Linked View Visualization Using Clipboard-Style Mobile VR: Application to Communicating Forestry Data

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Figure 1: Constructing a low-cost, mobile VR device as shown makes it possible to hold the display up to ones eyes and see a stereoscopic 3D visualization and also interact with a linked complementary 2D visualization displayed on the bottom of the screen.

ABSTRACT

We present a first demonstration of multiple complementary linked view, 2D + VR visualization on a mobile, low-cost VR device along with an application to visualizing multivariate forestry data.

Index Terms: Human-centered computing—Virtual reality; Human-centered computing—Interaction techniques;

1 INTRODUCTION

Recent advances in low-cost and do-it-yourself virtual reality (VR) displays, such as the FOV2GO project [3] and, later, Google Cardboard [2], Samsung's GearVR [1], and similar devices have opened the door to move applications of VR out of the research lab and into the hands of a wide range of users, from computer gamers to scientists, students, and patients suffering from chronic pain (e.g., [9]).

We are interested in exploring the potential of these new widely accessible forms of VR for data visualization. Inspired by the iN-Verse low-cost viewer developed at USC's MxR lab [3], we fitted an iPad with a pair of low-cost lenses that fit over the top third of the screen (Figure 1). This makes it possible to turn the top third of the device into a stereoscopic display. Our software interfaces with the rotational sensors on the iPad to update the display based upon the user's current heading, thereby creating an effective low-cost VR device that users simply hold up to their eyes. What is unusual about this form factor when compared to others, like Google Cardboard, is that the bottom two-thirds of the device can also be used for data visualization and for multi-touch input. Thus, the device is like a clipboard that provides a 3D view when held up to the eyes and a complementary 2D view when held in the hands.

We believe this holds promise for data visualization because of the potential to present complementary data in the two views. Visualizing data in "multiple complementary linked views" [7] is a foundational technique in 2D data visualization. The idea is less common in 3D immersive visualization of spatial data, but there are some examples (e.g., [6]), including several that link a 2D multi-touch table with a VR 3D data view [4, 5]. However, these prior systems have required large, custom hardware.

This poster contributes the first example of a 2D plus 3D VR linked view visualization on a mobile device, which makes it practical to use in many settings, including K-12 classrooms.

2 APPLICATION

To demonstrate the potential with a real-world dataset, we have used the platform with interdisciplinary collaborators to visualize the US Forest Service's Forest Inventory and Analysis dataset, which contains more than 20 million trees (20,595,807) across 629,644 forested plots systematically located across the U.S. [8]. The prototype visualization includes just three of the plots, selected by forest scientists as interesting, representative samples of a forest with high basal area, a forest with significant recent growth, and a forest with significant changes in tree count over the years. Each plot is sampled via in-the-field measurements every five years, and our visualization includes measurements for 2003, 2008, and 2013. For each plot, measurements are made for every tree that falls within the bounds of 4 circular subplots; hence, the pattern of trees clustered within 4 circles seen in some of our imagery.

Although the tool could certainly be used for exploratory data analysis, the primary objective of the scientists in this case was to explore the potential of more engaging modes of presenting their data to the public. They are particularly interested in outreach to children; thus, we decided to employ representational 3D models of the different tree species for the 3D view of the forest with the

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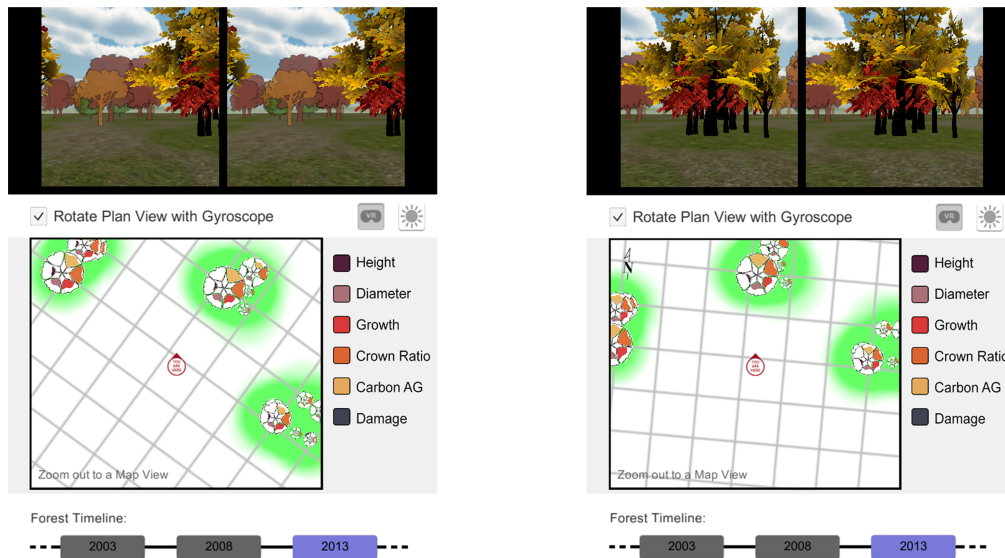‡e-mail: barrywilson@fs.fed.us
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Figure 2: The visualization before (left) and after (right) a multi-touch rotation gesture was applied in the 2D view.

plan that the scientists and teachers could use the tablet devices that are now common in K-12 classrooms to lead students in virtual field trips to the forests to discuss change over time.

