Current Limitations of Virtual Reality Technology Regarding Human Senses

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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Spring, 2020

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Introduction

René Descartes, a French philosopher from the Seventeenth Century, once said "Cogito Ergo Sum," meaning "I think, therefore I am," in search for his identity. Similar to how the renowned philosopher once agonized over human identity, scientists have been searching for a way to mimic the world in a completely new environment using advanced technology: virtual reality. However, scientists first had to figure out the difference between the real world and the virtual world before mimicking the world by creating a new environment. Among many factors, human perception has been considered the most important factor to differentiate real world and virtual world. Current virtual reality system in the market mainly utilizes headset with sight and hearing, and motion sensor to provide users with interactive experience. Although using headsets give users sight and hearing, other human senses cannot be utilized to give a full real-world experience. Therefore, focusing on limitations of current virtual reality system is important in order to implement other human perception in virtual reality, which could possibly provide a better virtual world experience. In process of finding an answer, a paradigm shift works as a main STS framework to find out the actual limitations of the current virtual reality system and possible solutions to overcome the limitations.

Research Question and Methods

What are the limitations in implementing basic human senses such as touch, smell, and taste in current virtual reality systems? Virtual reality is a fairly new field of study, and for that reason, so-called virtual reality ready equipment such as Oculus Rift and HTC Vive on the market only uses two human perception: sight and hearing. By having users interact with the created virtual world through headset, the users become immersive in a way with the created world. However, current technology does not allow full-immersive virtual reality that is

portrayed in several different media, where users would feel exactly the same in virtual world as how they feel in real world. Doing case study analysis with pre-existing technologies could lead to a possible alternative solution to improve usability and suggest a basic idea about what problems current technology possesses. For this reason, case study analysis with current existing technology is utilized to find out how current technology could be tweaked and used to improve human perception in virtual reality. Technology in other fields could be a hint to implement human perception in virtual reality. Two case studies are used to relate Brain Computer Interface to virtual reality and suggest possible solutions. The first case study is virtual reality sound testing with cochlear implant users to test visual feedback and response time. The second case study is brain computer interface stimulation to provide touch feeling back to amputee and paralyzed individuals.

Background Information

According to statistics gathered by International Data Corporation (2019), the expected world-wide market size for virtual reality is approximately 16.8 billion U.S. dollars, and is further expected to grow to 160 billion dollars by 2023. The virtual reality market is rapidly growing, and will not stop growing in near future according to the data. Such increase in market size demonstrates the importance of virtual reality technology in the near future.

After investigating the different user experiences between physical reality and virtual reality, a group of researchers, Fraser et al. (2000), suggested several limitations that cause the difference. According to the researchers, possible problems in virtual reality include network delays, haptic feedback, and limited field-of-view. The researchers claim that negated problems in virtual reality indeed cause broader effects on users with their usage of virtual world. Another group of researchers, Durlach et al. (1995), performed detailed research on requirements of

virtual reality, such as psychological requirements, visual channel, audio channel, haptic interface, position tracking and mapping, motion sensor, computer hardware and software, networks, and other interface components in order to implement virtual reality. All these requirements are related to, or have been used to build a current virtual reality system with two human senses: sight and hearing.

There are many factors that differentiate virtual reality and the real world. Among all those factors, human senses are considered the most important factors. Unfortunately, limitations of current technology do not allow other senses such as smell, taste, and touch to be utilized in the virtual world. Once virtual world utilizes all five senses, a boundary between the real world and virtual reality would collapse, and cause a paradigm shift.

Hearing and sight implementation for virtual reality is far from perfect at the moment. Audio channel on virtual reality headset only sends a digital two channel signal and visual screen just sends image displayed on the pixel. There is also no known information regarding virtual reality and future technologies to implement five senses other than hearing and sight.

STS Framework

Paradigm shift is not a distant definition to virtual reality, but rather a familiar concept with virtual reality's rapid growth and change in importance. According to Thomas Kuhn (1962), paradigm shifts are not considered revolution, but rather as addition to the knowledge. Once a new technology is established in relation to brain computer interface that controls five senses, there would be a major paradigm shift for virtual reality, with people not able to differentiate between virtual reality and the real world. However, there are scholars who criticize Thomas Kuhn's idea, paradigm shift. According to British philosopher Martin Cohen, paradigm shift

does not give much benefits to specific fields of study, because it does not explain any phenomena or give a definitive conclusion regarding how society has changed (2015).

