CS 5754 Virtual Environments (Spring 2022): Immersive 3D Analytics with Stock Data (Team 4)

Sai Deepak Gattidi
saideepakg@vt.edu
Computer Science
Virginia Tech

Harsha Vardhan Reddy Bonthu
harshareddy97@vt.edu
Computer Science
Virginia Tech

Swetha Annavarapu
aswetha@vt.edu
Computer Science
Virginia Tech

Bharath Kumar Reddy Kusuluru
bharathk@vt.edu
Computer Science
Virginia Tech

Abstract

In this paper, we present a novel way of visualizing stock data in an immersive 3D virtual environment to enable a superior understanding and analysis of financial data. In this competitive financial landscape, we aim to leverage the advantages which Virtual Reality provides and create a platform where users can interact, understand and analyze the Wall Street Stock Market. Our design consists of 4 virtual screens in a workplace environment to stimulate the feeling of working at an esteemed organization. Each screen will be capable of displaying stock data of 2 companies, totaling 8 different organizational stock data which can be compared simultaneously. We also offer numerous time horizons for each screen to choose from for the user and provide accessibility for improved user experience. We will review existing 3D visualization techniques in the financial industry, discuss the technical setup in both Unity and Oculus Quest, and explore different design considerations to make our product as efficient and simple to use even for a person outside of financial background. We conclude by looking into different ways to augment the technical capabilities of our product and contemplate the impact of VR on the financial industry.

Keywords: immersive analytics, virtual reality, stock data

1 Introduction

Stock traders are in charge of purchasing and selling tradable financial assets including stocks, bonds, futures, options, and swaps, to mention a few. They also undertake in-depth study and analysis of how financial markets function, such as when new macroeconomic data or other pertinent news is released. Traders employ typical work spaces in their everyday work, which may consist of many monitors on which various financial information, charts, tables, and indicators are displayed simultaneously. In such an atmosphere, a trader must maintain constant focus while monitoring continual developments in the financial markets. It's easy to make a mistake when some economic data is neglected, for example, and the trader ends up losing money or missing out on a potential profit.

The majority body of data is presented in 2D space in today's systems. We'd like to look at the additional possibilities that adding a third dimension to information presentation opens up. We'd also like to assist humans in grasping a basic insight into the current market condition. This also means that trading decisions will be made faster and better. Additionally, this will make it easier for people outside of the financial profession to comprehend and grasp complex information visually. Currently traders use multiple desktop screens to view different stock data over different time periods. While this has been useful, it is a tedious process and requires monetary investment for the hardware, if the user wants to work comfortably on full scale. The graphs are 2-dimensional (2D) in most cases, and users might miss out on some important trends in the data. Even if the data is represented in 3-dimensional (3D) graphs, the user can not fully perceive the 3D graph on the 2D screens.

So we want to enable the user with a more engaging and superior experience by using Virtual Reality. We want to provide the user a better functionality where they can interact and understand stock data better and help them take faster decisions. This can result in profits and make it a more interesting for the user. We plan to build this using Unity and then eventually load into Oculus quest for the client to work with. Eventually, we plan to improve upon and build our MVP upto industry standards so that companies can utilize it and increase their profits.

2 Related Work

The concept of Virtual Reality(VR) has evolved greatly since its origin in 1960s. VR is defined in several ways by various researchers. All of them define VR as immersion, interaction and presence in the environment. With the increased availability of Head Mounted Devices(HMD) since early 2010s, there has been a lot of research interest in the virtual reality space.

Previously, graphs were represented in 2D flat-screens. Gephi [4] is a popular open-source software developed using Java. It helps users customise and view large graphs in real time. Cytoscape [10] is another open-source software using Java. It was initially developed to visualise bio-molecular structures, but later extended to visualize graphs in all domains. Graphviz [7] is another popular system, using C language, which has multiple layouts to visualize data from various domains.