3 3D VIEW AND INTERACTION

The 3D view consists of a data-driven, dynamically generated 3D forest scene, where the 3D tree models are selected and scaled based upon tree species, height, and trunk diameter variables. Since the sampling pattern used by the scientists results in quite a bit of blank space in the scene, we also include randomly placed billboard trees in the style of architectural models to indicate uncertainty in the data in these sparse regions. Interaction with the 3D view is done through physical rotation of the device, looking up to playfully experience the forest as in Figure 1, or looking around to more seriously analyze the distribution of tree species, heights, and growth, decay, or harvesting over time. As the 3D view is rotated, the glyph-based visualization in the linked 2D view rotates correspondingly so that the two views stay in sync.

4 LINKED 2D VIEW AND INTERACTION

The 2D view consists of a glyph-based multivariate visualization, like a map of each tree in the plot, but where the icon for each tree is a glyph that encodes 6 data variables for each tree. These additional data help scientists to understand the carbon content of the forest and develop estimates that are used to make climate policy decisions. There is also a data legend and interactive timeline. Interaction with the 2D view is accomplished via multi-touch input (Figure 2). The map can be translated, rotated, and zoomed. These interactions immediately update the linked 3D view so interaction with the map serves as a VR navigation technique. Touching the timeline at the bottom changes the year of data displayed.

5 OUTLOOK

We believe the current prototype is useful to report to the visualization community because the low-cost makes it widely accessible, and the linked-view VR technique could be applied to so many different visualization scenarios. These include: (a) brain imaging where neurosurgeons benefit from stereoscopic 3D displays but often wish to also see complementary slice-based data because they have trained to understand the brain anatomy using slices, and (b) immersive

analytics where the abstract data presented in stereoscopic views can be usefully filtered using 2D interactive parallel coordinates and related plots.

REFERENCES

[1] Gear VR. https://www.oculus.com/gear-vr/.
[2] Google Cardboard. https://vr.google.com/cardboard/.
[3] M. Bolas, J. Iliff, P. Hoberman, N. Burba, T. Phan, I. McDowall, P. Luckey, and D. M. Krum. Open Virtual Reality. In *2013 IEEE Virtual Reality (VR)*, pp. 183–184. IEEE, 2013.
[4] D. Coffey, N. Malbraaten, T. B. Le, I. Borazjani, F. Sotiropoulos, A. G. Erdman, and D. F. Keefe. Interactive Slice WIM: Navigating and Interrogating Volume Data Sets using a Multisurface, Multitouch VR Interface. *IEEE Transactions on Visualization and Computer Graphics*, 18(10):1614–1626, 2011.
[5] K. Kim, B. Jackson, I. Karamouzas, M. Adeagbo, S. J. Guy, R. Graff, and D. F. Keefe. Bema: A Multimodal Interface for Expert Experiential Analysis of Political Assemblies at the Pnyx in Ancient Greece. In *2015 IEEE Symposium on 3D User Interfaces (3DUI)*, pp. 19–26. IEEE, 2015.
[6] J. W. Nam, K. McCullough, J. Tveite, M. M. Espinosa, C. H. Perry, B. T. Wilson, and D. F. Keefe. Worlds-in-Wedges: Combining WIMs and Portals to Support Comparative Immersive Visualization of Forestry Data. In *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*. IEEE, 2019.
[7] C. North and B. Shneiderman. Snap-Together Visualization: A User Interface for Coordinating Visualizations via Relational Schemata. In *the Working Conference on Advanced Visual Interfaces (AVI)*, pp. 128–135. ACM, 2000.
[8] B. M. O'Connell, B. L. Conkling, A. M. Wilson, E. A. Burrill, J. A. Turner, S. A. Pugh, G. Christiansen, T. Ridley, and J. Menlove. The Forest Inventory and Analysis Database: Database Description and User Guide for Phase 2 (version 7.0). 2017.
[9] D. Schroeder, F. Korsakov, J. Jolton, F. J. Keefe, A. Haley, and D. F. Keefe. Creating Widely Accessible Spatial Interfaces: Mobile VR for Managing Persistent Pain. *IEEE Computer Graphics and Applications*, 33(3):82–88, 2013.