Ethical Challenges of Digital Immersive and VR

Dr. Robin Kabha

ABSTRACT

The paper discusses the development of virtual reality technologies starting by laying a foundation of the conceptualisation of the inspiration of the concept itself. Ranging from ancient panoramic portraits, the early devices which attempted to immersive the user in the media they were presenting. This eventually led to the development of progressively advanced technologies further catalysed by the advent of exponential computer advancement. There are three current categories of devices which are present in the market today regarding immersive virtual reality. The ethical implications in various themes are explored; the critical aspect that was identified is the concept of choice. "Choice" is the main factor which directs the use of these technologies which by themselves are benign.

Keywords**: HMD: Head Mounted Display, VR: Virtual Reality, Immersive VR Ethics**

Introduction

The introduction of new technologies and developments can often serve to introduce new aspects and dynamics into the everyday life of humans. With the advent of these new dynamics, there is an element of considerable uncertainty. This uncertainty has the potential to fuel conjecture, which due to a lack of understanding of these novel introductions can lead to potentially harmful or unwanted consequences. If one does not have a foundational understanding of the technologies, then one cannot critically appraise the different aspects of said technologies. To properly establish a base understanding of virtual reality and immersive technologies, this paper will first introduce the concept and explain its workings. This familiarisation with the background material will have the function of introducing unfamiliar readers with the aspects of virtual reality and immersive technologies. The paper will then proceed to the aspect of exploring the ethical issues that are present in virtual reality and immersive technologies and the additional issues that can probabilistically arise in the future.

Aims and Objectives

This research paper aims to explore the ethical issues related to the field of immersive virtual reality technologies. The objective of the paper is to examine the issues to ascertain better the potential ethical consequences and what their possible ramifications may be in the present as well as the near future.

Research Justification

As the mass adoption of these technologies is only a contemporary development, it has not been extensively explored; therefore it would be prudent to explore these issues so that there is better preparation beforehand.

Methodology

This section will briefly describe the methodology to be utilised in the endeavour.

Research Methodology

The research will be executed through secondary research mixed interpretative method through the use of scholarly literature to ascertain the main themes that present themselves in these articles. A summarisation of each article will not be presented. Instead, the gist of the article and what was gleaned from it will be presented. Each theme will contain an essence of the significant issues which will be further analysed in their sub-sections.

Virtual Reality and Immersive Technologies

Introduction

This part will comprise of a descriptive piece to lay a foundational knowledge base of the virtual reality and immersive technologies. While it is possible to get a general idea from reading the word, it is this very aspect that is the cause of the inherent confusion itself. As the terms themselves are not very focused, instead utilising a general description of the idea that is being conveyed. This can lead to a lack of standard communicational terms between people, as every person will have a different view of what these technologies comprise of. This variation of understandings

is often derived from each's own experiences and exposure to different situations and their range of knowledge with these technologies.

The term itself is very expansive and is very broad and all-encompassing. This is evident from the term itself, as the descriptive lexicon points towards the technologies which aim to create virtual realities or interface the virtual entities or elements into reality itself. This melding of the real and physical world is most commonly referred to as Augmented Reality (AR) (Carmigniani et al., 2011).

History

The concept of virtual reality has existed for quite some time; the inspiration for the concept of virtual reality can be conjectured to have arisen from early panoramic paintings. These paintings were created with the intention of covering the entire field of vision of the observer to create a sensation of being physically present at the location itself. As early as the 1800s the invention of the stereoscope which used two mirrors to project an image served to further increase the reach towards total immersive experiences, the device is still produced today and is a popular children's entertainment toy (Zone, 2014). The field began its rapid advancements with the development of electronics and computer technologies. The "Link Trainer" can be considered the first real flight simulator. This was a considerable advancement, as the United States military purchased six of these devices for training pilots safely, and during the Second World War, over ten thousand devices were used to train over five hundred thousand pilots (Allerton, 2010).