Although these show users a large portion of the data, the 2D representation often hides some of the data that would be more easily visible if it were presented in a 3D format. According to Dwyer et al. [6], "Immersive Analytics is the use of engaging, embodied analysis tools to support data understanding and decision making." Tan et al. [11] evaluated analytical task performance on monitors to wall displays and found that a physically large display produces significant benefits due to enhanced immersion and presence, which biases participants to adopt an egocentric view of the data. Based on these findings, Reda et al. [9] investigated the impact of physical size on actual visual examination of data, and discovered that more pixels resulted in greater discoveries and insights.

3D Graph Explorer [8] is a VR application that allows users to visualize and interact with graphs using mouse and keyboard. It makes advantage of Gephi's layouts and adds functionality like graph visualization, exploration, and manipulation.

There has been a high focus of works in the field of graph visualization in the recent times. Donalek et al. [5] proposed a paper on the practical and optimal use of virtual reality as a platform for scientific data display and exploration. They used the Linden Scripting Language to create scripts for highly dimensional dataset visualization in a virtual environment, which permits interaction with the Second Life virtual world. Data is represented using spatial coordinates, colors, and dimensions.

There are many projects developed in recent years, which make use of extended reality to better visualize the financial data. Few such works are Citi Holographic Workstation [1], InVizble [2], Looker [3].

In our project, we are implementing line graphs for the time-series stock values. The data points are represented spatially in a 3D space. The data for each stock can be visualised for different timelines to analyse the stock performance.

3 Problem Description

Stock analysis is rapidly growing and several companies are investing in developing tools to analyze stock data effectively. Lately, multiple brokerage firms are evolved trying to make trading very easy. Lower service fees, access to online tools, and the option to monitor investment in real-time helped more people to jump into trading right away. Thus, the trading industry has been growing rapidly, forcing big organizations to invest in developing creative ways to help people with analyzing years of stock data.

Since the pandemic sent financial traders home from the trading floors, the professionals have encountered a number of challenges arising from remote trading. Like most industries, trading was forced to find new ways to operate in increasingly restrictive conditions. The stage was perfectly set for virtual reality (VR) to enter the trading arena. It help overcome the limitations of physical spaces and replace the traditional brick-and-mortar trading floors. In most cases, a trader can see no more than six to eight screens on a physical trading floor. Virtual Reality, however, allows traders to view and interact with dozens of screens. As a result, traders can handle much more data at a time than they can do in physical spaces.

Traders just don't have enough real estate on their desk. However, VR enables observing multiple trends and then immersing him or herself in the data without being constricted by physical limits. Also, it allows traders to see data in 3D and overlay data on top of one another. Such a feature gives financial professionals more flexibility to customize their research and analysis without any physical restrictions.

Being seen rapid growth of people involving in stock trading and traders started working from home due to the pandemic, it is lucrative to incorporate virtual reality in trading industry. The use of Virtual Reality technology aid traders' work, by enabling creation of customized information spaces, replacing complex computer setups. The days when any spare bedroom can be transformed into a trading floor is approaching. In the VR system, users can immerse into virtual space with multiple screens with customized charts as many as a user needs to observe-without running into hardware or space limitation issues. Additionally, perception of handling changes in financial markets can be increased with the use of spatial sound, and as a result, the trader could perform better, by getting aural notifications triggered within his/her surrounding.

Figure 1: Traditional trading workspace.

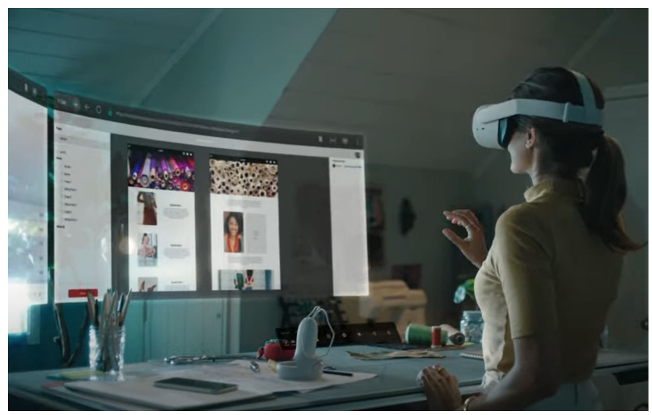

Figure 2: VR trading workspace.

