Immersive Analytics with WebVR and Google Cardboard

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Abstract

We present our initial investigation of a low-cost, web-based virtual reality platform for immersive analytics, using a Google Cardboard, with a view of extending to other similar platforms such as Samsung's Gear VR. Our prototype uses standards-based emerging frameworks, such as WebVR and explores some the challenges faced by developers in building effective and informative immersive 3D visualizations, particularly those that attempt to resemble recent physical visualizations built in the community.

Index Terms: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual Reality; H.5.2 [Information Interfaces and Presentation]: User Interfaces—Graphical user interfaces

1 Introduction

Immersive Analytics (IA) is an emerging research domain that investigates the use of novel display and interface technologies in analytical reasoning and decision making [1]. IA builds upon paradigms such as virtual and mixed reality (VR/MR), natural interaction, touch interfaces and multisensory arrays, aiming to develop collaborative, interactive systems that enable users to be immersed in their data. VR, MR and in particular the latter's graphic-centric subdomain, Augmented Reality (AR), often focus on the realistic, graphical portrayal of physical objects. We believe that, much as VR and MR have been used in the past to display a building or a piece of furniture in situ, it can do so with physical representations of data. Recent research on data physicalization has elaborated on the potential and challenges of such visualizations [2].

Both physical and VR visualizations have their benefits. Physical representations can be observed, touched and handed from one participant to another, offering users a simple, yet natural interaction style. VR aspires to replicate and extend much of this natural, physical interaction through advanced interfaces. The user can be immersed in an environment where they can build data depictions to replicate physical objects, organise data spatially and inspect it from different angles, much like in the physical world. However, unlike physical visualizations, VR allows you to dynamically alter and manipulate data representations in ways that are not currently possible in the physical world, e.g., filtering, zooming or changing the depicted data without refabrication.

In this work we focus on replicating 3D physical visualizations, using emerging standards-based web technologies for VR. We focus on web technologies as we believe these work better in the data visualization ecosystem, compared to game engines often used in VR, such as Unity and Unreal. Our approach is to build our visualizations so that they closely resemble their physical counterparts, by including properties such as ambient lighting and natural shadows etc. We present our initial investigation of a WebVR-based platform for immersive analytics, using a Google Cardboard headset with a view to extend it to other similar platforms such as Samsung Gear VR and the Oculus Rift. For this preliminary investigation we have chosen to loosely replicate the 3D bar charts from [3] in VR.

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2 Background

Nowadays, developers and researchers are exploring how to move beyond the current WIMP interfaces and utilize the opportunities of multi-sensory input and output devices. In 2014 Donalek et al. [4] wrote about "Immersive and collaborative data visualization". In 2015 Chandler et al. [1] coined the term "Immersive Analytics", discussing usability and design issues of immersive environments intended for data analytics; early 2016 saw several workshops: Shonnan, IEEE VR and a Dagstuhl workshop, each on Immersive Analytics. Synergistic concepts such as beyond-the-desktop visualization [5] have also been discussed.

Donalek et al. [4] discuss iViz, a Unity3D-based data visualizer which attempts to address the lack of optimization for complex data in immersive worlds, such as OpenSim. iViz has full support for the Leap Motion controller and the Oculus Rift headset and allows multi-user collaborative data exploration. Masters of Pie explored ways in which they could visualize big data in VR (www.mastersofpie.com), rendering data points onto a spiral which arched over the user. They used handheld VR peripheral controllers to interact with the data, by changing the virtual dimension properties of both the spiral and data points.

Lu et al. [6] present a position paper on the current state of mobile immersive environments that are relevant to the field of big data and data visualization. Their paper is concerned with applications involving VR and MR with respect to the potential for IA and data visualization. They list many applications in many fields in which new VR and MR technologies could realise IA in industry and academia.

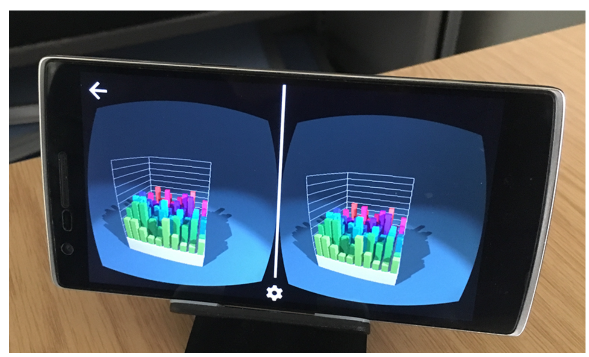

Figure 1: Example 3D scene rendered with the WebVR polyfill and Three.js, captured inside Google Chrome for Android displaying a 3D bar chart visualization.

3 Design and Implementation

Our current IA prototype is built using the WebVR polyfill (https://webvr.info/), a JavaScript implementation of the WebVR specification and Three.js. The use of web technologies removes common compatibility problems associated with cross-platform mobile application development. Unlike game engines, web technologies provide efficient mechanisms for loading complex data and allow better integration with contemporary tools in the visualization ecosystem. In addition, the web can be the least platform-dependant way for building and sharing visualizations [5].

