

Understanding Virtual reality

What are the fundamental concepts one should understand if they are to design for virtual reality? What are the limitations and drawbacks of the medium?

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01 Introduction

This research project is about understanding how to design for Virtual Reality and hence understand Virtual Reality. This project is exploratory in nature. VR is not a new medium, but its popularity and accessibility are new. Like all new media, we have a new set of constraints and concepts to deal with, if we were designing for the mentioned media.

Virtual reality is a simulated experience that could be a new reality or modifying the reality we know. By taking over our senses and providing stimuli, we create a new environment that only exists in our minds yet feels real.

Virtual reality has existed for a while now and has been being developed over a long time. The use of VR has been prevalent in flight simulation and other industries. However, due to recent improvements, the head-mounted displays can be mass-produced at a relatively cheaper price point. This opened a whole era for virtual reality as it entered the entertainment market.

This exploration is largely based on a book by Jason Jerald named The VR Book.

02 Exploratory Question

What are the fundamental concepts one should understand if they are to design for virtual reality? What are the limitations and drawbacks of the medium?

03 Analysis

3.1 Various Realities

There is a spectrum of reality that we need to understand when we talk about virtual realities. On one end, we have the real world, and on the other is a virtual world.

The real world or real environment is the space or reality we live in. It is essential to understand how we perceive and interact with the real world in order to replicate it.

Augmented reality or better known as AR, is a modified version of reality. We add cues using virtual elements to the real world. Ideally, the virtual elements should be indistinguishable from the real world.

Augmented virtuality is the opposite of augmented reality, where we add real-world elements to a virtual world. A good example is VR films.

Virtual reality or virtual environments are realities that are entirely made from scratch. No real-world elements are used, and the person in it should feel as if they in an entirely different world.

3.2 Communication

Virtual realities are entirely about communication since we take over the senses and convey information. We not only convey how the world looks or the other physical attributes of the world but also how it

works. In an ideal case of Virtual Reality, the machine or the system and the human are one being.

There are various kinds of communication that need to be established between the human and the system to create a virtual reality. We need to convey the structural information, which is not only how the world looks like but also how it interacts with itself.

Then we need to convey the visceral information, which is more abstract and has to do with the feel of the content. And lastly, there is the indirect communication which deals with what the user thinks of the reality and how they interact with the world.

3.3 Reality Systems

There are various systems one can use to communicate virtual realities. We can choose which senses to take over to build our experiences.

In the case of visual displays, we have three options a head-mounted display, world-fixed displays, or hand-held displays. Head-mounted displays are as the name suggests a helmet or goggles with screens that we wear on our heads. As the display moves with the head, for the images to be stable, position and orientation tracking are required. Head-mounted displays offer the most exceptional immersion of all the options and the most common way of consuming VR. World-fixed displays are multiple displays or curved displays around the user. The downsides are that it needs to be a room and very large displays. Lastly, there are hand-held displays, phones, and such. They

are great for AR and easy to access. However, they lack the processing power and position tracking. For audio, there are various forms of spatialized audio that we can take advantage of. The use of headphones with head-mounted displays is a widespread setup.

Haptics is another essential sense to engage. There are two ways one can do so. One way is to create a replica of the structure in the virtual world in the real world. Another way is through vibrations in controllers or gloves or some form of equipment. There is also self grounded haptics where we can have an equipment that pushes or pulls like exoskeletons and world grounded haptics where the device is attached to the physical world. Like the physical bikes, we have in arcades. We control the virtual bike using a physical replica of it. This gives us a sense of weight and force.

There are also motion platforms like treadmills and multi-directional treadmills to provide us with a sense of movement and also improve immersion.

There are other senses we can take advantage of to create more immersive experiences; however, they tend to be more specialized and require unique equipment.

3.3 Immersion

Immersion is the most crucial aspect of virtual reality. There is a lot that goes into achieving immersion, although we never truly achieve it. Since the user

always knows that it's a virtual world. Even still, without immersion, virtual worlds break. We need to think about how extensive our reality system is. If the visual matches the movement and interactions. The feeling of being surrounded by a virtual world achieved by a 360-degree view and spatialized audio. Quality of the video and audio. The interactability and response of the virtual world and the consistency of the world with everything else. Through immersion, we can create a sense of presence for the user in the virtual world. Which is the ultimate goal of virtual reality and the closest it can get to reality. A break in presence can ruin a virtual experience. Although it is unavoidable, as it has to do with reality, we can get pretty close. Asking users to turn off phones, keep quiet, and use VR in an uncluttered area is vital to maintain the presence achieved.

