Personalized Compass: A Demonstration of a Compact Visualization for Direction & Location

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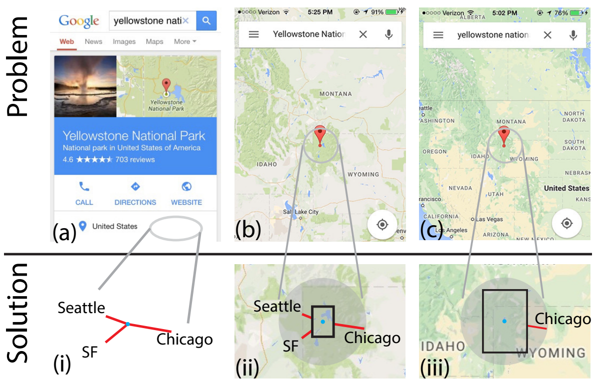

Figure 1: Where is Yellowstone National Park? Answering this question from a mobile search result often involves (a–b) unnecessary application switching and (b–c) repetitive zooming. (i–iii) A P-Compass uses important POIs to provide a first-order approximation to the answer, and can function independently or with a map. (a–c) Screenshots from a smartphone. (i–iii) Proposed visualizations to be superimposed on the screenshots at the designated locations. (© 2016 CGUI Lab, Columbia University.)

Abstract
Maps on mobile/wearable devices often make it difficult to determine the location of a point of interest (POI). For example, a POI may exist outside the map or on a background with no meaningful cues. To address this issue, we present Personalized Compass, a self-contained compact graphical location indicator. Personalized Compass uses personal *a priori* POIs to establish a reference frame, within which a POI in question can then be localized. Graphically, a personalized compass combines a multi-needle compass with an abstract overview map. We analyze the characteristics of Personalized Compass and the existing Wedge technique, and report on a user study comparing them. Personalized Compass performs better for four inference tasks, while Wedge is better for a locating task. Based on our analysis and study results, we suggest the two techniques are complementary and offer design recommendations. In this demonstration, we present an iOS application comparing Personalized Compass with Wedge for map-based location and direction tasks.

Author Keywords
Visualization; off-screen locations; spatial cognition; maps.

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces—Graphical user interfaces (GUI)

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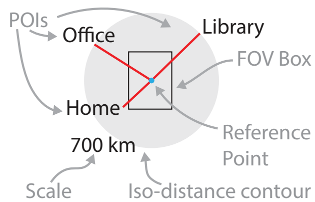

Figure 2: Anatomy of P-Compass.

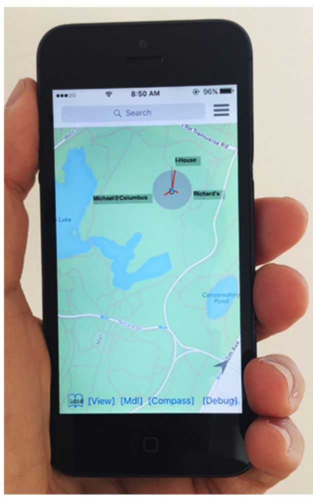

Figure 3: P-Compass prototype. (© 2016 CGUI Lab, Columbia University.)

Introduction

As the display area of an information space becomes smaller, information is often left out. When important information required by a spatial cognition task is not displayed, an otherwise reasonable task could become difficult (e.g., route planning to an off-screen destination). A small display also increases the probability of Desert Fog [2]—a condition in which the display information is devoid of meaningful cues to assist users in making decisions. These two issues are often discussed separately in the literature. In this paper, we refer to them together as the "Where is x?" problem, occurring whenever some POI x is off display, or on display but with Desert Fog present.

The "Where is x?" problem is frequently encountered on small maps, such as those displayed on mobile devices. Take location search as an example. Figure 1(a) shows a search result for the keywords "Yellowstone National Park" on a smartphone. The embedded stamp-size map is rich in information. Ironically, due to Desert Fog, it fails to communicate *where* Yellowstone National Park is. To find out the answer, users may tap the stamp-size map to switch to a map app and then continue fighting Desert Fog by repeatedly zooming out (Figure 1b–c). When a satisfying overview is eventually reached (Figure 1c), details such as Yellowstone Lake are no longer visible, and the original application context (the web search engine) has been dismissed. Similar "Where is x?" problems are often encountered in social media, Internet articles, and local business reviews—whenever a stamp-size map is presented.