4 Proposed Approach

Given the large amount of information that a trader must follow at the same time, the high cognitive load, and the direct financial consequence of their judgments, it is critical to investigate how traders' cognitive capacities can be enhanced through the use of current technology. One way we can achieve this is to provide the user with multiple interfaces or screens to interact with. We initially discussed on how we can achieve this. One possible way was to present the 2D stock data, add depth perception to it and convert into 3D graph. Even though it helps with better visualization, it doesn't provide a significant boost from the existing 2D screen technology we presently use. So we planned to increase the number of screens. Ideally the trader at financial corporate companies like Goldman Sachs, BlackRock, JP Morgan, etc., the traders have 3-5 screens at their disposal to look and analyse. So we debated on what would be the ideal number without overwhelming the user and allow for maximum usability and decided finally upon 4 screens. You can see the flow diagram 11 of how user interacts with the proposed application.

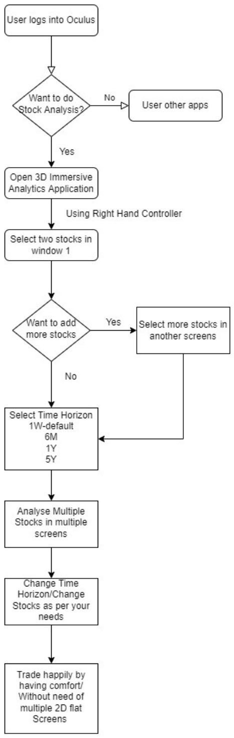

Figure 3: Flow Chart

We spaced them in the created Virtual Workplace environment, so that it won't look too clumsy but close enough so that the user can easily switch from one screen to another without any kind of discomfort. This design was approved by the team and we went ahead with the implementation using Unity.We have used the an asset from the Asset Store in Unity for our background. This can be seen in the figure 4.

4.1 Product Description

As we developed the product from scratch using Unity's Canvas component, we chose an overlay upon which the screens were superimposed. This prevented the graphs from being muddled in the environment and adds a layer of opaqueness to the entire canvas. We had an assortment of buttons for the user to interact, which included the following:

- **Stock Dropdown**: We had all the companies listed here one by one as two Dropdown options. Each user can select upto two different companies per screen. The user can change the company selection any time they want and the graph changes according to the selection they have made.

- **Time Horizon**: We have chosen 4 different time horizons ranging from weeks to years. By default we had the Week selected which showed the data for the past one week.

Figure 4: Background workplace for the canvas

As illustrated in the Figure 6, the user can select any two stocks with their preferred timezone and the plotted data-points pops up on the canvas. In the Figure 5 we can clearly see the distribution of the 4 different screens available to the user and how easy it is for the user to move around them freely. We in the future iterations would like to include a co-ordinate system and a legend to improve user experience.

