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HaloDot: Visualization of the Relevance of Off-Screen Objects

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ABSTRACT

The increasing usage of maps on mobile devices reinforce the need to solve some visualization and usability issues that constraint the user's interaction with information visualization applications.

When exploring map information on a small screen device, the points of interest are often located off-screen. Despite the existence of several techniques for the visualization of off-screen objects, most of them use representations to indicate the direction and/or the distance towards these objects but none of them represent their relevance.

This paper describes the work in progress to achieve a visualization that provides clues about the relevance of off-screen objects.

Categories and Subject: H.5.2 [Information Interfaces and Presentation]: User Interfaces – Graphical user interfaces. I.3.6 [Computer Graphics]: Methodology and Techniques – Interaction techniques.

1. Introduction

Presenting and exploring large amounts of graphical data (for example, maps) on small screens are key research topics. In scenarios that involve searching of points of interest (PoI) in large maps in mobile devices, pan and zoom techniques can be used to explore surrounding areas that are not visible on screen. However, these techniques are cognitively complex and frequently disorient the user. To mitigate this problem it is important to have solutions that give visual clues to off-screen objects.

Several approaches have been proposed to overcome the problem of visualization of maps on small screens. They can be classified into Focus&Context and Overview&Detail techniques [BCG06]. Although the capacity of these techniques to provide an overview of the whole space, they present some disadvantages to provide clues about the location of off-screen objects [BCG06]. The techniques that are explicitly proposed for visualization of off-screen objects use graphical representations such as lines, arcs or arrows designed along the borders of the visible area to convey information about the distance and direction of off-screen objects [ZMG*03, BR03, GI07, GBC*08].

Another important research topic in mobile visualization is the development of mechanisms to show the most relevant information to the user reducing the amount of information shown. The relevance in a mobile context should capture not only the location of an object (e.g. distance and direction) but also other contextual factors, such as temporal constraints and properties or attributes of an object. Our approach to relevance is based on the basic assumption that as the distance decreases in any relevance dimension (e.g., spatial, temporal, and properties) the relevance of the object increases.

One way to reduce the information displayed is using filtering techniques that determine the relevance of each object and use this information to exclude the less relevant ones. The research approaches in this topic aim to establish an appropriate distance function that integrate several contextual factors beyond the location, namely semantic and temporal relevance [SRR*08, PCA09].

Let's imagine the following scenario: a user A standing in the center of the visible area of Figure 1 wants to find restaurants but with preference to Italian ones. Suppose that the result is the off-screen restaurant 1 and 2. Although, objects 1 and 2 are equidistant from the user, the object 1 is more relevant than 2, because the former is an Italian restaurant. For instance, if the application uses the Halo[BR03] technique to give awareness of off-screen objects the user cannot distinguish the most relevant object.

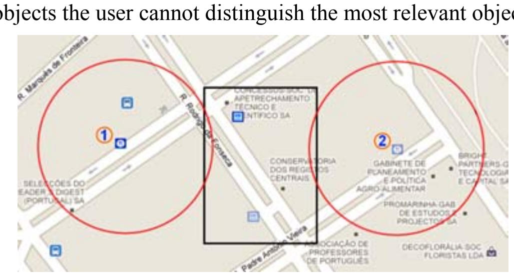


Figure 1: *The role of relevance for a user.*

The objective of our work is to enrich off-screen visualization techniques, taking into account the relevance of off-screen objects. The aim is to help users to find relevant information surrounding the area that is displayed on the screen. In this paper, we present HaloDot that enrich the Halo visualization technique with visual clues that express the relevance of off-screen objects.

This paper is organized as follows. Section 2 describes related work in off-screen visualization techniques and relevance visualization. Section 3 present the work in progress using the Halo technique, explaining some of the stages and decisions we have been through. Finally, section 4 points out our future work.

2. Related Work

The HaloDot visualization is related to off-screen visualization techniques and with the representation of relevance.

2.1 Off-Screen Visualization Techniques

Although some people are used with pan and zoom operations to find off-screen objects, in a mobile context, this kind of interaction may be time consuming when there is no clue about the location of off-screen objects.

The basic example of an off-screen object indicator is a simple arrow that is extensively used in video games, virtual environments and navigational tools, where they help the user to find objects or places [GBC*08]. These arrows are placed on the borders of the screen pointing at the direction of the off-screen objects. Similar to this technique, City Lights [ZMG*03] consists in drawing small lines at the border of the display, also at the direction of the off-screen objects. Unlike the arrow-based techniques, it also conveys the size of the off-screen object and offers an abstract and coarse representation of object distance by giving lines of two colors, each representing a specific distance range.

Baudish [BR03] introduces a variation of the City Lights technique, called Halo, which consists in surrounding the off-screen objects with rings that are just large enough to reach into the border region of the visible area. Based on the visible portion of the ring, users can infer the location and the direction of the object at the center of the ring based on the arc position and arc curvature (Figure 2(a)).

