Dual-Mode User Interfaces for Web Based Interactive 3D Virtual Environments Using Three.js

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Abstract. 3D objects are now being embedded within HTML pages without the need for additional software, such as browser plug-ins. However, 2D and 3D web content are still typically treated as separate entities with limited interaction. Our research presents a working prototype implementation of a dual-mode user interface for interactive 3D environments. The developed interface allows the user to instantly switch between a traditional hypertext interface and an immersive 3D environment that incorporates 2D HTML elements. The results from an initial user study show that 2D and dual-mode interfaces allow for quicker retrieval of information than 3D websites alone and result in higher user satisfaction.

Keywords. Dual-Mode user interfaces, 3D web, Three.js

1 Introduction

Innovations in web technology (e.g. HTML5 and WebGL) are allowing for advanced 3D graphics to be integrated and rendered directly in a web page without the need for additional software, such as browser plug-ins. However, there are currently no standard approaches to effectively combining traditional 2D web content, such as text and images with interactive 3D environments. Furthermore, while 3D graphics provide a more immersive and richer user experience; they also have the potential to inhibit the user because they add additional user interface interactions. For example, 3D environments require a user to interact with content via a viewport and typically require a user to navigate to a location to retrieve information. This slows down a user's ability to complete common web tasks, such as retrieval of textual information. In this paper, we present a prototype implementation of a dual-mode approach to interface design for

* https://threejs.org/

adfa, p. 1, 2011.

information dissemination in interactive 3D environments using Three.js, a WebGL 3D graphics JavaScript library. A web-based interactive digital heritage application is created that allows a user to switch instantaneously between 2D and 3D user interfaces. We also present a user study to identify the initial effectiveness of the prototype.

2 Background and Related Work

Advanced 3D graphics are increasingly being used in web applications in a variety of areas [1], such as digital heritage [2, 3], surgical training and museum exhibitions. However, the use of interactive 3D web environments for web content is still limited, despite the availability of modern graphics hardware. A key reason for this limited use is the lack of integration between traditional 2D content and 3D environments [2,]. Often 3D applications, such as virtual museums focus on graphics, immersion, and interactivity rather than traditional web tasks such as the locating and viewing of information. Interactive 3D web environments need a more integrated approach to 3D and 2D content if they are to see greater adoption.

Seo, Yoo and Ko [1, 4] explore how 3D objects and 2D HTML elements can be more tightly integrated by having HTML elements exist within 3D space and associating them with the 3D objects they are referencing. Jankowski and Decker [5] propose a dual-mode user interface where a user can switch between a hypertext mode and a 3D mode at any time. The hypertext mode incorporates 3D objects alongside hypertext based interactions. The 3D mode adds hypertext annotations to a 3D scene. Their results show that the dual-mode user interface had the "best overall task performance" when compared to hypertext and 3D alone. However, while the dual-mode was rated the highest overall, the hypertext UI was rated "easier to learn" than the 3D UI and dual-mode UI. Participants also found that presentation and readability of text in the 3D UI was worse when compared to the dual-mode and hypertext UI. There were also improvements suggested by the testers, which included a preference towards a keyboard control system in addition to the mouse control system that was already in place. Searching for content was not available in the dual-mode UI, meaning that searching for content on a webpage, commonly performed by pressing Ctrl + F on a Windows PC, could not be performed and therefore slowed down the retrieval of data. Despite these limitations, the dual-mode user interface was the clear winner, both practically, aesthetically, and preferably [5].