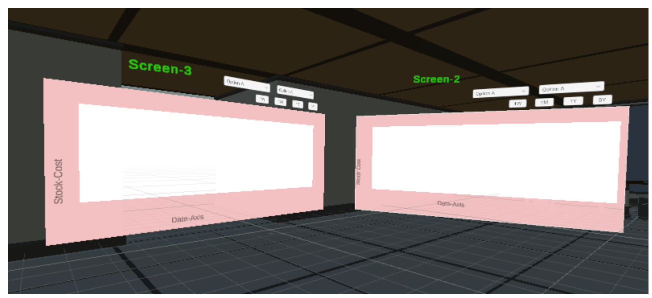

Figure 5: Multi Screen Setting in VR

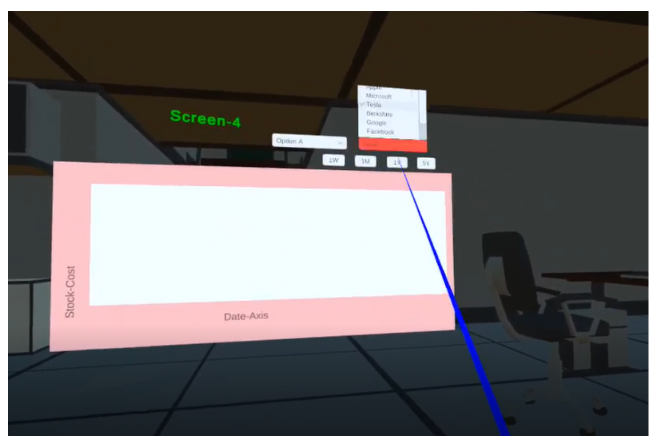

Figure 6: Single Screen along with Oculus integration

4.2 Dataset

We have scraped the data from Yahoo Finance. It is a reliable source, thereby guaranteeing that the data we have is accurate and resilient. We have chosen top 10 companies, which have high impact on the American economy and ignite interest for the laymen user.

Eventually we would like to extend this repository to over 100 companies, but given the time constraint we initially chose the following ten companies (with their stock symbols):

- **Apple** : APPL
- **Microsoft** : MSFT
- **Berkshire Hathaway** : BRK-B
- **Meta Platforms, Inc.** : FB
- **Nvidia** : NVDA
- **Walmart** : WMT
- **JP Morgan** : JPM
- **Goldman Sachs** : GS
- **American Express** : AXP
- **UnitedHealth Group** : UNH

The ideal way is to pull the data from an interactive API in real-time and populate those into the graph. However, given the size of the data and it's pre-processing, it might introduce a latency as to when the user requests for a graph and when it resolves in front of him/her. Instead, we decided to download the data as CSV files of the respective companies and load them into our Unity Asset data store. We had the following parameters at our disposal: **Date, Open, High, Low, Close, Adj Close and Volume**. We took the date timestamp for our time horizon calculation and the Closing value to be displayed on the graph.

4.3 Technical Description

There are plethora of time horizons for a user to choose. For the initial MVP, we went forward the following time steps with the options being displayed on the buttons:

- **Week** : 1W
- **Month** : 1M
- **Year** : 1Y
- **Five Years** : 5Y

We can add six months, two years and days tickers afterwards in the the next MVP. We downloaded data for the past 5 years. When the user selects the Week button, we display seven latest data points. For the Month we show the last 30 days stock. For the year, displaying 365 points would be too clumsy, and won't fit well on the canvas. So we chose the data week wise, thereby totaling 52 data points. For the 5 years one, we choose it monthly to make it 60 data points (5x12).

For this project, we have used UNITY for development and integrated with Oculus Quest2. We have created everything using canvas without loading any pre built libraries available in the unity store. Infact, we have developed scripts to plot points and connect those datapoints.

Steps to activate and use our software:

- Firstly, user need to put on Oculus quest2 and load the apk into the quest by connecting using USB cable.
- Then, user need to set guardian and should be able to see the main screen.
- User selects apps icon and then select filter option appearing on the top right of the screen.
- User selects unverified apps from the filter and then he would be able to see our app named "StockAnalyzer".
- User can open the app and will enter into the virtual trading space, where he can see multiple desks, tables and screens aroung him.
- User can hover onto any one of the screen and select stocks and time frame of data he/she wants to see.
- Finally, the graphs appear on the screens, where one graph overlay on other graph and can move the graphs around to analyze.

Figure 7: Oculus Quest-2

5 Evaluation and Discussion

We can see the graph being plotted on the screen as given in the figure 8. The user can see the stocks and see how it raise, fell or fluctuated in the given time period.

