Egocentric Space-Distorting Visualizations for Rapid Environment Exploration in Mobile Mixed Reality

[1]Christian Sandor* [1]Andrew Cunningham† [1]Ulrich Eck‡ [1]Donald Urquhart§ [1]Graeme Jarvis¶
[1]Arindam Dey‖ [1]Sebastien Barbier** [1]Michael R. Marner†† [2]Sang Rhee‡‡

[1]University of South Australia
Wearable Computer Laboratory

[2]Kyungnam University
Department of Computer Science and Engineering

(a) (b) (c) (d)

Figure 1: In our mobile mixed reality system, we enable users to rapidly grasp the location of points of interest that are outside their field of view by using our Radial Distort visualization. (a-c) show three frames of the animated visualization. (d) shows a schematic view of the final image of our animation.

Abstract

Throughout the last decade, mobile information browsing has become a widely-adopted practice. Most of today's mobile internet devices contain facilities to display maps of the user's surroundings with points of interest embedded into the map. Other researchers have already explored complementary, egocentric visualizations of these points of interest using mobile mixed reality. However, it is challenging to display off-screen or occluded points of interest. We have designed and implemented space-distorting visualizations to address these situations. Based on the informal user feedback that we have gathered, we have performed several iterations on our visualizations. We hope that our initial results can inspire other researchers to also investigate space-distorting visualizations for mixed and augmented reality.

Index Terms: H.5.1. [Information Interfaces and Presentation]: Multimedia Information Systems—[Artificial, augmented and virtual realities] I.3.6 [Computer Graphics]: Methodology and Techniques—[Interaction Techniques]

*christian@sandor.com
†andrew.cunningham@unisa.edu.au
‡ueck@net-labs.de
§swiftless@gmail.com
¶fanged@gmail.com
‖Arindam.Dey@postgrads.unisa.edu.au
**sebastien.b@rbier.com
††marnermr@cs.unisa.edu.au
‡‡syrhee@kyungnam.ac.kr

1 Introduction

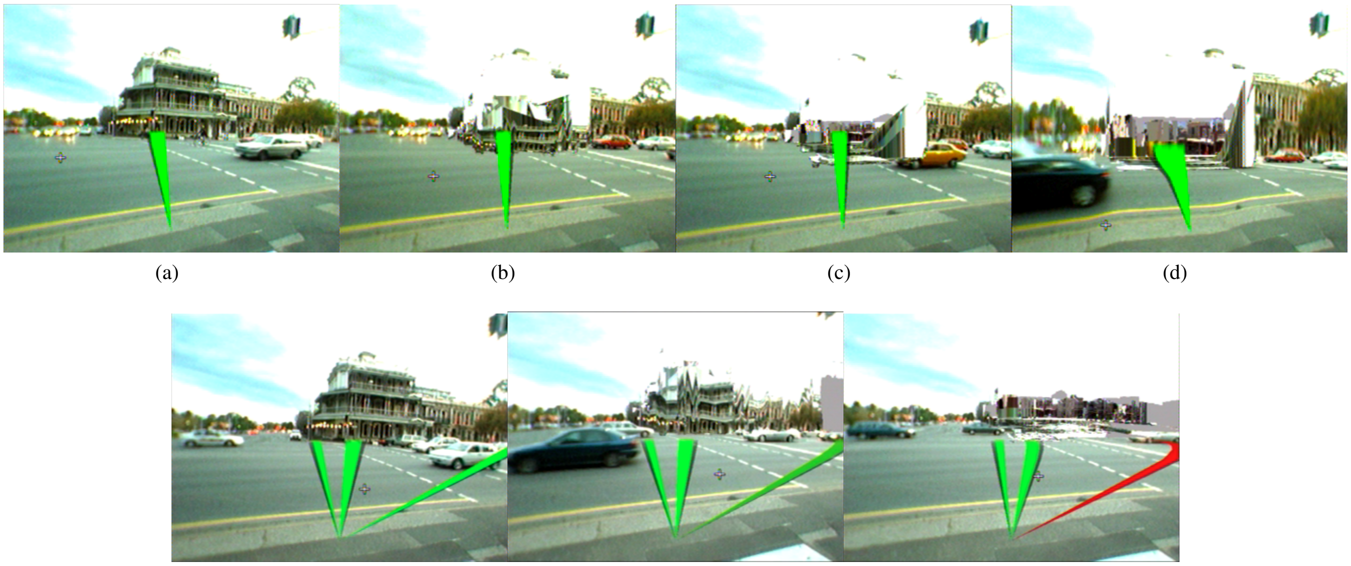
Most of today's mobile internet devices contain facilities to search the user's immediate environment. The search results are then displayed on a map. In the following, we will refer to these search results as *points of interest*. Several research projects have aimed to provide more intuitive visualizations by using augmented reality to overlay points of interest on a video image of the real world. In one recent example presented by Nokia [5], users can use their mobile phone as a magic lens on the environment. This type of egocentric information display provides perceptual advantages that allow users to grasp spatial relations faster than compared to an exocentric map display [6].

