A Tool for Extending Mixed Reality Space from Web2D Visualization Anywhere

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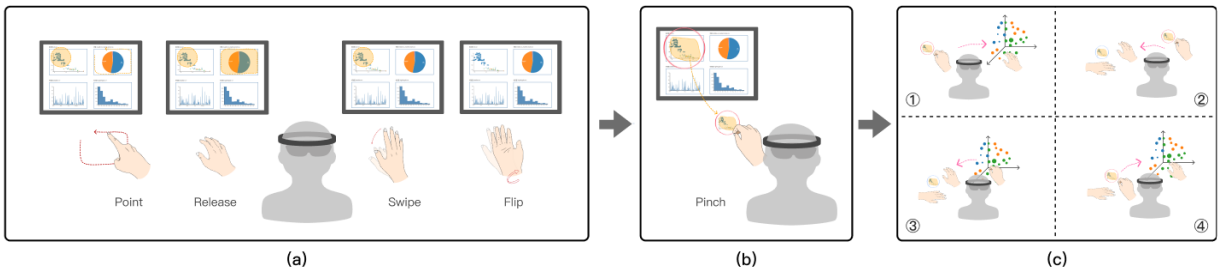

Figure 1: X-Space interaction stage. (a) 2D visualization selection, (b) Visualization data transfer, (c) ① Convert 2D visualization data into 3D visualization, ② Store 2D visual data to data storage box, ③ and ④ are the conversion of visualization data in 3D visualization and data storage box respectively.

Abstract

In this paper, we present a tool based on HoloLens and Web bookmarks. It can extend Web2D visualizations into mixed reality 3D space anywhere and anytime. The tool captures data bound in 2D visualizations, deconstructs them into a data stream, and then transfers them to mixed reality 3D spaces by freehand interaction. At the same time, we equipped the tool with a data API for existing 3D visualization construct tools.

Index Terms: Immersive and Virtual Environments; Visualization System and Toolkit Design; Human-Computer Interaction; Human-centered computing

1 Introduction

Multi-source mixed reality visualization is a visualization method that combines 2D plane visualization and immersive visualization. It presents unique advantages in data understanding and collaborative interaction.

However, hybrid visualization systems are expensive to build for three reasons. First of all, Web development and AR development are two different technical solutions, which need to build a separate background to transmit data. Second, each hybrid visualization system is an independent application. The construction process is laborious and not reusable. Most importantly, for published Web2D visualizations, there are a lack of mixed reality 3D space extension tools that are reconfigurable and reusable.

In this paper, we implemented X-Space, a tool that can extend the mixed reality 3D space for Web2D visualization anytime and anywhere. The capabilities of X-Space are twofold. Firstly, it directly extends mixed reality to existing Web visualizations. The second is to provide a unified data transfer framework so that there is no need to customize the data transfer scheme for each 2D visualization.

2 X-Space System Design

We created X-Space, a tool to help users quickly transfer 2D visualizations into 3D Space. X-Space aims to (1) help users deconstruct Web-based visualizations; (2) realize the natural and easy switch of visualization data from 2D to 3D space; (3) provide a mixed reality visualization 3D space.

As shown in Figure 2(a), X-Space consists of the Bookmarklet tool on the Web client, HoloLens application on the mixed reality client, and a mobile server. It uses a client-server architecture. The mobile server is responsible for transferring information between client devices. While the Bookmarklet tool is responsible for deconstructing 2D visualization data, the HoloLens application serves as an interface for freehand interaction input and a vehicle for 3D visualization space.

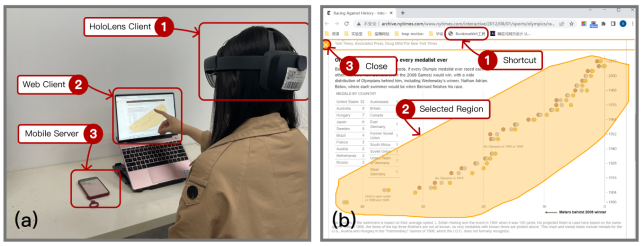

Figure 2: (a) X-Space components, (b) Bookmarklet tool interface.

2.1 HoloLens Application (Mixed Reality Client)

HoloLens application uses the Vuforia plug-in to locate a flat device, which is used to realize coordinate conversion between screen space and mixed reality space.

Gesture recognition: HoloLens application provides static gestures and dynamic gestures, as shown in Figure 3(a). The HoloLens app uses data about the position and rotation of the hand joints to define these gestures.

Data storage: HoloLens application saves received visualization data as a local data JSON file, which is then presented to a user in 3D space as a data ball or an immersive visualization.

We pre-defined prefabs of 3D spatial objects in the HoloLens application. As shown in Figures 3(a) and 3(b), the data ball consists of an outer transparent light sphere and an inner image file. The immersive visualizations use a DxR prefab made by Ronell et al, which is a 3D construction tool that users can choose from.

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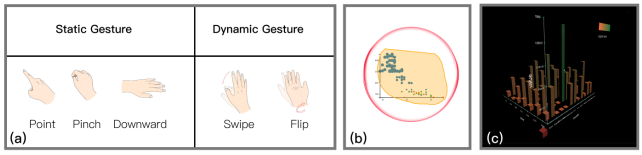

Figure 3: (a) X-Space gestures, (b) Data ball, (c) Visualization built by DxR.

