment, the icon tracks the user's position on the map.

In theory, positional information should greatly simplify the cognitive work required to understand one's position. Readers of traditional maps determine their location on the map by matching landmarks in the environment with landmarks on the map [2]. With positioning information, the user simply needs to perceive the position of the icon on the map. On the other hand, a range of factors, such as tall buildings and atmospheric conditions, can increase the amount of error in the position estimate. It could be that positioning information supplied by GPS is too inaccurate to be useful. Worst still, the inaccuracy could confuse users, especially since the position icons used in commercial products typically give no indication of the degree of uncertainty.

This paper briefly outlines a study that investigated this issue. Participants were asked to navigate using a map-based application on a PDA with and without positional information. The intention was to see if positioning information led to more effective navigation (in terms of reduced timings and errors) and also to explore participant's subjective impressions of the information.

FIELD EXPERIMENT

Participants

Twenty-four participants took part in the study. Half were male and half female. All were unfamiliar with the area in which the experiment took place.

Materials

The map software was a commercial product called "Tomtom Citymaps Europe 2003". It was installed on an iPAQ 3630 handheld computer. The GPS unit was a Garmin eTREX GPS unit. It was connected to the PDA via a serial cable. The position estimate was displayed as either a crosshair or an arrow (see figure 1). The software used a "map matching" algorithm to place the position symbol on the part of the road network that was nearest to the estimate. Users could pan (i.e. scroll) the map by dragging a stylus across the iPAQ's touch-sensitive screen. They could also change scale by using a scroll bar positioned on one side of the screen (see figure 1).

Experimental Design

The study used a within-subjects design. The independent variable, navigation aid, contained three conditions: "PDA" (map software only), "GPS" (map software plus positional information) and a baseline paper map condition. Conditions were counterbalanced across routes.

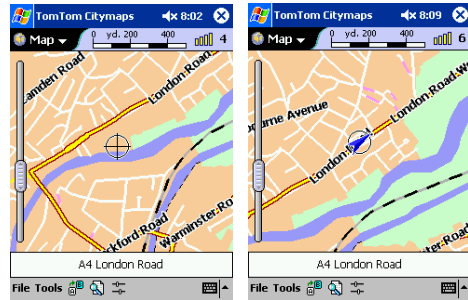


Figure 1: Screenshots of the map software showing the crosshair (left) and arrow (right) symbols

Routes

Three routes were designed. To successfully navigate each route, participants needed to make 10 correct decisions. Each route was approximately 1 km in length and included two waypoints. The routes were indicated on the map using a marker for the starting position, the two waypoints and the destination.

Data

Participants were timed on each route. Errors were scored whenever participants deviated from the shortest route by more than 5 meters. Qualitative data were collected in the form of unstructured observations and a semi-structured interview carried out at the end of the experiment.

Procedure

Participants took part in the experiment individually. At the beginning of the PDA conditions (i.e. the "PDA" and "GPS" conditions), they learned how to use of the zoom and pan controls. In the GPS condition, they were told that the map would show their position using either a

crosshair symbol or an arrow. If the GPS unit was unable to provide an estimate the symbol would appear as a clear circle. They were told that the position information was fairly inaccurate and would, in practice, lag some way behind their current position. They were also told that the heading implied by the arrow could be unreliable too. They were then shown their current location on the map, and the orientation of the map. They were informed that their task was to navigate to the destination via the two waypoints, taking the shortest possible route and to walk as quickly as possible.

RESULTS

Mean timings were 14.96 minutes (SD=3.70) in the PDA condition 15.54 minutes (SD=5.05) in the GPS condition and 12.75 minutes (SD=2.44) in the paper map condition. Mean errors were 1.67 (SD=1.76) in the PDA condition, 1.79 (SD=1.59) in the GPS condition and 0.96 (SD=1.27) in the paper map condition. A repeated measures ANOVA revealed a significant main effect for timings at the 0.01 level ($F=7.530$, $d.f.=2$, $P=0.001$), while a Friedman's test revealed a significant main effect for errors at the 0.01 level ($\chi^2=9.455$, $d.f.=2$, $P=0.009$). Post-hoc analyses revealed two significant contrasts in both cases i.e. paper map versus PDA and paper map versus GPS. In short, there was no evidence that positional information provided by GPS helped participants to navigate more quickly or make fewer errors.

Qualitative results

A large proportion of the participants said that the positional information provided by GPS was too inaccurate to be helpful. They said it lagged too far behind their current position and, therefore, did not

help them to make navigation decisions or even provide reassurance. Many indicated that they still used traditional methods to determine their position, in particular comparing street names on the map with street names in the environment.

In fact, positional information seemed to confuse them rather than help them with the lag causing them to think they were further back than they really were. This led to a number of missed turns. Participants had been warned that the position symbol would lag. However, there seemed to be a trust in the technology anyway. One participant said that she remembered these warnings but was "predisposed to thinking that technology is correct in spite of any warning that it might not be". In some cases, the confusion was caused by software placing the position symbol on the wrong street.

One unexpected benefit of positioning information was that it served as an "anchor point" when panning or zooming e.g. participants could pan forwards and then re-locate their position more easily.

Some said that the GPS symbol would help a great deal at the start of a journey. Others said it would be useful in rural areas where there were no street signs. In the words of one participant, GPS was "good for mountains". It was also pointed out that GPS would help a great deal when lost.

Discussion

Positional information did not lead to significant gains with respect to either improved timings or reduced errors. Users' subjective impressions of the information suggested that, during the navigation task, it was, at

best, redundant and, at worst, confusing. The confusion was caused by inaccuracy, either a lag that caused users to think they were further back than they were or a failure of the map matching algorithm to select the correct street.

One solution to the issue of uncertainty would be to convey the level of certainty to user. If the GPS unit provides sufficient information to estimate the level of inaccuracy, this could be reflected in the position icon e.g. a transparent position icon that grows or shrinks depending on the level of accuracy¹.

REFERENCES

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¹ This idea has been suggested in [1]. The contribution of this paper is to demonstrate the need for this type of representation.