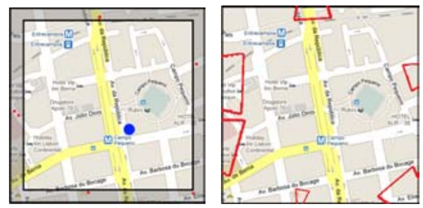
Burigat *et al.* [BCG06] compared the Halo with Scaled (Figure 2(b)) and Stretched Arrows (Figure 2(c)). These arrow-based techniques follow the same ideas as the previously mentioned, with the difference that their scale and length, respectively, grow as the distance between the off-screen point and the on-screen region increases. The study shows that Halo and arrow-based techniques do not differ substantially in simple spatial tasks, such as finding the nearest off-screen object but differ in order, estimate and locate tasks [BCG06].

EdgeRadar [GI07] is an extension of City Lights by improving its notion of distance. EdgeRadar creates a small overlay region on all four edges of the screen to represent the off-screen space. It represents distances by compressing them proportionally into the border. This technique was shown to be useful for visualization of off-screen moving targets (Figure 3(a)).

Gustafson [GBC*08] presented Wedge, which represents each off-screen object with an acute isosceles triangle with the tip located at the off-screen object, while the other two corners are located on-screen (Figure 3(b)). Unlike all the previous techniques, it provides three degrees of freedom; a Wedge can change its rotation, its intrusion into the users screen and the angle of the triangle, and still point to the same off-screen object.

(a) (b) (c)

Figure 2: *Halo (a), Scaled Arrows (b) and Stretched Arrows (c).*



(a) (b)

Figure 3: *EdgeRadar (a) and Wedge(b).*

2.2 Visualization of Relevance

The concept of relevance and how to represent it has also been subject of various research studies.

In mobile environments it is not enough to select or filter the most relevant but it is essential that the filtered objects properly symbolized the relevance values of the objects [Rei07]. Reichenbacher argues that these visualized differences in relevance can lead with more usable mobile maps applications. He has proposed some concepts for relevance in mobile maps and suggested some practices to represent and measure the relevance of the regions and objects of a map, such as, the more visible an object is the more relevant it tends to be, the possibility to use "warm" colors, like red and orange, to represent more relevant spots, while the less relevant ones would be represented with "colder" colors. Such fact is also mentioned in [SSM11], that states that colors can be used to represent various meanings, one of them temperature (warm = red, cold = blue).

Although color seems to be an important attribute that guides people's attention, Wolfe J.M [WH04] identifies others. The results were grouped into five categories according with the probability of successfully guiding the users' attention. Color, Motion, Orientation and Size were identified as the ones with a better chance of success.

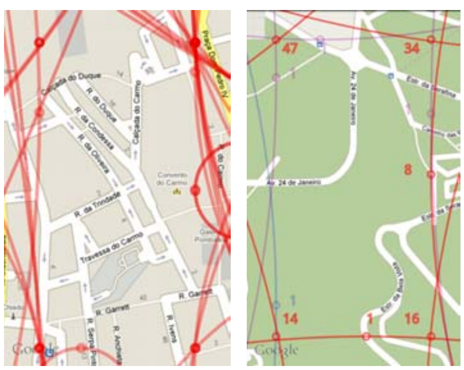
In the initial phase of our work, we observed that none of the visualization techniques of off-screen objects conveys the relevance of the off-screen objects. We aim to provide visual clues (based on color and transparency attributes) to convey information about the relevance and the distance of off-screen objects, i.e., the distance it takes for the representation of the PoI being visible on-screen. We started our work using Halo technique and a function that returns a value of the relevance of a PoI belonging to [0, 1]. The value of the relevance of each PoI, is calculated according with the user preferences and his geographic position [PCA09]. This means that the relevance takes in account the distance between the user and the PoI, which is different from the distance represented by the Halo's arc.

3. Work in Progress

Our goal is to provide visual clues that express the relevance of off-screen objects.

Taking into account the features of the techniques already used to visualize the location of off-screen objects, we have decided to begin our study using Halo. Unlike simple arrow techniques, Halo gives insight of the distance to the off-screen objects. Although the circles may overlap, the same problem occurs with Scaled as Stretched Arrows, when many points of interest are close together, getting worse if they are too far away, since larger symbols will be displayed.

To give additional information to the user, about the direction of the off-screen object, we have drawn the arc of the Halo with a small circle at the point of intersection between the Halo's arc and the intrusion border, i.e., the inner limit of the area where the Halos are visible. This approach combines Halo with the direction provided in City Lights technique. We named this small variation, HaloDot (Figure 4(a)).



(a) (b)

Figure 4: *HaloDot (a); HaloDot with number clues (b).*

To express relevance, we have chosen the graphical attributes color and transparency. Figure 5 applies this approach to the scenario presented in the introduction. The most relevant object is represented with the red HaloDot and the less relevant is represented with a blue and more transparent HaloDot.

Figure 5: *HaloDot applied to the scenario of Figure 1.*

To reduce cluttering in the intrusion border, we propose the aggregation of the halos. Next we explain these approaches.