2.2 Bookmarklet Tool (Web Client)

We've packaged the functionality of the X-Space Web client into the Bookmarklet tool, as shown in Figure 2(b).

Region selection: When users select visualization regions, the Bookmarklet tool will add/remove the corresponding region tracks in real-time on the web page.

Data extraction: When users transfer data, the Bookmarklet tool first retrieves visualization data within the selected region and then deconstructs it for transfer. We use Harper et al. 's method to extract the underlying data of 2D visualization. But unlike the Chrome plug-in implemented by Harper et al., our Bookmarklet tool is more compatible and can be used across multiple browser platforms.

Visualization image data is intercepted by the html2canvas library. Bookmarklet tool retrieves the image information and uses base64 encoding for data transfer.

2.3 Communication module design

X-Space server is installed on users' mobile phones. The mobile server uses Websocket protocol to realize real-time and bidirectional data transmission. The mixed reality client sends gesture interaction data to the server. The web client sends visualization data to the server. During communication, the mobile server only forwards data without any processing. The whole communication framework supports work in LAN and mobile hotspot network environments, which ensures that users can complete the work of data transfer in various work environments.

3 Interaction Design

The interaction design of the X-Space tool follows the principle of reality-based interaction. As shown in figure 1, the whole interactive process can be divided into three stages : (1) 2D visualization selection; (2) Visualization data transfer; (3)Data storage box and 3D visualization.

3.1 2D visualization selection

As shown in Figure 1(a), we treat a 2D screen as a canvas in 3D space, in which users can manipulate visualizations they are interested in as interactive objects.

Select 2D Visualization: X-Space uses the "Point" gesture for selection. We provide visual feedback by highlighting selection areas that are most commonly used in 2D. X-Space allows the user to make a continuous selection of multiple objects.

Remove 2D Visualizations: X-Space removes the last selected area using the "Swipe" gesture with the eraser metaphor. Similar to the canvas page-turning behavior, we introduced the "Flip" gesture to clear all selected regions on the screen.

3.2 Visualization data transfer

Visualization transfer is the process of 2D visualization to 3D space. As shown in Figure 1(b), we use the classic "Pinch" gesture to grab 2D visualizations. X-Space uses a transition animation to help the users understand the process. During data transfer, X-Space first generates a red sphere of energy around 2D visualization. This wraps 2D visualization into a data ball to lock user's interaction object. The data ball then moves to the user's interactive position autonomically and follows the user's hand until the user exits the "Pinch" gesture.

3.3 Data storage box and 3D visualization

As shown in Figure 1(c), X-Space allows users to generate 3D visualization directly from 2D visualization data, and also provides a data storage box, allowing users to store visualization data that they don't need to explore at the moment.

We use the drawer metaphor for a data storage box. X-Space uses a downward flip of the non-dominant hand ("Downward" gesture) to open the data storage box. The data storage box sits above and follows the non-dominant hand. When the user exits the "Pinch" gesture under the "Downward" gesture, visualization data enters the data storage box to form a data ball.

Users can directly save visualization data into the data storage box after selecting 2D visualization, or select visualization in 3D space to save into the data storage box. Conversely, users can also select a data ball in the data storage box to generate a 3D visualization. 3D visualizations and data balls of 3D space can be converted into each other.

4 Use Cases

As shown in Figure 4, we use X-Space to extract 2D visualizations from multiple sources and forms. Examples include scattering charts, thematic river charts, stack bar diagrams, bubble word clouds, heat maps, pie charts, etc. In 3D space, we use DxR construction tool to generate visualization directly.

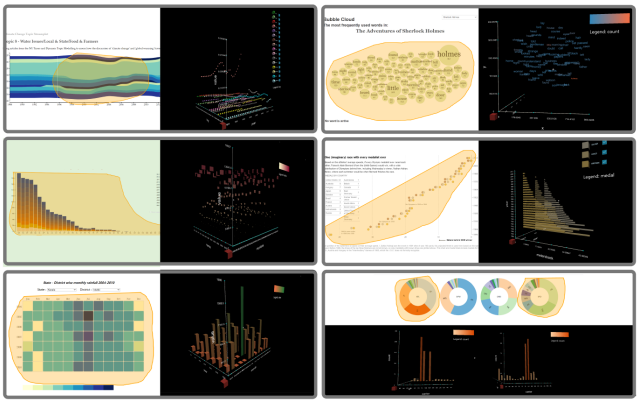

Figure 4: Examples of extraction using X-Space.

5 Conclusion and Future Work

We proposed X-Space, a tool for transferring Web-based 2D visualization data to 3D space. It integrates 3D space for 2D visualization with freehand interaction. X-Space currently renders immersive visualizations through DxR. Meanwhile, X-Space also provides a data storage box on the mixed reality client for temporary data storage. Future work includes (1)Multi-device, multi-person collaboration; (2)Compatibility of 3D visualization construction tools.

6 Acknowledgement

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References

[1] Harper, Jonathan, and Maneesh Agrawala. "Deconstructing and restyling D3 visualizations." Proceedings of the 27th annual ACM symposium on User interface software and technology. 2014.

[2] Lu, Min, et al. "Interaction+: Interaction enhancement for web-based visualizations." 2017 IEEE Pacific Visualization Symposium (PacificVis). IEEE, 2017.

[3] Sicat, Ronell, et al. "DXR: A toolkit for building immersive data visualizations." IEEE transactions on visualization and computer graphics 25.1 (2018): 715-725.