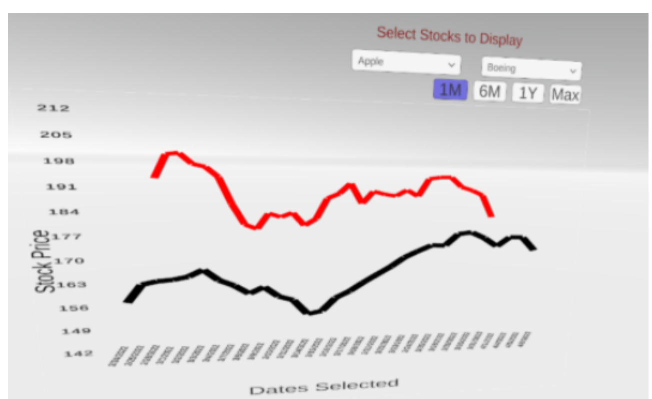

Figure 8: Graph plotted on the canvas

We have collected user experience of using our software using a questionnaire. There are certain requirements placed in order to qualify for the study: participants should be above 18 years; participants should have basic knowledge of using stocks. Initially, users are given with product usage guide, which can be used a guide to understand several features of the product. Later, they were asked to use the product and test the features. At the end of session, feedback has been collected and scores are calculated using SUS and NASA TLX.

Through this experiment, we wanted to check how traders can use 3D space for doing several stock data analysis.

5.1 SUS Score

System Usability Scale is a quick and reliable tool for measuring the usability. It consists of 10 item questionnaire with five response options for clients, from Strongly agree to Strongly disagree. A total of 10 subjects participated in the experiment. We selected SUS score to measure the usability index of our virtual environment as SUS can be used on small sizes of data with reliable results. And also it can differentiate between usable and unusable system.

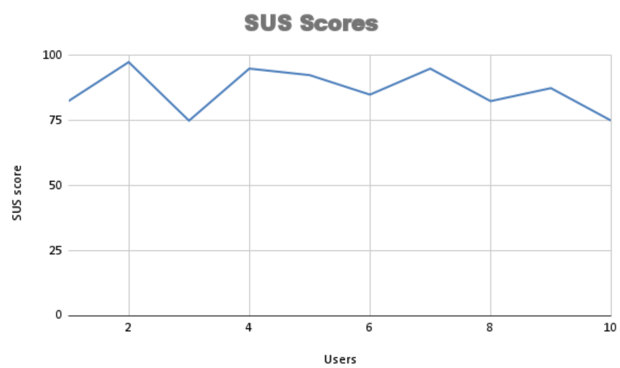

Figure 9: SUS Scores

5.1.1 Interpreting SUS score

Participant's scores for each question are converted to new number, added together and then multiplied by 2.5 to convert the original scores of 0-40 to 0-100. Though scores are 0-100, these are not percentages.

Based on the research, a SUS score above a 68 would be considered above average and anything below 68 is below average. In below figure, we reported SUS score for each user, on 10 subjects we received an average score of 86.75.

5.2 Interpreting usable system from SUS score

1. I think that I would like to use this system frequently : The users have taken a liking for the product and use our product more frequently

2. I thought the system was easy to use: Our product was simple and fairly easy to use for a layman

3. I found the various functions in this system were well integrated: There was fluidity and well integration between Unity and Oculus

4. I felt very confident using the system: Users were confident while using the system

5. I think that I would need the support of a technical person to be able to use this system: Given the simplicity for our system people don't need to know in depth about the technical components involved

6. I thought there was too much inconsistency in this system: Our model was fairly consistent

7. I found the system very cumbersome to use: Our model was efficient and ways to use

8. I needed to learn a lot of things before I could get going with this system: Easy for anybody to be onboarded to use our project

5.3 Interpreting unusable system from SUS score

1. I found the system unnecessarily complex: Some users when they tried to understand how our system works, might have felt that the integration was complex

2. I would imagine that most people would learn to use this system very quickly: Someone who hasn't used Oculus at all, has a bit of learning curve on the quest

5.4 NASA TLX Score

As a second measure of evaluating our environment we selected NASA Task Load Index(NASA Task Load Index). NASA TLX is a bit different scale from SUS, as SUS measures usability index of the system, NASA TLX is a tool for measuring and conducting a subjective mental workload on user. Only disadvantage of the NASA TLX is that since we are collecting feedback following the task, user is prone to forget details of the task. It allows you to determine the mental load of a participant while they are performing a task. It rates performance across six dimensions to determine an overall workload rating. In below figure, we attached average score of NASA TLX across six dimensions.

