Two-Dimensional Scatterplots and Parallel Coordinates Plots in VR

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***Abstract*—Nowadays, people have access to a wide range of data. However, understanding how it relates to real-life events is an elaborate and time-consuming process. We developed an approach for immersive data analysis using 2D Scatterplots to represent time-dependent continuous data, and Parallel Coordinates technique to track specific data points across several dimensions. A Timeline visualization connects the information to discrete events making it easier to correlate different types of information. We conducted a user evaluation that highlighted the potential of the proposed approach.**

***Index Terms*—Information Visualization, Virtual Reality, Immersive Analysis, 2D Scatterplots, Parallel Coordinates Plots**

I. Introduction

The concept of Information Visualization, commonly referred to as InfoVis, has long piqued people's interest [2], [4]: creating interactive and visual representations of complex data to reinforce human cognition by allowing the user to better understand the complex data structures, to discover causal patterns and to have a better understanding of the information, leading to assessments that could be missed otherwise.

InfoVis' exploration of novel ways for people to view and interact with abstract data, combined with Virtual Reality's ability to provide an immersive experience that may combine 3D and 2D visualizations [9], lead to new ways of representing information and interacting with it [5], [8], [10], and to the field of Immersive Analytics [7].

In this work, we present an approach in the realm of Immersive Analytics that combines techniques from both the field of Information Visualization and the field of Immersive Environments. To that end, we use as case study an example pertaining to the financial domain. In this field, understanding how geopolitical, social and economic events are related is very important, but it is a complex and time-consuming process. We therefore proposed and evaluated an immersive visualization of both asset performance and relevant financial indicators to help discern what is influencing value change. To this end, we allow users to explore 2D Scatterplots both individually as well as connected in a 3D Parallel Coordinates visual idiom.

II. Approach

We proposed the implementation of more than one visualization technique in immersive environments with several interaction methods thought to provide familiarity and immersion. Since our goal is to enable users to find possible correlation between different sources of information, we believe a visualization encompassing multiple representations and a natural and immersive interaction with heterogeneous data might help us more easily accomplish this goal.

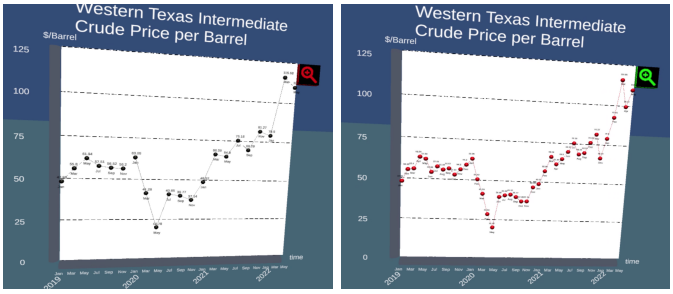

Fig. 1. Temporal data represented by scatterplots, with normal (left) and denser time sampling (right).

As the main display, 2D Scatterplots are used to represent high-dimensional temporal data regarding the performance of assets and economic relevant markers (Fig. 1). The users are able to interact with these plots by getting closer and selecting the points that they intend to analyze. The plots are placed in circle around the user (Fig. 2), facing the center. Users can rotate them around 360º to better position the active plots in the direction they are looking. The plot the user is looking towards gets closer to the center, allowing the user to get in range of selecting the points with just one or two steps. Each plot has the option to maximize the temporal scale in the top right

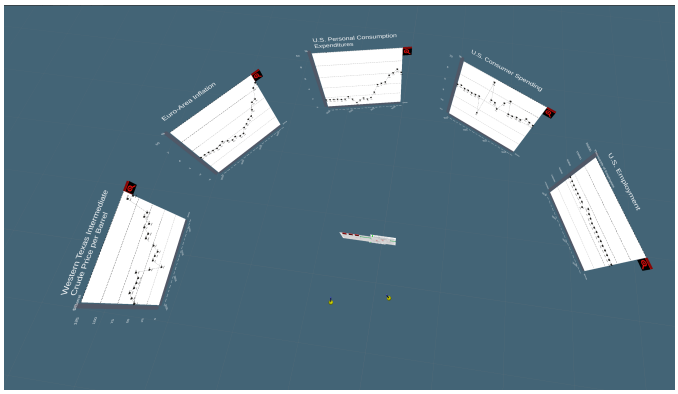

Fig. 2. Scatterplots radial placement around the user.

