Virtual Lenses for Immersive Analytics

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ABSTRACT

Immersive analytics is an emerging research area that aims at exploiting the advantages of virtual environments for effective data analysis. Although interactive lenses have proven to be useful tools for supporting a variety of analytic tasks, only little research has addressed the development of lenses in the context of immersive analytics. In this work, we present first results of our work on lenses for immersive data analysis, where our focus is primarily on lens interaction. We implemented our ideas for the Oculus Rift and applied them for supporting the visual analysis of 3D sonar data.

Index Terms: Human-centered computing—Visualization—Visualization techniques—Treemaps; Human-centered computing—Visualization—Visualization design and evaluation methods

1 INTRODUCTION

Immersive analytics aims at providing multi-sensory interfaces that allow users to immerse themselves in their data [7]. Such an immersion has great potential to provide higher user engagement, more conscious experiences, and more seamless workflows in comparison to traditional desktop environments [3, 7]. This may ultimately lead to a more effective analysis, especially when the primary dimensions of the data are spatial [1].

In this work, we address the use of virtual lenses for data analysis purposes. A lens is an interactive tool that shows an alternative representation of a selected part of the world. Lenses have been applied to a variety of analysis tasks on different types of data [2]. Virtual environments provide the opportunity to enhance the lens metaphor by representing lenses as virtual and graspable tools that can be interacted with in a more direct and natural way [4, 6]. Our goal is to bring the benefit of lenses to bear in the context of immersive virtual data analysis environments. In the following, we describe preliminary results of our ongoing work in this new field of visual data analysis research.

2 LENSES AS VIRTUAL TOOLS

There are two aspects to be considered when developing lenses for immersive analytics. First, how should the lens and its effect be displayed in the virtual environment? Second, how should the lens be interacted with utilizing the modalities of the virtual environment?

2.1 Display

Following the classic lens metaphor, we decided to represent the virtual lenses as 3D discs that can be positioned and oriented freely in the environment. The lens interior shows an alternative view of the virtual world depending on the active lens effect. The lens ring serves as a delineation between the regular and the alternative view. As can be seen in Fig. 1, the virtual lens is not that different from traditional interactive lenses. Yet, the way one can interact with the lens will be different.

2.2 Interaction

Natural and direct interaction is one of the key aspects to provide a high degree of immersion. Thus, our aim was to make the lens interactions as natural as possible taking into account interaction costs, especially physical motion costs and the time needed to execute an action.

Lens creation and removal  In the first place, we need a means to create lenses when they are needed for a particular task and to take them away once the task has been accomplished. To keep the focus of the user on the data and to avoid clutter in the virtual world, interaction tools such as lenses can be stored in a kind of semantically structured toolbox that allows the user to add or remove certain tools to or from the virtual world on demand.

Figure 1: Using a virtual lens for looking into a 3D sonar dataset.

Figure 2: VR menu as a toolbox for lens creation and disposal.
As shown in Fig. 2, we implemented a radial VR menu in which lenses of different type are available. Small icons in the menu provide an visual indication of the different lens effects. To add an instance of a selected lens to the virtual world, it can be grabbed directly with the user’s virtual hands (e.g., by using the hand trigger of an Oculus Touch Controller or a grab gesture with a Leap Motion). Multiple instances of lenses can exist in the virtual world. When a lens is no longer needed, the user can simply grab the lens and put it back to the toolbox.

Lens manipulation and parameterization A key operation to be carried out with a lens is to select the part of the world for which an alternative view should be shown. To this end, the lens must be manipulated in various ways. Positioning and orienting the lens are straight forward in a virtual environment. The user simply grabs the lens disc and can manipulate it in six degrees of freedom as if dealing with a real-world object.

For resizing a lens, there is no real-world correspondence, because real-world objects are usually fixed in size. Yet, there is a quasi-standard gesture for resizing: the pinch gesture. We adapted this gesture to allow users to resize lenses as follows: Grab the lens with both hands and move the hands apart or bring them together in order upscale or downscale the lens size.

While manipulating a lens serves to select which part of the world should be shown differently, parameterizing a lens is important for specifying the alternative representation. We follow previous work and add 3D user interface controls directly to the lens ring. The controls enable the user to switch between a set of predefined lens effects and to adjust their parameters as needed. To minimize occlusion, the interface is kept compact and displayed only on demand.

For a more direct selection of the lens effect, it is also possible to show different alternatives on the front face and the back face of the lens [6]. Switching between the two effects is then as simple as flipping the lens in the virtual world.

Lens combination Lenses as see-through tools naturally lend themselves to combining their individual effects. Based on the idea of Viega et al. [5], we enable users to combine the effects of multiple lenses by grabbing and intersecting them much like combining camera lenses and filters in reality. Of course, this should be restricted to lenses where a combination leads to a meaningful and clear result. Fig. 3 illustrates an example where a lens showing a volume visualization of the data’s first derivative has been combined with a lens applying a maximum intensity projection.

Remote lens interaction All interactions introduced so far assume that the user is close to the lens. However, in a virtual world, this may not always be the case. The user may have moved away from the data in order to acquire an overview. The question now is how users can interact remotely with a lens that is not in their reach? Of course, one could walk up to the lens and grab it. However, this would be time-consuming and the user would lose the deliberately chosen point of view.

Addressing these issues, we integrated a technique for lens interaction from a distance which maintains the user’s point of view and is still based on direct interaction. The idea is to interact with lenses proxies, rather than with the remote lens. First, the user selects an out-of-reach lens via a selection beam (or through the toolbox). This triggers the animated appearance of a semi-transparent proxy of the lens in front of the user. The user can then interact with the proxy and all adjustments are automatically applied to the remote lens.

Interaction Feedback An important aspect for a high degree of immersion is multi-sensory feedback for user interactions. As this also applies for lens interaction, we provide haptic and acoustic feedback in addition to visual feedback. VR headsets such as the Oculus Rift with touch controllers provide the technical possibilities to do so.

3 APPLICATION EXAMPLE

The described lens techniques have been applied to support the analysis of 3D sonar data. The data was recorded with a sub-bottom profiler and contains measurements of the reflections of different materials in the water column and the seabed of a certain area in the Baltic sea. For the data collectors, it is of interest to examine local areas with high value changes (e.g., for analyzing structural anomalies) in context of the global distribution of reflection values (e.g., for detecting material layers in which an anomaly is located). To support these tasks, several alternative visual representations of the data are necessary, which provides a nice opportunity to apply our lens techniques.

As shown in Fig. 3, the base visualization is a direct volume rendering of the data. Lenses can be added to locally display a different representation. The figure shows two virtual lenses visualizing the maximum intensity projection and the first derivative. In their overlap, both effects are combined. Using the immersive lenses lead to the discovery of a buried wooden wreck in a material layer 0.5m below the seabed (bright structure inside lens overlap).

4 CONCLUSION

In this work, we presented first results on how such lenses can be implemented as virtual graspable 3D objects that can be interacted with in a natural way. We considered interaction techniques for creating, removing, positioning, orienting, and combining lenses. A proxy-based approach allows for interacting with lenses that are out of reach. To demonstrate the usefulness of our approach, we prepared an implementation for the Oculus Rift and applied it to support the analysis of a sonar volume dataset. We are convinced that interactive lenses for immersive analytics bear a great potential. For future work, we plan to extend and fine-tune our concepts, and to investigate lenses for collaborative data analysis.

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REFERENCES