EyeSeeX: Visualization of Out-of-View Objects on Small Field-of-View Augmented and Virtual Reality Devices

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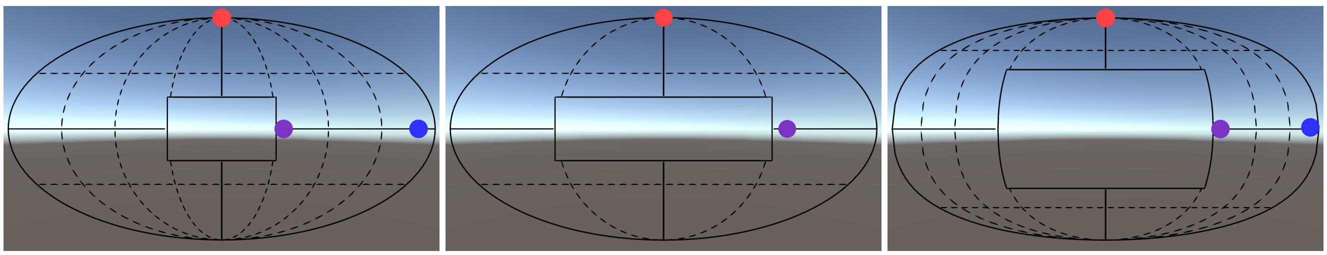

(a) *EyeSee360 [1] visualizing three objects.* (b) *EyeSeeX (strategy I: reducing information).* (c) *EyeSeeX (strategy II: compressing information).*

Figure 1: **EyeSee360 and EyeSeeX (all are visualizing the same three out-of-view objects).** ***Best seen in color.***

ABSTRACT

Recent advances in Virtual and Augmented Reality technology enable a variety of new applications (e.g., multi-player games in real environments). However, current devices suffer from having small fields of view, making the process of locating spatially distributed digital content similar to looking through a keyhole. In this work, we present *EyeSeeX* as a technique for visualizing out-of-view objects with head-mounted devices. *EyeSeeX* improves upon our previously developed technique *EyeSee360* for small field-of-view (FOV) devices. To do so, *EyeSeeX* proposes two strategies: (1) reducing the visualized field and (2) compressing the presented information. Further, *EyeSeeX* supports video and optical see-through Augmented Reality, Mixed Reality, and Virtual Reality devices.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g., HCI): Miscellaneous

Author Keywords

Out-of-view; head-mounted; augmented reality; virtual reality; hololens; off-screen; visualization technique

INTRODUCTION

Over the past few years, head-mounted Virtual Reality (VR) and Augmented Reality (AR) devices have been steadily advancing from a technological point of view. Although the technology is improving, current devices still suffer from having small fields of view (e.g., Microsoft HoloLens). This is a problem when it comes to locating spatially distributed digital content. In previous work, different visualization techniques have been developed to overcome this problem (e.g., *EyeSee360* [1]). However, no technique was specifically developed for small field-of-view devices. In this work, we present *EyeSeeX*, a technique for visualizing the 3D position of out-of-view objects. *EyeSeeX* is based on *EyeSee360*. However, *EyeSee360* adds clutter for devices with smaller fields of view. Therefore, *EyeSeeX* proposes two different strategies to avoid visual clutter: (1) reducing the visualized environment (e.g., 180° instead of 360°) and (2) compressing the presented information. Both strategies are presented in this work. Furthermore, we added support for Virtual Reality. Thereby, *EyeSeeX* supports video and optical see-through Augmented Reality, Mixed Reality, and Virtual Reality devices.