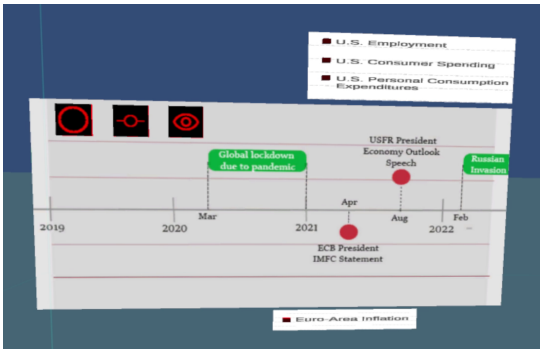

Fig. 3. Timeline of discrete events.

corner, accessing more detailed information about a specific metric or asset (Fig. 1 right).

A second visualization will dictate which plots are visible to the user. The solution includes a Timeline representing geopolitical, economic and social events in a temporal scale (Fig. 3). The user can select which events are active, dynamically updating the Scatterplots display. For each event, several relevant financial indicators are displayed and if chosen, the respective plot will be added to the pool of Scatterplots present in the scene.

A third visualization technique, Parallel Coordinates, is also available. After selecting the intended plots, the user can opt to link the plots, better following individual points through several charts (Fig. 4). Any selected point will also highlight points of different Scatterplots in the same time scale, including plots represented in the Parallel Coordinates visualization. Also, users can freely move, rotate, and scale the whole visualization object directly with their hands.

As mentioned before, interaction techniques are crucial to immerse the user into the environment and, consequently, the visualization of data. Given that these representations are not far and unreachable from the user original position, it makes sense to choose the simple virtual hand technique as well as

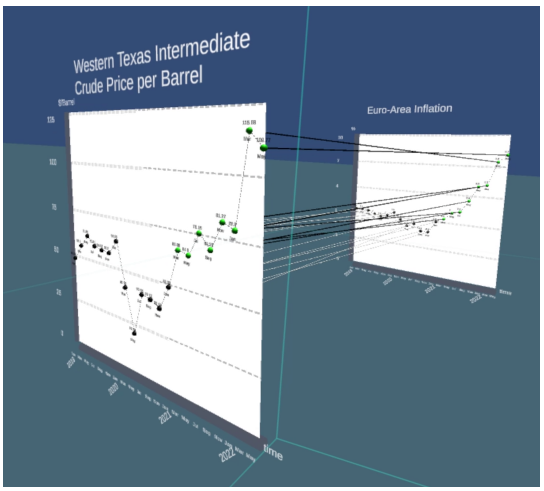

Fig. 4. Parallel Coordinates visualization with some points selected.

real walking as the selection and navigation techniques [6], respectively.

III. Evaluation and Results

We conducted a user evaluation, where the VR prototype was compared to a Desktop setting. The Desktop setting resorted to the Bloomberg platform [1], which provides global financial indicators and assets charts. Every necessary web page was opened in a browser tab before the test and participants were given the opportunity to explore the multiple plots.

The tests consisted in executing four tasks, each composed of two to three financial questions promoting data analysis. Both the questions and the answer were given verbally. Since the presented data did not change between setups, the datapoints asked in each differed slightly (e.g. maximum values instead of minimum values, different dates) without changing the difficulty and the essence of the tasks.

At the end of each setup, participants were asked to fill out the System Usability Scale questionnaire [3]. To avoid bias, participants alternated between setups and corresponding tasks, following a Latin square design.

A total of 20 participants (13 males and 7 females) between 16 and 35 years old took part in the tests. While the time measured during each task determined that our solution did not provide the fastest data analysis between both setups, the results from the system usability questionnaire and the user feedback showed that our solution is more appealing, intuitive, and easy to use than the Desktop baseline.

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