3 System Description

The prototype system implements a digital heritage application in the form of a 1960s diner. The application allows a user to explore a recreation of a 1960s diner and objects that might be found in a diner of this era, such as a juke box and pinball machine. The prototype system was implemented using HTML5, CSS3, JavaScript and WebGL via the Three.js JavaScript library. Three applications were created, a "2D Website", which is a 'flat' web page, that contains 3D renders of the objects in the diner, as shown

in Figure 1 left. The second application, shown in Figure 1 right, is a "3D Website" implemented using Three.js. It contains a 3D diner that the user can explore and interact with specific objects. When the user is within the vicinity of an object 2D textual information is presented. Finally, a "Dual-Mode Website" was implemented which combines both the "2D Website" and "3D Website" together, enabling users to switch between the two websites by pressing the "2" and "3" keys on the keyboard, respectively. The dual-mode website has the added functionality of seamless transitions between modes.

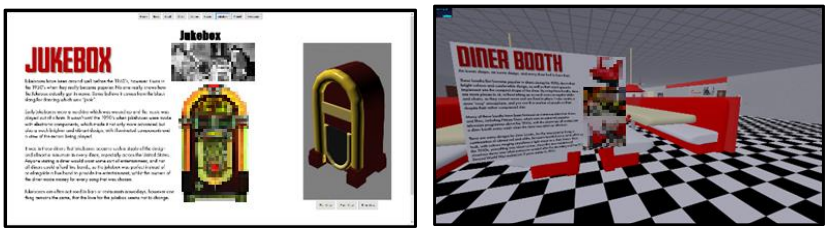

Fig 1: Left - "2D Website", which allows a user to select a tab at the top, and then learn about each component of the diner, complete with 3D rendered images. Right - "3D Website" which allows the user to interact with objects to display information.

4 Testing

The prototype testing focused on measuring the speed at which information could be retrieved using the three applications to assess the effectiveness of the user interface. In the 2D mode participants were required to retrieve the answer using standard hypertext and mouse click interactions. In the 3D interface participants had to navigate the 3D environment to retrieve information from information boards. In the dual-mode the user could switch between user interfaces at any point; however, the questions in the "Dual-Mode" encouraged the user to return to 3D mode to avoid them simply staying in the 2D mode. Each question was timed from the moment the user made interaction with the application after reading the question and the timer was stopped the moment the participant finished writing their answer. Once the speed tests were complete, participants were asked to fill out a questionnaire which would measure their satisfaction with each application and how much they agreed with a series of statements on a Likert Scale that targeted the user interface, the aesthetics, the performance, the ease at which information could be retrieved and the simplicity of switching modes. To test the prototype, we recruited 11 participants. Each participant was given a brief description of the experiment, a consent form, and a short pre-study questionnaire before the testing to establish the participants' profile. Following the testing participants were given a post-study questionnaire. The questionnaire asked each participant to state how much they agreed with statements relating to the user interface, the ease at which information could be obtained, how aesthetically pleasing the applications were and the website's

performance. The ratings are calculated by scoring a 1 for “Strongly Disagree”, 2 for “Disagree”, 3 for “Neutral, 4 for “Agree” and 5 for “Strongly Disagree”.

The results from the prototype testing indicate that the 2D website achieved the highest rating for the user interface, with the dual-mode website only one point lower. The ease at which information could be found was rated the highest on the dual-mode website, with the 2D website close behind. The 3D website was regarded as the most aesthetically pleasing and the 2D Website was considered to have the best performance. These results will inform the progression of the research and development process. It was clear that both the 2D and dual-mode websites were close in every test, as well as the feedback that was given about them, and it was made apparent that the 3D website lacked in all but one area, obtaining lower satisfaction ratings, as well as lower speed test times. These findings are comparable to the research by Jankowski and Decker [5], who identified that their dual-mode applications are easier and more efficient than 2D or 3D interfaces alone [5].

5 Conclusions and Future Work

We have presented a dual-mode user interface to enhance user interaction with web content when presented in conjunction with 3D virtual environments. This pilot study has shown the promise of dual-mode interfaces for 3D virtual environments. Future work will improve the dual-mode interface by integrating the 3D view more closely with the 2D view and expand the 2D annotations within the 3D content. We will also expand the scope of the study to fully assess the merits of dual-mode interfaces.

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