The concept as described by the author Stanley G. in his story "Pygmalion's Spectacles" which introduced the idea of a pair of goggles that allowed the user to experience a virtual world utilising their physical senses (Weinbaum, 2016). This concept itself is very similar to contemporary virtual reality devices. While devices being developed currently are not as impressive as the aforementioned concept, being limited to visual and auditory simulations, they do nonetheless hold that concept as an eventual goal to be reached. The "Sensorama" which featured an arcade-style cabinet that aimed to stimulate all the senses. It utilised stereo speakers, a stereoscopic display, a smell generation device and vibrating chair (Boas, 2013). In the 1960s the "Telesphere Mask" introduced the first example of a Head Mounted Display (HMD), contemporary immersive virtual reality devices closely resemble this format (Flores-Arredondo et al., 2015).

In the following year (1961) the device known as "Head sight" incorporated motion tracking into the display, featuring separate screens for each eye. It was originally developed to allow for remote viewing of dangerous locations by the military (Żmigrodzka, 2017). In 1965 Ivan Sutherland described the concept of "Ultimate Display" which aimed to simulate reality to a point where the simulation would be indescribable to the real world. The concept included the use of an HMD supplemented with 3d audio and tactile feedback, the ability to allow the user to interact with objects in the virtual world as realistically as possible and advanced computer hardware to compute the virtual world. As Sutherland himself put it "The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming, such a display could literally be the Wonderland into which Alice walked" (Ivan, 1965, p.2).

The concept of such a realistic scenario was impossible at the time and remains so, as the manipulation of matter to such a large and precise degree would require technologies that do not exist yet (Fluke et al., 2016).The "Sword of Damocles" eventually served as a proof of concept but was too heavy and cumbersome to use and could render primitive wireframe graphics (Boas, 2013). The term virtual reality itself was formulated in 1987 by Jaron Lanier, who developed a range of virtual reality gear such as the Data Glove and Eye Phone (Dekate et al., 2014).The mass public had access to virtual reality devices in the form of arcade machines in 1991, but these were still primitive (King et al., 2010). In 1995 Nintendo launched the "Virtual Boy", which at this point was the first video game console that was portable and capable of displaying 3D graphics (Chavan, 2014).

The concept of virtual reality reached enormous popularity with the advent of a

science fiction movie called "The Matrix", in which the characters resided in a completely virtual world simulated to such precise levels that it was identical to the real world and the character being totally unaware of this. This movie introduced the concept of virtual reality to a massive audience and had a significant cultural impact which still resonates in the contemporary world (Jurgenson, 2011). The rapid development of computers and advancement in technologies would further catalyse the development of virtual reality technologies in the 21st century (Koomey et al., 2011). This will be discussed in the next subsection.

Present

As the technological sector underwent exponential growth and advancement, the capabilities of computers grew. Computers started getting smaller in size, consume less power and featured increasingly greater processing capabilities (Strawn & Strawn, 2015).All of these factors have allowed the development of features which would have been impossible in the previous decades. The decreasing size allowed devices to shrink in size and become more portable and less encumber some relatively to their earlier counterparts. The decreased power consumption requirements permitted the use of mobile power sources and reduced heat generation along with the reduced cost of operation. The increase in computations power allowed for the simulations of increasingly complex environments in both depth and scale. There are currently several devices in the market. The majority of these devices share a similar theme of an HMD consisting of individual displays for each eye and are accompanied by stereo headphones (Kress & Starner, 2013). This subsection will introduce the most prevalent devices that are in the contemporary market. This is not an exhaustive list of all the devices, and thus several devices or systems which are highly obscure or niche may not get listed.

It can be reasonably argued that the current trend of virtual reality headset was catalysed with the introduction of the HMD known as the "Oculus Rift". Developed by Palmer Luckey who was frustrated by the limitations of the head-mounted displays at the time (Davis et al., 2015). The issues ranged from lack of technical features and hefty price tags which made them unaffordable to the average users. He experimented with old HMD hardware purchasing them through varying avenues like auctions. Eventually, a prototype was created (Branda, 2015). It caught the attention of John Carmack who used it to display proof of concept at a gaming show. This introduction of an affordable HMD with capabilities which significantly achieved the ideas of virtual reality devices from the earlier decades to such a high degree caught the public's attention (Kushner, 2014). After this, each large tech giant company from Microsoft to Sony started development of their own HMD. The virtual reality craze had begun, and everyone wanted to be a part of it (Hecht, 2016).There are many significant challenges in developing a reliable HMD, but these are outside the scope of this paper, this will not be explored in depth except where they are pertinent to the topic of the paper itself.