3.1 Color

Color is a powerful attribute that guides people's attention; therefore, we use it to represent the relevance of each object. Using a "warm-cold" analogy [SSM11] [Rei07], we decided to color the most "relevant HaloDots" with red (hot) and the less relevant with blue (cold); the objects with an intermediate relevance were colored with purple, since it combines both colors (Figure 6).

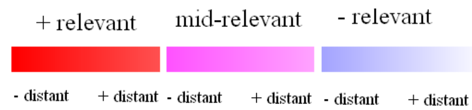


Figure 6: *Color and transparency to express relevance and distance.*

3.2 Transparency

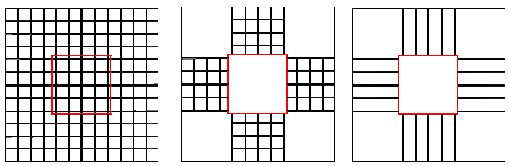
The original Halo uses transparency to deal with distance [BR03], the further an object is the more transparent the Halo will be. We decided to apply a minimum transparency level, so even objects that are too far away still have a visible HaloDot (Figure 6).

Assuming that the more visible, the more relevant an object is [Rei07], if the transparency level was selected only based in the distance of the off-screen object to the visible area, there would be the risk that, if a relevant (red) object off-screen was further away than a less relevant (blue) one, the second HaloDot's arc would be more visible. This could induce the user to pick the wrong object. To avoid this, the transparency level is also dependent on the object's relevance. An interval of minimum and maximum transparency is set according with the object's color, that is, with its relevance. This way, a relevant object will always have a more visible HaloDot than a less relevant one.

3.3 Aggregation

One of the Halo's problems is that it becomes hard to understand when overlapped by others [BR03, BCG06, GBC*08], especially if the Halos are at the corners of the display. Although this problem is minimized with HaloDot, when the number of Halos is too big, the visualization is still difficult. In resemblance of what is done with on-screen symbols, we decided to merge the HaloDots: a HaloDot represents a region of interest, i.e., a region with one or more points of interest. To achieve this, we consider a hypothetical grid overlaying the map, based on geographic, not screen, coordinates, which divides the space into cells (Figure 7(a)). When two or more points are inside the same cell, only one HaloDot will be drawn. This means that, in the worst case, we will have as many HaloDots as cells. The relevance (color and transparency) shown by a HaloDot corresponds to the most relevant object it represents.

After this change, the overlap at the corners was still a problem. In analogy with EdgeRadar, where the corners represent a larger off-screen area than the borders [GI07], we decided to just draw one HaloDot per corner. Although this means that the HaloDots at the corners represent more points, since they correspond to bigger cells (Figure 7(b)), and that the aggregations may change by panning the map, we believe that this will improve the technique, since it greatly reduces the overlap and the intrusiveness of the HaloDot, therefore, improving interaction.



(a) (b) (c)

Figure 7: *(Red Square= on-screen space). The hypothetical cells (a). Larger cells at the corners (b). Aggregation of orthogonally arranged cells (c).*

Even with this merging, there is the risk that some HaloDots have centers with a close latitude or longitude, meaning they can overlap the HaloDots and their textual information. To solve this problem we have considered two approaches: to aggregate all HaloDots that are in cells arranged orthogonally to the borders (Figure 7(c)) or to aggregate the HaloDots that have their intersection points too close.

Another problem is to set the center of the aggregated HaloDot. So far, we have developed two options, the center being the midpoint of the points represented or the most relevant point. While the first may be more intuitive, the second guides the user's attention to the most relevant points of his search, and still not hiding information about the others.

3.4 Number

After merging HaloDots, we got a new problem: how to show the amount of points each HaloDot represents. We have tried changing the thickness of the arc and/or point of intersection, depending on the number of points represented, but it ended up being very intrusive, even incomprehensible. Another solution is to give textual information, near the point of intersection with the intrusion border, about the number of off-screen objects it represents (Figure 4(b)).

3.5 Usability Planning

The next step of our project is to understand if the implemented features of this Halo variant are perceptible to the user.

For that, we will ask the users to perform some tasks to test those features. These tasks consist on finding a certain number of points-of-interest located off-screen, on different scenarios and with different requirements. By asking the user to find some points located off-screen, we expect the user to get used with the Halo technique and then to see if he understands that one HaloDot may represent more than one point. By asking the user to find the most relevant points, we want to see if the user is well guided by the HaloDot's color and transparency. And finally, by increasing the number of points on the map and change the various configurations of the HaloDot (type of aggregation or center of the Halo used) we expect to understand the user's preferences.

4. Conclusions and Future Work

In this paper we presented the work in progress about the color and transparency-based visual representation of the relevance of off-screen objects. We have also enriched the Halo technique to emphasize the direction of the off-screen objects. Moreover, we have used aggregation to avoid cluttered images.

The next step of this work is to perform user usability tests to access the proposed approaches. We want to go a step forward and make a more extended and precise comparison with other variations of the off-screen objects representations (e.g. arrows, lines) and relevance hints. This will enable to understand and how to optimize them to represent relevance of off-screen objects.

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