ALMEIDA Mickael (class 40)

XREALITY ASSIGNMENT

TABLE OF CONTENTS

INTRODUCTION

We will be working around perception of distances inside a virtual environment. The question we want to answer is: “How the virtual environment can modify our perception of distances”. To answer that question, we want to test two hypotheses, which are opposite. Our tested hypothesis is therefore: “Users of virtual environments can better estimate distance in a more visually enriched scene”. Thus, we also have a null hypothesis that we are attempting to disprove, and which will be the fallback conclusion for the research: “Visual enrichment of a scene has no impact on the ability of users in virtual environments to better estimate distance”.

We will be creating two virtual environments, that are exactly the same. We will however change one parameter. In one of the environments, the scene will be very simple, whereas the second one will be decorated with assets and textures. In both scenes, we will have to follow the same route, interact with 2 objects placed at the exact same place, and reach the end of the route. The path should be complex enough, so that we don’t see the end point from the starting point, in order not to bias the user perception of the distance traveled.

As a result, we will take feedbacks from users who participated in our experiment, with qualitative feedback (in which environment they feel they traveled more) and quantitative feedback (in which environment they actually traveled more). Obviously, users should not know that the environments are exactly similar, in order not to bias their perception.

STATE OF THE ART

This theme is not new. There have already been quite a few experiments and researches led around perceiving distances in virtual environments.

For example, paper n°1* talks about how using a similar method, except it was using Head-Mounted Displays, they asked a group of 50 person to sketch the layout of rooms, guess their dimensions and draw their path. Using their result, they drew a lot of statistic, from which we can find the distance estimations. They computed the difference between estimated distance and actual distance. While participants always overestimated distances, they actually overestimated them more in an unfurnished environment. As for sizes perception, participants thought of smaller sizes in an unfurnished environment than in a furnished one.

Furnishing condition	Distance estimation	Size perception
Furnished	0.411	-1.138
Unfurnished	0.474	-1.645

This study shows that people tend to overestimate distances, but underestimate sizes and volumes. They tried to find a segment of one meter or equal to their size and compute the distances and the sizes using this estimation. This can explain why there has been almost no impact on the distances evaluation but had one on sizes evaluation. When asking to participants which intent suited each room (bathroom, kitchen …), they gave more accurate answers in furnished environment. The authors of the paper identified three factors that can impact distances and sizes perception, which are: cognitive profile, furnishing and navigation speed.

Paper n°2* adds a lot of new questionings about virtual environments, such as the shape of the character. This can also influence the user’s perspective, its appreciation of distances and accuracy, or its ability to manipulate an object. The paper talks about the techniques that can be used to perform simple tasks in these virtual environments and the difficulty to put up a single universal method.

DESIGN

In my experiment, I chose to use a path in the shape of a zero. Users start on a side of the zero and are forced to follow the path, as there will be a wall to prevent them just turning back and reaching the end. For the simple environment, wall and floor are of a simple white/grey texture. The interactive elements are green, and the end element is red. For the decorated environment, we see different textures for the walls and the floor. There are also a lot of elements which decorate the borders of the path. Some of them are animated.

When users reach the end, a message appears on their screen, with the traveled distance printed in an encrypted form. The data collection strategy consists on asking users to give me this encrypted distance as well as their impressions and feelings. It only relies on will, and no data is kept inside the program or sent to any server. After that, information is only kept in an anonymous spreadsheet, in order for me to analyze the results. When the experiment will be over, user data will be deleted.

Since I have to give users the program directly, I warn them about epilepsy, and about the data collection strategy.

IMPLEMENTATION

One of the big problems I had to face was: How can I get a numerical value of the actual distance traveled by the user? I had to do a bit of research, and I found a way to do it. What happens now in the application is, whenever something is updated, we compute the distance between the current position of the user and his previous position. Then we add this distance to the total distance traveled.

A second challenge that I have been faced with was: How to recover this distance traveled by the user, without him being biased by the numbers and respecting my data policy. I had to find a way to get the data, without it being stored anywhere but in my data sheet. So, I thought about printing it on the screen. But the user would be biased when we ask him in which environment, he thought traveled the longer distance if he saw the numbers prior to the question. To overcome this difficulty, I thought about encrypting the data using a simple Caesar cypher. In the end, the user won't be able to understand the distance traveled, but I can ask him to tell me what is written, and I can decipher it to analyze my experiment results.

EVALUATION

As a direct result of my experiment, I gathered the data and feelings of my participants into a spreadsheet. Following is a copy of it. Environment 0 is the unfurnished one and environment 1 is the furnished one. The distances collected here are the translation of the output that is shown on the user's screen, so they didn't know their results during the experiment.