The devices present on the market today have a wide range and variety of features and capabilities. There are currently three main categories in which they can be divided into specific characteristics that set them apart from each other. Following are the categories and a brief list of devices that fall under the categories as mentioned earlier.

Mobile/ Budget Devices

These devices utilise relatively inexpensive hardware to serve the function of an HMD. As such they are very primitive and lack the finesse of a dedicated HMD. The most common among these consist of an apparatus to house a display, like a phone, and through the use of software and the hardware of the phone, like accelerometers to mimic HMD. As the devices are makeshift and the phones are not developed to deal with the processing power required to function as an HMD device they only give a very rough experience compared to higher-end devices. These can be considered entry market devices which allow users to "get a taste a taste for the real thing" (Kuo et al., 2013).

Mainstream Consumer dedicated Devices

This is the category where the majority of the devices related to HMDs fall. These can be considered true HMDs, unlike the previous category. These devices are specifically designed to work as HMDs, and their specification reflects this. They are larger and

require a considerable amount of computational power to perform their jobs. The computational power is so significant that a large number of consumer computers struggle to operate at satisfactory levels. The most commonly known devices in this category are the Oculus Rift (LaValle et al., 2014), HTC Vive (Dempsey, 2016) and PlayStation VR (Jerald et al., 2017). The downsides to these devices are that they are cumbersome to use and typically require a thick wire connect to the device itself to transfer the data from the computational device to the display. Devices themselves are large and significantly increase awkwardness of movement due to a heavy and large object being directly strapped to the face (Schuchert et al., 2012).

High End/ Bleeding Edge

These devices consist of the latest and greatest technological innovation. Utilising cutting development and experimentation to produce HMDs that are highly specialised to serve a specific function. These are most commonly employed by organisations that have access to a large amount of financial resources. Some examples of these would include pilot training modules used by the United States military. Handling of sensitive materials by Biopharmaceutical companies and so on. It is through these developments that further advancements are made in the consumer market section. As the nature of this category is subject to obscurity and information is not as common, this will not be explored in great depth. The issues pertinent to this category will be however explored, and their ramifications and implications will be presented as well (Blascovich et al., 2011).

Future

Based on the development trends of the past and present that have occurred in this area, it can be reasonably assessed what future advances might occur. While these projections are based on real-world data, they cannot take into account the nature of spontaneous events or unforeseen technical advances. Such factors can render predictions inaccurate to a varying degree based on the magnitude of the developments and the effects they have on the field as a whole. Therefore developments can be projected to mostly include advances on current technical capabilities, barring any huge leaps of discoveries (Smith, 2013).

Ethical Issues

This part will entail the ethical issues utilising the technologies described in the previous part providing background and context. The issues that will be established in this part will have their scopes limited to the technologies that are mentioned in the paper. While it would be possible to utilise the issues presented in other contexts, this paper will not attempt such an endeavour but will instead provide recommendation or suggestions into other avenues of investigation based on the current findings presented in this paper.

Privacy Concerns

Privacy is considered a fundamental human right. Each has a right to keep his personal life and information regarding it, private. As is the current case with the issues that are arising in the contemporary world regarding the privacy law concerns dealing with all things that fall into the digital realm, VR itself is subject to these concerns as well (Parent, 2017). It can be clearly defined as a computational device with advanced sensors and features required to make it properly function. The concern that is presented here is that just as the capabilities of the computational devices that are currently in use, like the personal computer and mobile phone are being used a means to gather information, with their consent or otherwise from a person; this would inexorably spread to VR devices as well.

HMDs commonly utilise advanced tracking technologies like cameras and other positioning devices to track the user and mirrors their actions in the virtual world. While these devices serve their technical function, they can also be used to spy on the user and utilised to data farm their personal information (Roesner et al., 2014). While there have been arguments made that if one is innocent, one would not need privacy (Solove, 2011). This argument while sound on the surface is inherently flawed. It fails to take into account the malicious intent of others and the degree to which an individual's personal information can be exploited against them (Solove, 2011). A significant example of this is bank-related fraud and blackmailing and extortion; all cases in which personal information is used against an individual and causes harm (Ogwueleka, 2011).