Egocentric visualizations, however, introduce several new challenges; how to display points of interest that are, 1) behind the user, 2) outside of the user's field of view, or 3) occluded by real-world objects. Our research embodies an initial exploration of a class of visualizations to tackle these problems: space distorting visualizations. To show points of interest outside of the user's field of view, we employ a technique we call *Radial Distort* (Figure 1). To show occluded points of interest, we combine two techniques: first, we *Melt* the occluding objects, then we use a *Fisheye* to magnify points of interest (Figure 2 (a-d)). In case of points of interests that are both occluded and outside of the user's field of view, we combine all techniques (Figure 2 (e-g)). Finally, to make our visualizations more understandable for users, we provide cues about distortions through bending *Rays*.

In order to explore our distortion-based visualizations, we had to create a textured 3D model of the user's environment. We have successfully implemented an automatic pipeline for textured 3D model reconstruction of the environment we were running our experiments in: the city center of Adelaide, South Australia.

2 Related Work and Contribution

The contribution of this paper is the identification of the usefulness of egocentric space-distorting visualizations for mobile mixed



(a) (b) (c) (d)

(e) (f) (g)

Figure 2: (a-d): Occluded locations can be observed by our Melt visualization: the occluding geometry is flattened while projecting the video onto it (a-c). Finally, a fisheye magnifies the occluded location(d). (e-g): Locations that are occluded and off-screen are displayed to the user by combining Radial Distort, Melt, and Fisheye.

reality through the implementation of three visualizations (Radial Distort, Melt, Fisheye) and a unifying distortion cue (Rays). While similar techniques have been investigated in completely virtual environments [4], this concept has not been explored in detail for augmented and mixed reality. However it is a standard technique in information visualization [1]. While we consider our visualizations to be useful by themselves, we believe that there are many more space-distorting visualizations to be explored.

The problem that our Radial Distort visualization addresses has already been investigated by Bell et. al [3]. Compared to their approach (using arrows that point to off-screen points of interest), the Radial Distort visualization conveys more environmental contextual information to the user. Our Melt+Fisheye visualization significantly improves our previously developed x-ray system [2], which relied on an edge-detection of the video image. While this worked well in some cases, it did not work in situations where the video image did not contain clear edges. Melt+Fisheye has no such restriction.

3 Evaluation

After completing an initial prototype of our visualizations, we tested and refined them for ten days in the streets of Adelaide. We have shown our visualizations repeatedly to pedestrians that happened to be near our experiments. Based on their feedback, we have made two important additions to our initial prototype.

First, we added the Fisheye visualization, which was not included in our initial prototype. Users had complained that the locations revealed by the Melt visualization were difficult to see when points of interest were given a relatively small amount of screen real-estate (i.e., when they were far away). The Fisheye helped to ameliorate this problem.

Second, we added Rays to our initial prototype. Although computer science researchers can easily grasp space-distorting visualizations, non-computer scientists often find them confusing. After adding rays which bend and flow with the distortion, users could better grasp our space-distortions after a brief explanation.

4 Conclusions and Future Work

We have presented our initial explorations of space-distorting visualization for mobile mixed reality. We have identified several points for future work, most importantly to conduct a formal evaluation of our visualization techniques. As a prerequisite, we have to improve the tracking accuracy of our prototype, which currently consists of rotational input provided by an InterSense InertiaCube3, and hardcoded positions. We are currently working on an edge-based tracker in order to provide pixel-accurate augmentations.

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