EYESEE360

EyeSee360 is a technique for visualizing the 3D positions of objects located in the user's periphery, outside their field of view. Figure 1a shows how *EyeSee360* appears. *EyeSee360* concentrates information about out-of-view objects onto a grid system in the user's periphery similarly to EdgeRadar, which served as an inspiration for the technique [3]. This grid system compresses 3D position information onto a single 2D plane. The inner rectangle of *EyeSee360* represents the user's FOV, and the area outside the rectangle represents the area outside of the user's view. Each dotted line represents a 45° section of the user's view. The horizontal line indicates the altitude of the object, while the vertical curved lines point to the horizontal direction of the object. For example, the red dot (called proxy) in Figure 1a represents an out-of-view object that is exactly

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90° above the user, while the purple proxy represents an object that is about 45° to the right of the user. The color of the proxy illustrates the distance of the object. It is based on a color gradient from red to blue, in which red means the out-of-view object is close and blue means it is far away.

NON-CLUTTER STRATEGIES

EyeSee360 adds visual clutter to the screen, especially for small field-of-view devices. The inner rectangular area represents the device's field of view, leaving the center of the screen uncluttered. However, the size of this area is predefined by the device's field of view, which is problematic when the field of view is rather small. Therefore, we try to improve this by implementing two strategies to increase the size of the inner area.

Strategy I: Reducing Information

The first strategy is to reduce the amount of information being displayed. Therefore, we reduce the amount of space in which out-of-view objects will be visualized. In Figure 1b we reduced this space from 360° to 180° , doubling the size of the inner area. This strategy is helpful in scenarios in which it is not necessary to visualize objects behind the user (e.g., while driving a car towards a crossing). However, in many scenarios it is not possible to reduce the visualized space.

Strategy II: Compressing Information

The second strategy is to compress the information in the periphery. This may negatively affect the accuracy of users' estimations regarding the positions of out-of-view objects, or it could increase the time necessary to find an out-of-view object. However, it increases the focus area and removes clutter from the screen (see Figure 1c). In *EyeSeeX* we support three different kinds of compression that can be applied to each axis individually or both at the same time (x-axis and/or y-axis):

None This is the default setting. The visualization technique does not compress any information for the axis on which this is applied.

Root A root-function is used for compression. Thereby, the inner area is increased and information about out-of-view objects is more compressed towards the borders. The degree of this compression can be specified by manipulating the root-function. For example, in Figure 1c we used a square-root function, but it is also possible to choose different root-functions.

Maximum This compresses the axis by compressing everything onto a single point. For example, if this compression is applied to the y-Axis, a line on the x-Axis will remain. Thereby, the technique is still able to visualize 360°around the user, but without height information. This is useful for many scenarios in which objects are placed on a ground level and no height information is required.

SUPPORT FOR DIFFERENT REALITIES

Originally, *EyeSee360* was developed and tested for video see-through Augmented Reality [1]. This technology was used first because it allowed us to develop a quick and low-cost solution. However, video see-through Augmented Reality devices suffer from a delayed looped camera image and decrease the human field of view. Therefore, *EyeSee360* was adapted to optical see-through Augmented Reality in a next iteration [2]. With this work, we introduce *EyeSeeX*, which adds support for Virtual Reality. Thereby, *EyeSeeX* supports video and optical see-through Augmented Reality, Mixed Reality, and Virtual Reality. Our development was done in Unity and our implementation is available under an Open Source license[1].

FUTURE WORK

In future work, we want to evaluate the compression of *EyeSeeX* for Virtual and Augmented Reality. It seems clear that the compression negatively affects users' position estimations. However, we want to evaluate how much it affects the position estimation and whether it has a negative effect on search time. Furthermore, *EyeSee360* was developed and tested for video see-through Augmented Reality. Therefore, we want to evaluate the improved version, *EyeSeeX*, for optical see-through Augmented and Virtual Reality.

DEMONSTRATION

For the demonstration at the conference we plan to show *EyeSeeX* on a Hololens device. We will place several out-of-view objects in the virtual environments. The audience will be able to test *EyeSeeX* with and without compression themselves by finding the virtual objects in the environment with the Hololens.

CONCLUSION

In this work we presented *EyeSeeX*, an improved visualization technique based on *EyeSee360*. *EyeSeeX* proposes two strategies for reducing visual clutter on devices with small fields of view, and supports various different realities.

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[1] https://github.com/UweGruenefeld/OutOfView