Psychological Influence

It has long been argued that the types of activities a person engages in can, in turn, have a psychological effect on said person. The argument that is being applied to in this scenario is the utilisation of an HMD, which aims to recreate the digital world as close to reality as possible would further dissolve the gap between the real and unreal (Shrum, 2012). This would, in theory, reduce a person's mental capability of separating the real world from the virtual world, this would be especially dangerous to children, as they are in their growing and development phase which could be heavily influenced towards an ethically negative mindset (Li, 2013).However, the main issue that presents itself in these cases is often the problem of correlation and causation and the concept of eventuality (Verhulst, 2012). While there have been several debates and scholarly arguments that have occurred regarding the subject arguing about the negative influence that can happen; there have also been arguments that have concluded that a normal developed human being can entertain ideas and concepts without being influenced by them.

As such the counter-argument rises that individuals who are pre-disposed to violent urges and or mentally ill would be victim to some other stimulus which would trigger their illness into surfacing, and as such the virtual world is only consequential to the event and not a cause (Ferguson at al., 2014).The argument being that eventually the individual would be triggered by something eventually. There is a counter-argument against this concept which states that one should then attempt to create an environment in which this is not possible. This concept is unfeasible due to two reasons; it would be impracticable to mark and categorise every single element and then "bubble wrap" it to protect vulnerable individuals, instead the use of psychological evaluation and therapy would greatly benefit these individuals (Slade, 2010) ; the process removing the potentially unsafe elements can be regarded as a violation of the rights of those who are capable of safely interacting with then (Odenweller et al., 2014). It can be thus concluded that there might be a need of reasonable expectation regarding the safekeeping of vulnerable individuals, it should not impact the functioning of those nor deprive them of their rights as an individual (Reus-Smit, 2013).

Social Isolation

As the development of applications and programs which significantly mimic social interaction takes place, some individuals may be prone to substituting their real-life interactions with that of the virtual world (Harrison et al., 2011). The reasons at the root of this can be multidimensional, varying from individual to individual depending on their attributes and psychological development (Schwartz et al., 2013). As the virtual world would provide an acceptable enough replica of social interaction, it may ill-adaptively used as a substitute for real socialising. This would lead to social isolation where an individual might slowly develop a preference for the virtual world (Brey, 2014). As the variables of a virtual world are highly controllable, it allows each to design and fabricate an imaginary world that would suit them personally based on their desires (Teng, 2010).The real world contrastingly is not subject to such a large degree of control on an individual level. Therefore it would be less attractive and could even serve to repulse an individual (Snodgrass et al., 2014). Drawing from this, it can be further argued that those who are seeking to regulate the use of virtual reality devices themselves significantly are serving as agents to make the real world like the virtual world. By appealing to the danger of potential psychological hurts and unwanted stimulus, they only end up recreating the safeties of the virtual world in the real world, mirroring the essence of the virtual world.

Potential Abuses

The abuse or misuse of virtual reality devices from an ethics standpoint is also a prevalent issue. The premise being that these devices could be utilised for nefarious purposes which might not be possible without the availability of said devices (Tsoupikova et al., 2015). As an inherent function of the devices themselves is to provide a believable and realistic simulation of sensory input into the body, it would be possible to argue that as the stimulus itself is based on fabricated data, no physical harm occurs. This aspect would be highly attractive to armed forces around the world. As no physical damage occurs, there could be a great deal of denial in any harm having occurred to an individual. As most armed forces are held

to a particular code of conduct in regards to how they deal with different situations. Almost all the countries of the world as of the writing of this paper have signed off on "Convention against Torture and Other Cruel, Inhuman or Degrading Treatment or Punishment (commonly known as the United Nations Convention against Torture (UNCAT)) " (Murray et al., 2011). The use of immersive virtual devices could be used to subject an individual to extremely distressing stimulus; one simple example is the induction of extreme motion sickness by confusing the signal processing of the brain utilising mixed signals (Treleaven et al., 2015).