For obvious reasons, the issue occurs even when the area of a map reduces to zero, as when users try to determine the location solely from a geo-tag, a zip code, an address, or GPS coordinates. The "Where is x?" issue is ubiquitous, with or without a map.

Personalized Compass

We present Personalized Compass (P-Compass), a compact graphical representation that communicates the location of x with the support of personal *a priori* POIs. Figure 1(i) shows P-Compass as a standalone location indicator. It uses three major U.S. cities to establish a reference frame, which in turn indicates the location of Yellowstone National Park. Note that a P-Compass can occupy a relatively small footprint.

P-Compass can also be integrated into the zooming interface, as seen in Figure 1(ii–iii). The black rectangle in the center of the compass indicates the boundary of the visible map. As a user zooms in the map, the size of the black rectangle updates accordingly, providing immediate feedback on the relative scale of the visible map to the distances to the three major cities.

Figure 2 shows the anatomy of a P-Compass. POI needles and FOV box are discussed in the previous examples. An optional iso-distance contour assists the user in comparing distances to POIs (and separates P-Compass from the background), while an optional numerical scale denotes the distance to the iso-distance contour.

Prototype and Field Experience

We integrated P-Compass and Wedge [1] (Figure 5), a well-known technique to visualize off-display POIs, into a customized iOS/OS-X map app and used the app regularly in daily life for over a year. We manually entered a master list of personal POIs, and apply a simple greedy algorithm to select n POIs that are roughly equally distributed in orientation to automatically form a P-Compass. An image of our prototype can be seen in Figure 3. The field experience allowed us to understand the characteristics of P-Compass, and compare it with Wedge in real-world scenarios.

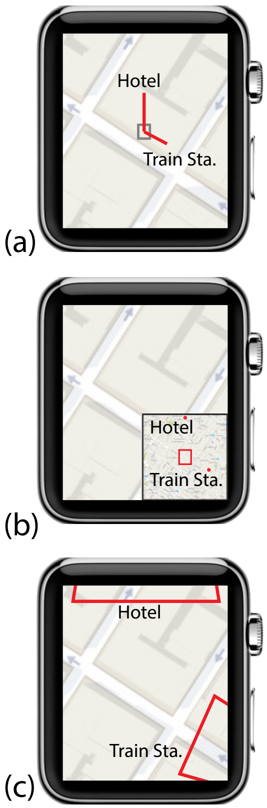

Figure 4: Where am I? Localization on a smartwatch form factor using (a) P-Compass, (b) Overview+Detail, and (c) Wedge. (© 2016 CGUI Lab, Columbia University.)

P-Compass–A Hybrid Technique
We observed that P-Compass is a hybrid technique that combines the advantages of several existing off-screen visualization techniques. The illustrations in Figure 4 compares P-Compass, Wedge and overview map. While P-Compass and overview map both add an overview to the underlying detail view (Figure 4a,b), the use of POI cues allows P-Compass to reduce the amount of occlusion. Furthermore, while P-Compass and Wedge both use proxies to indicate off-screen POIs (Figure 4a,c), the overview provided by P-Compass allows it to communicate the relationship between multiple off-screen POIs.

Issue of Scalability
In our field experience we observed that scalability is an important issue. Scalability refers to how the performance of a visualization technique is affected by the distance to an off-screen POI. While scalability is rarely discussed, it is important for two reasons: Not all off-screen POIs are near the display, as often assumed in the literature; further, with sufficient zoom any nearby off-screen POI becomes distant.

Wedge and P-Compass both have issues with scalability. Wedge is limited mostly to nearby off-screen POIs. As the distance to an off-screen POI increases, the angles between the base and the two legs increase nonlinearly and the rate of change quickly becomes indistinguishable. Beyond a certain distance, the two legs of a Wedge essentially appear parallel. The FOV box of a P-Compass, which becomes visually indistinguishable from a point for sufficiently distant POIs, does not scale either. In a sense, these two approaches both aim to *extend* the effective area of a display. Therefore, we refer to them as *display extension* methods.

The extended display area achieved this way is finite. Simply put, the probability that an off-screen POI falls into the small extended display area could be small. Most important, while it may not seem obvious, display extension methods require a relatively large display. The smaller the display area, the smaller the extended display area that can be achieved. (Wedge's max base length and P-Compass's FOV box size are both bounded by the size of the display.) Clearly, a different approach is needed to visualize off-screen POIs.