The prototype renders a split screen, stereo version of a 3D scene when in use with a Cardboard viewer (see Figure 1). The user is positioned in the centre of a virtual world into which we can load data visualizations. Currently, we load different datasets in JSON format. Due to the lack of interaction input, at this stage, we rotate

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

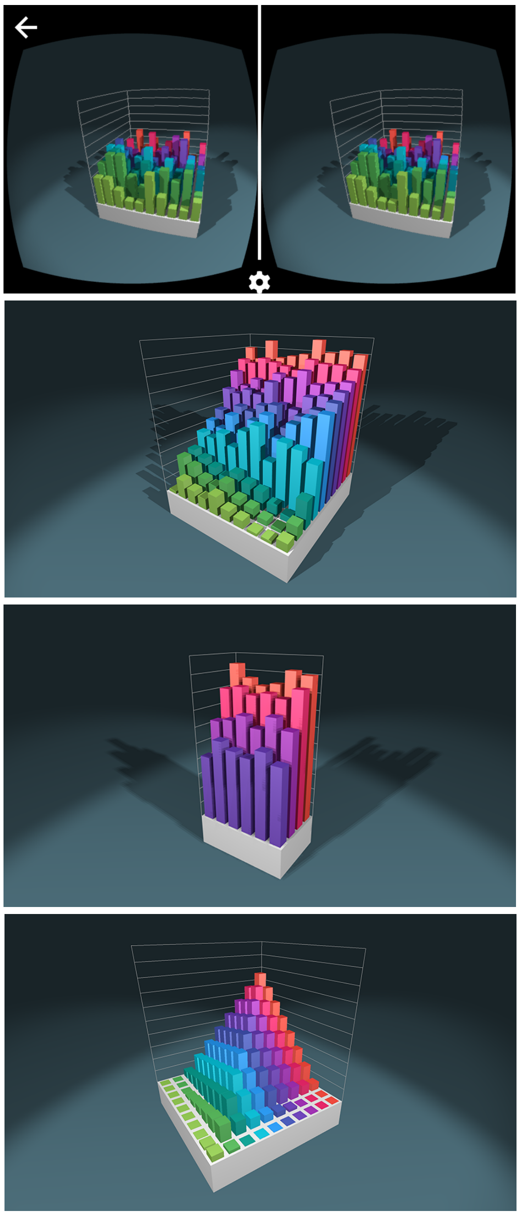

Figure 2: Image (a) shows the application in Cardboard mode on a mobile device with maximum quality effects. Image (b) shows the application in mono desktop view with high quality shadows, smooth lighting and full scene antialiasing. Running the visualization with these settings on a high end smart phone yields unsatisfactory frame rates. Image (c) exhibits low quality shadows, smooth lighting and full-scene antialiasing. It also demonstrates how data would be depicted if filtered. Rendering with these settings on a high end smartphone would yield a satisfactory frame rate of 60 frames per second. Image (d) exhibits smooth lighting only.

the visualization around the vertical axis for inspection. In addition, filtered data can be depicted by reducing the dimensions of the base-grid and axes, as shown in Figure 2(c).

Our system employs head tracking with 3 degrees of freedom (roll, pitch and yaw) for mobile browsers with Cardboard utilising a device's gyroscope. The scene can be also rendered on non-mobile, experimental builds of FireFox and Chrome, and viewed using an Oculus Rift. Viewing the scene on regular browsers renders a mono version of the scene with mouse controls. Using pure Three.js to render a stereo scene of the same visualization allowed us to maintain 60 frames per second, even with high quality effects. Although the frame rate was satisfactory, image crosstalk and a lack of lens distortion correction led to an uncomfortable viewing experience.

One approach to rectifying these issues was to use WebVR, on top of Three.js, gaining access to better support for alternative lens configurations for Google Cardboard and the Oculus Rift. However, the introduction of WebVR comes with a trade-off in performance, due to the complexity of additional rendering steps that the browser needs to go through. Whilst using the WebVR polyfill affects the frame rate of the application considerably when using high quality effects, such as shadows, full-scene antialiasing and smooth lighting, the image clarity is a vast improvement over the pure Three.js implementation.

In a heuristic evaluation, the overall experience of the WebVR version was deemed superior to the plain Three.js version. When using medium to low quality effects (see Figure 2) we can achieve a constant frame rate of 60 frames per second on high-end smart phones, for our ≈1000 polygon scene (≈500 per eye). Whilst there are currently trade-offs, application performance is expected to increase once WebVR is natively supported in mobile browsers.

4 Conclusion and Future Work

Motivated by the recent emergence of technologies such as WebVR and the Google Cardboard, we explore how they can be used for low-cost immersive analytics. In this work, we focused on recreating known physical visualization designs in VR, exploring the performance trade-offs between fast and realistic rendering. The use of WebVR shows promising results. As work in the development of WebVR is continuing, aspiring to bring native support for mobile and desktop browsers, we expect similar investigations to increase in number. Our next step is to investigate interaction and collaboration within the environment, as well as ways to easily load different datasets.

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