Final Project Report

CIS 3252

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Domain Frame

The domain that I chose to focus on is virtual reality. It's amazing how much virtual reality has improved within the recent years. Before, virtual reality used to be something in science fiction but now it is normal for people to own VR headsets in their homes. People are able to play video games like Beat Saber, meet new people in apps like VRChat, and even watch movies. With the release of the Quest 2, VR has been more accessible to people since it does not require to be connected to a pc and have base stations unlike other headsets like the Valve Index. With a headset like the Quest 2, it does not have the computing power to handle way more graphics compared to a headset that is connected to a pc. In the upcoming years there may be more wireless headsets that can handle advanced graphics. With more features like these, the cost of the headset increases. For example, the Valve Index costs $999 and it includes base stations. The Valve Index also includes premium features like finger tracking controllers and a Field of View (FOV) of around 130°. Meanwhile, the Quest is priced at $299 and has 90° FOV. That is why it is important to consider the different hardware and software characteristics. Certain people might lean more into a cheaper headset while VR enthusiasts might lean more into premium features. It is also important to identify what certain factors increase immersion. Certain people might prefer better immersion in order keep playing VR.

Problem Statement/Hypothesis

In my project, I will be using exploratory data analysis (EDA) to identify what hardware and software characteristics increase immersion. Internal stakeholders can include VR headset companies such as Oculus/Meta, HTC, and Valve. These companies can use this project as a reference to see which hardware and software characteristics they should prioritize in their

upcoming headsets. External stakeholders can include the customers planning a buying a VR headset. Immersion can give the user the illusion that they have stepped inside the “virtual world”. For some users immersion could be an important factor and can be a reason for them to keep playing VR.

Analytical Questions

1. What hardware and software characteristics increase immersion?

   This question is the most important because it questions which factors affect immersion.

2. Does higher FOV increase immersion?

   This is one of the characteristics that I predict will affect immersion. I feel like higher FOV will increase immersion.

3. Do headphones increase immersion?

   This is another characteristic that I predict will affect immersion. I feel like headphones will be the most immersive.

4. Does the type of locomotion affect immersion?

   This is another characteristic that I predict will affect immersion. I think that walking in place will be the most immersive while teleportation will be the least immersive.

5. Will there be any unexpected characteristics that affect immersion?

   This question is also important because there might be some characteristics that I did not mention that might affect immersion while some I mentioned may not affect immersion.

Data

The dataset I used contains 401 samples collected from a scientific user studying the relationships between the hardware and software characteristics of a VR headset and level of immersion perceived by the user. There are 23 different independent variables which are the

characteristics of the VR while there is 1 dependent variable which is the user's immersion on a scale of 0 to 100. 0 meaning no immersion while 100 meaning complete immersion. Independent variables such as stereopsis and depth-of-field were categorized as enabled (1) or disabled (1). Locomotion and sound system had multiple categories. For example, sound system had three categories: no sound (0), speakers (1), and headphones (2). Other independent variables were tested in different decimal values. For example, there were different contrast values from -0.8 to 0.8. For categorical variables I used boxplots while for numerical and decimal values I used scatterplots in my Python Notebook. There were no missing or messy values.

Findings

Based on my findings, the most obvious characteristics that affected immersion were sound system and locomotion. In the locomotion and immersion comparison boxplots, teleportation had the lowest mean while walking in place had a slightly higher mean and box than joystick movement. There were some outliers around the 80s in teleportation. In the sound system and immersion comparison boxplots, there were less immersion in no sound (0) than in speakers (1) and headphones (2). Headphones were slightly higher than speakers. There was an outlier around the 70s in no sound. A variable that I did not mention in my predictions that affected immersion was textures. In the textures and immersion comparison boxplots, textures enabled (1) was higher than disabled (0). There were some outliers on the high end in the disabled boxplot. In most of the other boxplots the means are about the same. Some boxplots are different because they have a bigger range between minimum and maximum values. For instance, in 3D models detail and immersion comparison the boxplots have around the same mean but the maximum

value in the high-poly models (1) was higher than low-poly models. I also noticed that for the scatterplots almost all of them had values all over the place. That is why at the end I made FacetGrid to see if other factors affected that variable. First, I did one with fov and immersion. I wanted to see if there was a pattern based on locomotion and sound system. There seemed to be some noticeable patterns but the points in the scatterplots were still scattered. I noticed that the linear regressions lines were either negative, positive, or flat. When the locomotion is teleportation (1) and sound system is no sound (0), the linear regression line is negative. There is also a negative line when locomotion is teleportation (1) and sound system (1) is speakers (1). There is a positive line when locomotion is teleportation (1) and sound system is headphones (2). When locomotion is joystick movement (2), all of the sound systems have a flat line. When locomotion is walking-in-place (3), all of the sound systems have a line that is almost a flat line but lean towards positive. With these results I feel like fov does not have an effect on immersion compared to other factors like locomotion and sound system. I also did another FacetGrid for fps and the scatterplots being similar the fov ones. There were no negative linear regression lines. All of them were either positive or flat. When locomotion is teleportation (1) and walking-in-place (3), the lines are positive. I noticed that for both the fov and fps scatterplots when locomotion is joystick movement (2) the points are all scattered. I then decided to do FacetGrid for the rest of the characteristics that used scatterplots like time, width, and height. It seemed like for most of them there were all having scattered values. Almost none had values that were close to the line. I then replaced sound system with textures since textures boxplots were a little different. With this change, almost all of the FacetGrid scatterplots had values all over the place. When I did sound system and textures, similar results happened. Probably the most notable one is when comparing fov with immersion and when there was no sound (0) and textures enabled

(1), most of the values were near the line. I feel like after all of these results everyone has their own preferences to what makes VR immersive. I feel this is a reason why in some VR headsets you can edit the settings yourself. I also feel like all the users in the study should have been given the same time. Maybe some users might have given it a low immersion rating because they didn't have enough time. I did notice in the FacetGrids with time there were more higher immersion scores given when there was more time. In this study, it is very difficult to determine what exactly increases the user's immersion since there were so many factors to consider. Something else I noticed from these results is that when locomotion is either joystick movement (2) or walking-in-place (3) and sound system either speakers (1) and headphones (2), the values tend to be on higher immersion. I feel like characteristics such as locomotion and sound are very important for immersion.

Conclusion

I felt like this project was a great opportunity to explore how different hardware and software characteristics affect immersion. I have always wanted to do a project on the topic of VR. It was a great experience to apply exploratory data analysis on this dataset. One thing I learned is to better is to when to appropriately use graphs like scatterplots, boxplots, and FacetGrids. Scatterplots were used in numerical values while boxplots were used in categorical variables. FacetGrids were used to see if there were any other values affecting the scatterplots. Another thing I learned from this project is to better read scatterplots and boxplots. As someone who has taken statistics before, I have seen these kinds of graphs before. This project taught me how to use these kinds of graphs to find correlations. A third thing I learned from this project is to better use Python for statistics. I now know what codes I use to make graphs like histograms,

scatterplots, and boxplots. The fourth thing I learned from this project is how to use analytics in a field like VR.

Reference

Selzer, M. (2022, February 22). *Virtual reality immersion dataset*. Mendeley Data. Retrieved May 14, 2022, from https://data.mendeley.com/datasets/kj79vpcsc5/2