Since we are aware of the world, bringing virtual a great way to elevate the illusion of presence is by physical structures, like having a chair in the same spot as in VR and the real world. For example, VR home, it is the space where you can choose what game to play or app to start. Additionally, you can watch surf the web and more. If we were to recreate the structure of the real room in the VR room, as in, put a virtual sofa where there is a sofa in the real world, etc. The ability to sit in this VR space can make the user feel as if it was the real world.

One of the negative sides of presence is the uncanny valley. It's the point where everything seems real, but you know it isn't. A great way to avoid it is not to create photorealistic content. However, this doesn't nec-

essarily mean a loss of presence as long as there is some sense to it.

Perception

Although a computer generates the virtual world, it is built because of how we see it. Since a virtual world is built with illusions and illusions are built on how we perceive things, it is vital to understand how we process information. The foundation of this point is that reality is subjective. However, there are patterns that occur and help us live in the same reality. Perception is not only limited to the visual plane but also space and time. Sensory cues are necessary to avoid unintended illusions that are too far from illusions occurring in the real world.

04 Health Effects

4.1 Motion Sickness

Motion sickness is a prevalent thing to come by in Virtual reality systems. There are various ways one can get motion sickness while in a virtual world simulator. Motion sickness primarily occurs because of the mismatch of the motion that we visually perceive but not feel it. Latency could be a factor. If we move our head and the world moves as well, this is called scene motion. Motion sickness is most common when there is some form of acceleration or constant change of velocity in the virtual world. A simple, consistent walk is less likely to cause motion sickness even though we aren't moving in the real world. However, if we are swimming, since there are more directions we can travel and involves a lot of jerking and direction change, we are very likely to get motion sickness.

Contrary to popular belief, if we add head bobbing to a walking animation, in the case of VR, it will most likely cause motion sickness. Angular motion is a lot harder for our bodies to understand than linear motion. Motion sickness occurs because our bodies are trying to maintain postural stability. However, due to the varying received stimuli and expected stimuli, our bodies do not know what to do to maintain posture or that thinks it needs to do something, but in reality, nothing needs to be done.

4.2 Eye Strain

Flicker is a common cause of eye strain. It can cause eye fatigue, nausea, headache, etc. Flicker is a technological hurdle as it mostly happens to low refresh rates. In VR, it is crucial to think about eye strain as the device is usually really close to our eyes. Also, since we are immersed in the experience, we are more susceptible. Like we are more vulnerable to photic seizure, which is caused by flashing lights. There is also binocular occlusion conflict when we perceive something at a distance behind something and yet can see it. This is very common in first-person games with HUD UI that are ported to VR.

05 Hardware Issues

As virtual reality is a motion intensive platform, physical fatigue is a common issue. Fatigue can also be caused by an improper center of mass of the head-mounted display or controllers. It is crucial to keep gestures simple to reduce motion and hence reduce fatigue. This very well illustrated in a comedy video by college humor, where they make fun of a fictional augmented reality computer. The ergonomics of head-mounted displays are a major concern, as they need to tight-fit as the user needs to move around. Also, we need to keep the surroundings in mind while experiencing a virtual world because we still exist in the real world, which may lead to physical injury. We also need to maintain hygiene as most devices are on our face and heavy, leading to sweating built up, which created ideal conditions for micro-organism growth.

06 Content Creation

When creating content for virtual worlds, consistency is very important. We need to create an engaging world, and lack of consistency can break presence. Basic structures need to be self-explanatory. Pathfinding should be natural and subtle, or apparent cues should be provided as a waste of time in VR could lead to motion sickness and eye strain. We should refrain from adding additional information, which has little to do with the primary goal of the experience. Goals should be clear and easily understandable. It can lead to a waste of time and a break in presence. It is also important to create challenging and rewarding activities to maintain a sense of presence through engagement.

Since we are creating a new world, the fundamental structure of the space around us is very important. We can use light to help in pathfinding convey visceral information and more. Audio cues are just as important as they are in the real world. If we do not have audio, the user is basically deaf in this virtual world. However, we need to keep in mind not to overwhelm the user with sound as well. The audio needs to match the world.

07 Interaction

Interaction in virtual reality is very unique. We can have interactions that are similar to the real world, or we can have a totally new way of interacting. To design interactions for a virtual world, we need to consider various frames. The space around us in the real world, as that would limit movement. The frame of the virtual space as that is what we need to interact with. The frames of the human body, the structure of the hand and torso. The position of the head and the eye line. We need to use these frames as a reference while creating interactions. Gestures are a suitable mode of interaction in VR. It also helps keep the immersion. As pressing doesn't give tactile feedback, however, our minds expect it. We need to provide appropriate feedback to all actions to maintain immersion.

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