Results and Discussion

The main problem with current virtual reality systems is that not all five human senses are utilized. The available technology for virtual reality systems only integrate sight and sound, representing two of the five human senses. Also, even two provided senses: sight and hearing are not considered optimal implementations. According to data gathered by Trendforce, PlayStation VR, Oculus Rift, and HTC Vive are the three most popular virtual reality devices in the 2019 VR market (2019). The three most popular virtual reality instruments in the market have a similarity in their products: they all use similar setups for their virtual reality system. All three products consist of virtual reality head-mounted display, controllers, and motion sensors, which do not incorporate other three human senses in VR.

Head-mounted display is the most common currently available method of virtual reality. Motion sensors detect movements provided by controllers and interact with the user, while the head-mounted display provides vision and hearing to the virtual reality system. However, the headset is considered heavy varying from 555g in the lightest to more than 900g in weight, which provides a poor usability. Moreover, Edd Gent, a science and technology journalist, wrote an article that emphasizes the potential risk that the virtual reality headset possesses to children. According to the article, virtual reality gives a negative physical impact to rats for spatial learning, and has no long-term research associated with the headset regarding its harm (2016). Although there is no guarantee that virtual reality would have the same negative impact on human beings, users of the headset must put their eyes very close to the screen unlike looking at monitors or screens from a distance. Widely used head-mounted displays clearly have

limitations, because of its nature of being heavy weight and having no research associated with wellness of using the head mounted display.

In order to overcome current limitations of virtual reality, the human brain must take part in implementing basic human senses. Although it is well known that the human brain controls the human body, not every detail of the brain is known to scientists yet, despite advancement in science. The human brain is a very complicated organ, and consists of many different parts. According to Brett Szymik, biologist of Arizona State University, movement of body and smell are associated with frontal lobe, touch, taste, and body awareness are associated with parietal lobe, hearing is associated with temporal lobe, and sight is associated with occipital lobe of the brain (2011). Throughout the decades in the twentieth century, scientists found out what part of the brain interact with specific human sense, however, implementing a whole new virtual reality system that utilizes each part of the brain to create a new world is rather unrealistic and not practical until there is a technology that supports interaction between specific part of the brain and digitalized human senses. For this reason, using brain computer interface to overcome limitations of current virtual reality systems must be approached carefully and only utilize brain computer interface technologies that already exist and could be applied to virtual reality.

The National Institute on Deafness and other Communication Disorder (NIDCD) defines cochlear implant as "… a small, complex electronic device that can help to provide a sense of sound to a person who is profoundly deaf or severely hard-of-hearing." (2018). A cochlear implant is not something that a normal person could do as it requires surgical procedures, and only could be performed for those who have very limited hearing ability. Surprisingly, this technology could potentially be utilized to overcome limitations of virtual reality systems. A virtual reality headset utilizes headphones to be attached to the ears in order to receive sound.

However, a cochlear implant sends digital signals directly to the auditory nerve from an internal processing device, which does not require headphones. Sechler et al., a group of researchers and computer scientists, published a research that tests sound localization of cochlear implant users using virtual reality. Although participants with cochlear implant had a slower response time than a normal user, they still were able to localize where the sound was coming from. If scientists are able to find a way to convert sound signals to electrical pulses and send directly to the brain, users would be able to use virtual reality gears without any outside gears, while having signals as if they are hearing in the real world. Using virtual reality without any outside equipment is very important as it lifts the limitations of virtual reality while using one of the basic human senses.

There are many more human senses other than sight and hearing. However, touch allows people to have control of their own body. Unfortunately, this is not the case for current virtual reality systems. Users are given with two controllers and few buttons to fill out necessary information. Brain computer interface again could be a solution to overcome this limitation. University Washington published a research paper in 2016 regarding direct stimulation to provide touch feeling using brain computer interface. People with serious injuries such as amputees and paralysis no longer have a feeling in their body parts. Researchers at University of Washington directly wired participant's brain to give electric signals controlled by a computer, which the participants were able to recover their touch with the given signal on the brain. This case study allowed paralyzed participants to recover their touch feelings with given aid, and when this technology is applied to virtual reality, people could be able feel touch while not doing anything.

Unfortunately, technologies such as cochlear implant and brain computer interface are not available to be applied to virtual reality. Current limitations of virtual reality are mainly caused by restriction of technology. For this reason, lifting limitations in virtual reality will not be practical until scientists develop viable technology to support the other human senses. Scientists will be able to find a solution to apply other human senses to virtual reality in the distant future.

Conclusion

Current virtual reality systems are limited and flawed by nature of its own technology; however, the system could improve when it is connected with brain computer interface. A cochlear implant and a brain surface stimulation are only two examples, but when the singularity comes, virtual reality will be in people's daily life. People would no longer be able to differentiate between real world and virtual world: a paradigm shift. Although it would take a long time to develop such technology, Brain Computer Interface will surely be the main framework for newly born virtual reality with limitations lifted.

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