Long Term Effects

As the contemporary devices have not been in use to such a large extent by such a vast number of people for extended periods. The ramifications of such actions cannot currently be accurately predicted. While conjecture and theories could be generated based on past and current knowledge as means of creating a probabilistic model of future prediction, it would not take into account the developments of the future that might take place (Carmigniani et al., 2011).

Potential Physical Hazards

The use of an HMD often requires the designers to create a balance between the immersion of the user in their virtual environment and the degree of awareness allowed regarding the real world. As the use of devices which render the physical senses of a human unable to ascertain the events of their surroundings is a potential physical danger. The most significant sense which suffers from this is sight; this is the consequence inherent to the design of the HMD itself. As the very quality of it is to immerse the user in a virtual environment, cutting them off from the real world (Sabelman et al., 2015).Hearing is the second sense which is effects depending on the extent of isolation that is employed by the user. While the general open back headphones allow sounds to bleed both outside from the inside the headphones and vice versa, closed back headphones or In-Ear Monitors (IEMs), are designed to use active or passive methods of cancelling or dulling out sounds from the outside world (Portnuff et al., 2011).

The primary consumer market does not currently have available a device for physical feedback from the environment apart from the use of haptic feedback motors which give small vibrational tactile feedbacks to convey the sense of touch in a virtual world; while there may exist some niche devices there not seem to be mainstream realistic physical feedback systems (Shahoian et al., 2012).The greatly reduce environmental awareness has several hazardous consequences for the users. This applies to both the stationary setup where the user does not move from their location and a mobile setup where the user has the added option of mobility. Both of these scenarios present respective dangers. The incapability of seeing the real world while wearing an HMD exposes the users to the risks that are associated with being unable to see (Howarth, 2011). While it may be argued that if used in a familiar environment and furthermore one which has been modified or designed in such a way as to remove objects which serve as a potential hazard could alleviate this problem to a significant degree the risk is still present.

One major issue that has presented itself early in the use of HMDs is the motion sickness that occurs in users. As in a virtual environment, that brain may be receiving stimuli which can be significantly different and not corresponding with the stimulus received from the other senses (Fernandes & Feiner, 2016). The most significant observation made in this regard is the great discrepancy that occurs in between the stimulus being received by the eyes and the stimulus of the inner ear tubes which serve to create a sense of balance. The inner ear tubes contain a fluid which uses the force of gravity acting upon to give the brain a sense of orientation about the body in relation to the earth. When the sense of sight provides the brain with an impression of movement, but this does not correlate with data arriving from the inner ear which is sending signals of being stationary, this causes the brain to get confused. The symptoms of this are collectively known as "motion sickness" (Keshavarz et al., 2014). It can be further argued that removing the awareness of the user from the environment will render them unable to detect potential hazards that occur, like natural hazards or accidents like fire. Developers have however undertaken some efforts by putting into place mechanisms to alleviate these issues. One such mechanism uses a camera placed on the device to show the outside world through varying opacity

ranges which get progressively higher the closer the user is to a physical obstruction, like a wall (Yao et al., 2014).

Unrealistic Expectations

The concept of development of unrealistic expectations that can occur with exposure to fictional or virtual environments is not new. It can be observed to have been occurring as far back as to the widespread adoption of written texts (Hazlett & Mag, 2011). The argument is that exposure to unrealistic or impossible ideas might influence the user into having an altered and inaccurate sense of reality. This can surface in the form of unrealistic confidence in possessing particular skills of abilities which they may have performed only in the virtual environment, or are impossible unfeasible in the real world (Bartle, 2011). The adult entertainment industry is also working to adopt VR into its strategy, planning to use it as a way to give an additional dimension of experience regarding their serves. Pornhub, a popular website for adult entertainment content has recently introduced a new category labelled "VR" porn. The material in this category is captured with specialised devices which capture the world in a 360-degree view, granting the user the freedom to move their view around for a more intimate experience (Alger, 2015). This is further compounded with the introduction of pornographic videogames (Wood et al., 2017).