Using POIs to Overcome Scalability
P-Compass achieves scalability by using *a priori* POIs as references to communicate the location of an unknown POI x. We refer to this method as the POI-reference method. In the "Where is Yellowstone National Park?" example (Figure 1), multiple POIs are enlisted to *interpolate* an on-screen x (Yellowstone National Park). A similar strategy could be applied to *extrapolate* an off-screen x. Figure 6(a) shows a P-Compass in which the reference points is at San Francisco, and the off-screen x (Yellowstone National Park) are at the periphery. (Figure 6b–c provide two alternative examples.) Unlike display extension methods, this strategy is invariant to the distance of POIs, the scale of the information space, and the size of a display.

User Study
Based on our field experience, we developed a "day in the city" scenario comprising five navigation tasks: 1) Locate an off-screen POI; 2) Estimate the distance to an off-screen POI; 3) Estimate the direction of an off-screen POI; 4–5) In-

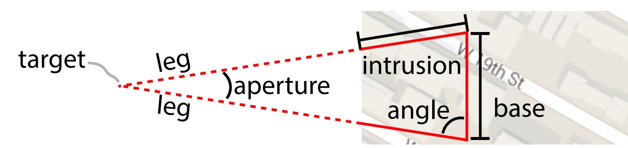

Figure 5: Anatomy of a Wedge (solid lines). The target can be located using visual shape completion (dashed lines).

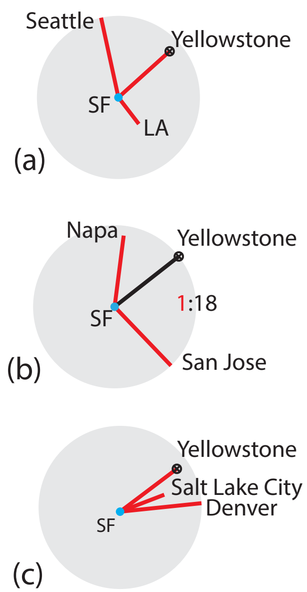

Figure 6: (a) Using supporting POIs to *extrapolate* an unknown POI (Yellowstone). (b–c) Two alternatives: (b) Emphasizes nearby POIs (mixed-scale representation); (c) Emphasizes POIs close to Yellowstone.

terpolate and extrapolate a POI based on other POIs. The study uses the prototype application described earlier, running on a desktop computer (task 1), a smartphone (task 2–3) and an emulated smartwatch (task 4–5). Figure 7 shows the setup of task 4–5.

26 participants (13 female) were recruited for a single-session (one hour) experiment. P-Compass performed better for task 2–5, while Wedge performed better for task 1, especially for close POIs. Participants also expressed strong preferences for P-Compass for task 2–5.

Design Recommendations

Our analysis and study reveal that P-Compass and Wedge complement each other. Wedge's strength, which is P-Compass's weakness, is to place an off-screen POI at its absolute location. However, the need to locate an off-screen POI makes it difficult to perform certain inference tasks, which are better carried out with P-Compass. In addition, as the distance to an off-screen POI increases, and/or the size of a display decreases, the benefits of P-Compass eventually outweigh those of Wedge.

We therefore make the following design recommendations: 1) Replace a compass with a P-Compass; 2) Use P-Compass for distant off-screen POIs; 3) Use Wedge for nearby off-screen POIs; 4) Take display size into account, since Wedge's effective zone gets smaller as display area decreases; 5) Give users control–depending on preferences and tasks, a user may want to manually choose one visualization technique over another.

Conclusion

This paper makes the following contributions: 1) P-Compass, a compact graphical location indicator designed to address the "Where is x?" problem; 2) An analysis of P-Compass and Wedge; 3) A formal user study comparing these two approaches with tasks derived from our field experience, showing the advantages of P-Compass for inference tasks; and 4) Recommendations to designers, based on our analysis and study results. A P-Compass can be integrated into a map or accompany visual content. As an extreme example, the standalone P-Compass in Figure 1(i) can even be directly embedded into text, much like an inline equation: [Seattle; SF; Yellowstone; Chicago].

Figure 7: Setup for the tasks using an emulated smartwacth.

We believe P-Compass is an important step toward realizing a visualization technique we term *spacepiece*, which could answer "Where is x?" with a single glance, much how a *timepiece* answers "What time is it?"

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