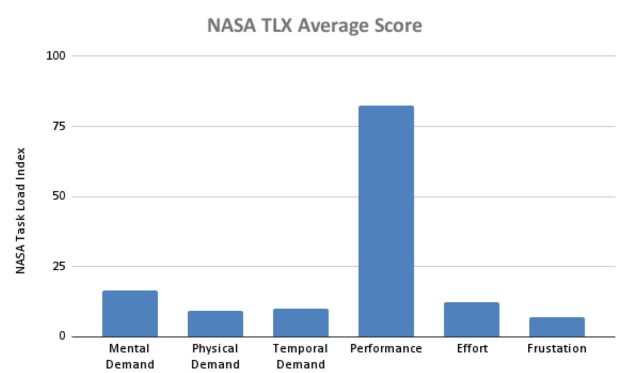

Figure 10: NASA TLX Average Score

5.5 Client Review

The clients for our project are Sai Gurrapu and Anudeep Guntaka. Both of them are Virginia Tech students and they have been investing in stocks since a few years. Sai is the co-founder of 2 startups-Wonderly and HitchHique. In an effort to expand his startup conquests, he is aiming to create an AI-powered trading project which is focused on the stock market, where users can get recommendations on what to buy/sell and get analysis on how each stock is performing. He was very interested in our project. Throughout the project progress, we have got suggestions from him, about improving the background scene, adding different stocks and about how we can make the system more user-friendly and useful. At the end, both of our clients used our product and liked the work. They hope to see more progress in it by adding some additional features and using the data real-time.

6 Conclusion

We received positive reviews for our project both from the reviewers and the academic staff. We did take the constructive criticism on different ways to improve our product for a superior user experience. We would like to throw light on the following takeaways from our project:

- **Unity**: We learnt a lot about Unity through the course of the project
- **Oculus**: We have used Oculus Quest 2 for our project and learnt how to integrate it with Unity
- Understood and duly followed the IRB Protocol, which forms a baseline for us to follow for our oncoming projects
- Realized the potential of how Virtual Reality can disrupt the stock analysis market

We intend to talk our project forward and add different kind of functionalities, such that it is capable of being integrated and be utilized in a professional company. There were many challenges we faced during the course of the project, which we take in as our learning and look forward to Virtual Reality flourish in the financial industry.

7 Acknowledgement

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8 Appendix

8.1 Part 1 of Survey- SUS Survey

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Index	SUS Avg Score	Questionnaire
1	1.533333333	I think that I would like to use this system frequently.
2	3.666666667	I found the system unnecessarily complex.
3	1.866666667	I thought the system was easy to use.
4	3.8	I think that I would need the support of a technical person to be able to use this system.
5	2.066666667	I found the various functions in this system were well integrated.
6	4.066666667	I thought there was too much inconsistency in this system.
7	2.2	I would imagine that most people would learn to use this system very quickly.
8	4.2	I found the system very cumbersome to use.
9	2	I felt very confident using the system.
10	3.933333333	I needed to learn a lot of things before I could get going with this system.

Figure 11: Questionnaire

8.2 Part 2 of Survey- NASA TLX

1. Mental Demand: How mentally demanding was the task?
2. Physical Demand: How physically demanding was the task?
3. Temporal Demand: How hurried or rushed was the pace of the task?
4. Performance: How successful were you in accomplishing what you were asked to do?
5. Effort: How hard did you have to work to accomplish your level of performance?
6. Frustration: How insecure, discouraged, irritated, stressed, and annoyed were you?