The ethical argument that presents itself here is that the role that these pornographic materials already play will be further exacerbated with the factor of increased immersion (Hald et al., 2014).This would generate unrealistic sexual fantasies in the users, which would alter their sexual desires to such a degree that they might not be able to receive satisfaction from real life sexual activity. It is also argued that the use of pornography would create the mentality of women being treated as sex objects in the minds of men, thus creating a derogatory impression of women not as individuals but as sexual objects (Eberstadt & Layden, 2010).However, some research indicates that the sexual dysfunctions that are attributed to the consumption of pornographic content may be merely correlations and not causational. Under these findings, it is prudent to further explore the consumption of pornographic media and the psycho and physiological effects it might induce in both males and females (Park et al., 2016).

Reality Distortion

As the currently available immersive virtual reality devices lack the advanced capabilities of perfectly mimicking sensory input that the human body normally receives from the environment, the threat of reality distortion can be understood to lay in the future. However, as with the advancement of all technologies, it is very probable that a point will be reached in the future where the incremental upgrade to these technologies would allow for complete isolation from the real world and total immersion in the virtual world. The evidence of rapid technological development is further supported bythe advancement of the computers, which in a few decades have undergone exponential advancement in terms of their processing capabilities and reduction in size. A further argument arises if the virtual world can become as tangible as the real world that one might prefer to exist in a virtual environment instead. Though it might be argued that the virtual world is not real, but this is countered with the argument of perception, for if one's perception is all that they have, the real world may as well be the virtual world and vice versa (Moritz et al., 2014).

Conclusion

As the themes above each demonstrate that ethical implications that are exacerbated with the advent of technologies that bring an individual closer towards a virtual environment, it would be prudent to keep consistent watch on the developments and uses of these technologies. While several problematic aspects are identified, they can be effectively controlled through the use of responsible use-education. The attempt to completely eliminate these ethical issues is not possible, as the process of elimination itself would inexorably violate other ethics. In essence, the problem can be linked down to one singular factor, choice, upon whether an individual chooses to use these technologies in a manner which is either beneficial or has adverse effects. As such it can be conclusively said that the technology itself is benign; it is only the users who act as an agent utilising their power of choice to decide the outcome through its use.

References

Alger, M., 2015. Visual design methods for virtual reality. *Ravensbourne. http://aperturesciencellc.com/vr/VisualDesignMethodsforVR_MikeAlger.pdf*.

Allerton, D.J., 2010. The impact of flight simulation in aerospace. *The Aeronautical Journal*, *114* (1162), pp.747-756.

Bartle, R., 2011. Unrealistic expectations. Manchester: Manchester University press.

Blascovich, J. and Bailenson, J., 2011. *Infinite reality: Avatars, eternal life, new worlds, and the dawn of the virtual revolution*. William Morrow & Co.

Boas, Y.A.G.V., 2013, January. Overview of virtual reality technologies. In *Interactive Multimedia Conference* (Vol. 2013).

Branda, E., 2015. Oculus Rift.*Journal of the Society of Architectural Historians*. 74 (4) (pp. 526-528)

Brey, P., 2014. Virtual reality and computer simulation. *In Ethics and emerging technologies* (pp. 315-332). Palgrave Macmillan, London.

Carmigniani, J. and Furht, B., 2011. Augmented reality: an overview. In *Handbook of augmented reality* (pp. 3-46). Springer, New York, NY.

Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E. and Ivkovic, M., 2011. Augmented reality technologies, systems and applications. *Multimedia tools and applications*, *51* (1), pp.341-377.

Chavan, S.R., 2014. Augmented reality vs. virtual reality: differences and similarities. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET),* 5 (6) (pp. 1947-1952)

Davis, B.A., Bryla, K. and Benton, P.A., 2015. *Oculus Rift in action*. Shelter Island: Manning.

Dekate, A., Kamal, A. and Surekha, K.S., 2014, February. Magic Glove-wireless hand gesture hardware controller. In *2014 International Conference on Electronics and Communication Systems (ICECS)* (pp. 1-4). IEEE.

Dempsey, P., 2016. The teardown: HTC Vive VR headset. *Engineering & Technology*, *11* (7-8), pp.80-81.

Eberstadt, M. and Layden, M.A., 2010. The social costs of pornography. *Princeton, NJ: The Witherspoon Institute*.