Env in which distance felt the longest	0	0	0	0	0
Real distance traveled in environment 0	26,25	23,18	8,443	9,6	8,2
Real distance traveled in environment 1	10,66	11,9	9,1	9,9	12,3
DELTA d0 - d1	15,59	11,28	-0,657	-0,3	-4,1

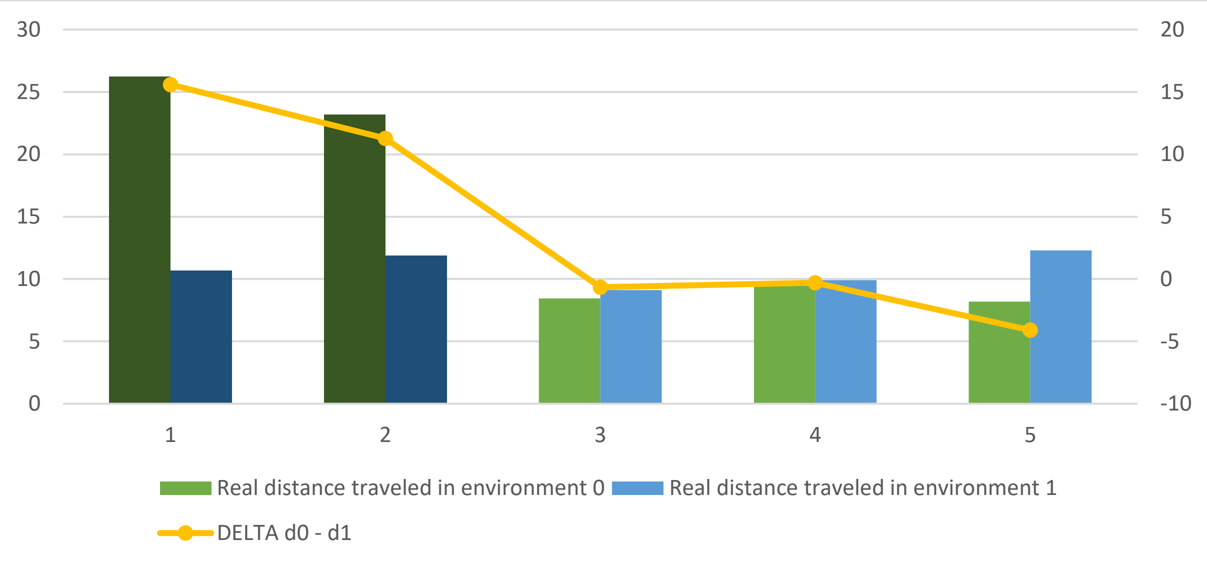
As we can see, all the subjects said they felt they traveled a bigger distance in the unfurnished environment. I also computed the difference between the actual distances traveled in environment 0 and 1.

DISCUSSION

For test subjects 1 and 2, I just gave them the two experiments. But for subjects 3 to 5, I thought I would avoid experience bias, which is when the subject uses one experiment to get used to the system and is more at ease in the second one, by making them first train on an example environment that has been given to us with the instructions for the experiments. Of course, this test environment is completely different than my environments in terms of distance, shape and furniture.

As we can see, the delta is positive without training, which means the subjects actually traveled a bigger distance in the unfurnished environment, and the delta is negative when they have been trained.

I gathered all my results in a graph, which copy you can find as follows.



While every subject affirmed feeling a bigger distance in the unfurnished environment compared to the furnished one, actual distance computed shows things differently. Subjects that did not train actually traveled a bigger distance, which is comprehensible because they had to get used to the controls and they did that in the first experiment. Subjects that trained however showed the opposite results, as they traveled a bigger distance in the furnished environment.

CONCLUSION

Based on the first experiment, which was to determine whether the furnishing of a scene had an impact of the user's perception of distances or not, we can validate our tested hypothesis: "<u>Users of virtual environments can better estimate distance in a more visually enriched scene</u>".

Based on my deltas observation, I can emit a new hypothesis: "<u>Visual enrichment of a scene has a greater impact on user's perception of distances than seeing itself travel the distance</u>".

This could be a possible future work to do in order to improve the accuracy of the results.

Moreover, I did not have enough participants to draw normal statistics (Shapiro-Wilk test, p-value test…). These results may thus not be representative of the global population.

Then, I did not interact with the sound at all. Some users were alone, some were surrounded by family or pets and some live in places where there is a lot of circulation outside. All of these are noises that could perturbate their perception. The experiments produce no sounds, but it could produce some to determine more accurate locations, or it could have a background music that could focus the user's hearing sense.

As for the environing sounds, I did not have a role to play in the environing light. As a lot of studies showed, we tend to evaluate less accurately distances when light level is low. I couldn't verify the ambient luminosity for each user's environment, nor their screen brightness, which are two more points of differences.

Finally, the controls of the experiments could be changed. Adding support for a gamepad could be a good idea, as it feels more natural for a lot of people to control a character in a virtual environment with a gamepad rather than with a mouse and a keyboard. As for people who are more used to keyboards and mice, there also was a problem in the controls, as the camera control with the mouse was very difficult and too sensitive.

One way to improve this experiment would be to gather more test subjects, in a controlled environment, with a constant ambient light, a constant screen brightness, a constant sound or a high-end reducing noise headset, and reworked controls.

BIBLIOGRAPHY

Paper n°1 :
https://www.researchgate.net/publication/283206503_Evaluation_of_Factors_Affecting_Distance_Perception_in_Immersive_Virtual_Environments_During_Virtual_Visits_of_Houses

Paper n°2: https://onlinelibrary.wiley.com/doi/abs/10.1111/1467-8659.00252