Fernandes, A.S. and Feiner, S.K., 2016, March. Combating VR sickness through subtle dynamic field-of-view modification. In *2016 IEEE Symposium on 3D User Interfaces (3DUI)* (pp. 201-210). IEEE.

Flores-Arredondo, J.H. and Assad-Kottner, C., 2015. Virtual reality: a look into the past to fuel the future. *The Bulletin of the Royal College of Surgeons of England*, *97* (10), pp.424-426.

Fluke, C.J. and Barnes, D.G., 2018, June. The Ultimate Display. *In Astronomical Society of the Pacific Conference Series* (Vol. 512, p. 473).

Hald, G.M., Seaman, C. and Linz, D., 2014. Sexuality and pornography.

Harrison, G.W., Haruvy, E. and Rutström, E.E., 2011. Remarks on virtual world and virtual reality experiments. *Southern Economic Journal*, *78* (1), pp.87-94.

Hazlett, A. and Mag Uidhir, C., 2011. Unrealistic fictions. *American Philosophical Quarterly*, *48* (1), pp.33-46.

Hecht, J., 2016. Optical dreams, virtual reality. *Optics and Photonics News*, *27* (6), pp.24-31.

Howarth, P.A., 2011. Potential hazards of viewing 3-D stereoscopic television, cinema and computer games: a review. *Ophthalmic and Physiological Optics*, *31* (2), pp.111-122.

Ivan E. Sutherland, 1965. The Ultimate Display. Information Processing Techniques Office, ARPA, OSD.

Jurgenson, N., 2011. Digital dualism versus augmented reality. *The Society Pages*, *24*. Available at: https://thesocietypages.org/cyborgology/2011/02/24/digital-dualism-versus-augmented-reality/. Accessed on : 13-Martch-2019.

Keshavarz, B., Hecht, H. and Lawson, B.D., 2014. Visually induced motion sickness: causes, characteristics, and countermeasures. In *Handbook of virtual environments* (pp. 652-703). CRC Press.

King, D.L., Delfabbro, P.H. and Griffiths, M.D., 2010. The role of structural characteristics in problem video game playing: A review. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, *4* (1).

Koomey, J., Berard, S., Sanchez, M. and Wong, H., 2011. Implications of historical trends in the electrical efficiency of computing. *IEEE Annals of the History of Computing*, *33* (3), pp.46-54.

Kress, B. and Starner, T., 2013, May. A review of head-mounted displays (HMD) technologies and applications for consumer electronics. In *Proc. SPIE* (Vol. 8720, p. 87200A).

Kuo, C., Jeng, T. and Yang, I., 2013. An invisible head marker tracking system for indoor mobile augmented reality. *Automation in Construction*, *33*, pp.104-115.

Kushner, D., 2014. Virtual reality's moment. *IEEE Spectrum*, *51* (1), pp.34-37.

LaValle, S.M., Yershova, A., Katsev, M. and Antonov, M., 2014, May. Head tracking for the Oculus Rift. In *2014 IEEE International Conference on Robotics and Automation (ICRA)* (pp. 187-194). IEEE.

Li, W., Farkas, G., Duncan, G.J., Burchinal, M.R. and Vandell, D.L., 2013. Timing of high-quality child care and cognitive, language, and preacademic development. *Developmental psychology*, *49* (8), p.1440.

Moritz, S., Voigt, M., Köther, U., Leighton, L., Kjahili, B., Babur, Z., Jungclaussen, D., Veckenstedt, R. and Grzella, K., 2014. Can virtual reality reduce reality distortion? Impact of performance feedback on symptom change in schizophrenia patients. *Journal of behavior therapy and experimental psychiatry*, *45* (2), pp.267-271.

Murray, R., Steinerte, E., Evans, M.D. and de Wolf, A.H., 2011. *The optional protocol to the UN convention against torture*. Oxford University Press, USA.

Odenweller, K.G., Booth-Butterfield, M. and Weber, K., 2014. Investigating helicopter parenting, family environments, and relational outcomes for millennials. *Communication Studies*, *65* (4), pp.407-425.

Ogwueleka, F.N., 2011. Data mining application in credit card fraud detection system. *Journal of Engineering Science and Technology*, *6* (3), pp.311-322.

Parent, W.A., 2017. Privacy, morality, and the law. In *Privacy* (pp. 105-124). London: Routledge.

Park, B., Wilson, G., Berger, J., Christman, M., Reina, B., Bishop, F., Klam, W. and Doan, A., 2016. Is Internet pornography causing sexual dysfunctions? A review with clinical reports. *Behavioral Sciences*, *6* (3), p.17.

Portnuff, C.D., Fligor, B.J. and Arehart, K.H., 2011. Teenage use of portable listening devices: A hazard to hearing?. *Journal of the American Academy of Audiology*, *22* (10), pp.663-677.

Sabelman, E.E. and Lam, R., 2015. The real-life dangers of augmented reality. *IEEE Spectrum*, *52* (7), pp.48-53.

Schwartz, H.A., Eichstaedt, J.C., Kern, M.L., Dziurzynski, L., Ramones, S.M., Agrawal, M., Shah, A., Kosinski, M., Stillwell, D., Seligman, M.E. and Ungar, L.H., 2013. Personality, gender, and age in the language of social media: The open-vocabulary approach. *PloS one*, 8 (9), p.e73791.

Shahoian, E.J., Martin, K.M., Schena, B.M. and Moore, D.F., Immersion Corp, 2012. *Vibrotactile haptic feedback devices*. U.S. Patent 8, 169, 402.

Shrum, L.J. ed., 2012. *The psychology of entertainment media: Blurring the lines between entertainment and persuasion*. Abingdon: Taylor & Francis.

Slade, M., 2010. Mental illness and well-being: the central importance of positive psychology and recovery approaches. *BMC health services research*, *10* (1), p.26.

Smith, R.C., 2013. *Uncertainty quantification: theory, implementation, and applications* (Vol. 12). Siam.

Snodgrass, J.G., Dengah, H.F. and Lacy, M.G., 2014. "I Swear to God, I Only Want People Here Who Are Losers!" Cultural Dissonance and the (Problematic) Allure of Azeroth. *Medical Anthropology Quarterly*, *28* (4), pp.480-501.

Solove, D.J., 2011. Why privacy matters even if you have 'nothing to hide'. *Chronicle of Higher Education*, 15.

Solove, D.J., 2011. *Nothing to hide: The false tradeoff between privacy and security*. Yale University Press.

Strawn, G. and Strawn, C., 2015. Moore's law at fifty. *IT Professional*, *17* (6), pp.69-72.

Teng, C.I., 2010. Customization, immersion satisfaction, and online gamer loyalty. *Computers in Human Behavior*, *26* (6), pp.1547-1554.

Treleaven, J., Battershill, J., Cole, D., Fadelli, C., Freestone, S., Lang, K. and Sarig-Bahat, H., 2015. Simulator sickness incidence and susceptibility during neck motion-controlled virtual reality tasks. *Virtual Reality*, *19* (3-4), pp.267-275.

Tsoupikova, D., Rettberg, S., Coover, R. and Nishimoto, A., 2015, July. The battle for hearts and minds: interrogation and torture in the age of war. In *ACM SIGGRAPH 2015 Posters* (p. 12). ACM.

Verhulst, B., Eaves, L.J. and Hatemi, P.K., 2012. Correlation not causation: The relationship between personality traits and political ideologies. *American journal of political science*, *56* (1), pp.34-51.

Weinbaum, S.G., 2016. *Pygmalion's spectacles*. Simon and Schuster.

Wood, M., Wood, G. and Balaam, M., 2017, May. They're Just Tixel Pits, Man: Disputing the'Reality'of Virtual Reality Pornography through the Story Completion Method. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (pp. 5439-5451). ACM.

Yao, R., Heath, T., Davies, A., Forsyth, T., Mitchell, N. and Hoberman, P., 2014. Oculus vr best practices guide. *Oculus VR*, *4*.

Żmigrodzka, M., 2017. Development of virtual reality technology in the aspect of educational applications. *Marketing of Scientific and Research Organizations*, *26* (4), pp.117-133.

Zone, R., 2014. *Stereoscopic cinema and the origins of 3-D film, 1838-1952*. University Press of Kentucky.

***