Shared Services Canada

Augmented Reality and Virtual Reality Research Brief

Market Research and Policy Support

Version: 2.0
Date: May 3, 2019

Executive Summary

Augment Reality (AR) is the concept of having the real-world view being super-imposed with computer graphics, whereas Virtual Reality (VR) is the concept of the "viewer" having their entire field of vision replaced with an artificially generate simulation. Different technologies can be used to achieve these concepts, and it is up to the user to choose what technology fits best with their objectives.

Although the gaming industry is the biggest driver of technologies and applications, it is not the only player in the industry driving innovation. Visual processes that can be improved by gaming industry concepts are being used in other industries. For example, construction workers and architects can be equipped with headsets to explore and better understand designs, repair and assembly line workers can also be helped by visual prompts displayed in headsets and can be supported by outside help with a see-what-I-see function, medical and educational fields can also benefit from new simulation opportunities presented by AR and VR. Any Government of Canada (GC) initiatives that rely heavily on visual information can benefit from these technologies.

Challenges do present themselves and should be considered before widespread adoption, such as injuries sustained while "immersed" in VR, privacy concerns regarding information being collected while wearing AR and VR technologies, and unknown adverse health effects from wearing AR and VR devices for long periods of time.

Shared Services Canada (SSC) should also consider the following points; 1) data ownership concerns regarding data generated while the technologies are in use, 2) the high cost of equipment and application development, 3) the relative "immaturity" of the current technologies being offered, and 4) adopting AR and VR out of necessity, rather than for the sake of innovation.

Business Brief

Augmented reality (AR) provides a live direct, or indirect, view of the real-world with aspects that are modified or "augmented" by aid of a computer. These computer-generated modifications can be applied across multiple sensory modes, including visual, audio, haptic (touch), and olfactory (smell). AR technology provides an enhancement to the surrounding environment and can be either constructive (add elements to the environment) or destructive (mask elements through localized occlusion without blocking the entire real world view of the user).

Virtual Reality (VR) on the other hand, occludes (obstructs) the entire field of view of the user (i.e. a headset and other sensory gear), and replaces the entire surrounding environment with a completely computer-generated one.

AR and VR concepts are found on the virtuality continuum, otherwise known as the mixed reality spectrum (the spectrum). One end of the spectrum is unmodified reality and the opposite end is digital reality, with anything in between falling under Mixed Reality (MR). The spectrum includes all possible variations and combinations of real and virtual objects, such as augmented virtuality, where elements of reality augment the virtual world. Virtual and augmented technologies are essentially interactive mediums that enable the combination of the virtual and real world where physical and digital objects may co-exist in real time.

Devices used to overlay digital elements onto reality (AR) include, AR enabled smartphones, tablets, and see-through hands-free head mounted displays (HMD). Most consumer AR applications are created for smartphones due to their proliferation and availability. At this point, HMDs do not have many consumer AR applications due to their prohibitive price point, however, many business use cases have been developed for professional use. This is due to the fact that the hands free nature of the HMD devices allows for more creativity in the development of applications, where other smaller but necessary sensors and cameras can be used in these purpose built devices. For VR, HMDs completely obstruct the user's field of view and replaces it with a digital environment are usually paired with any combination of controllers and wearable body trackers that let the user physically interact with the virtual world. Another concept for enabling VR is the Cave Automatic Virtual Environment (CAVE) where a user is completely immersed within a physical room with walls made up of rear-projection screens (or flat panel screens) that displays a virtual environment that can be interacted with via controller or camera sensors. HMDs are used to immerse the senses in VR, whereas the CAVE system is used to immerse the whole person within a virtual space.

Technical Brief

AR and VR make use of several different technologies. Both use sensors to gain a mapping of the surrounding environment, however VR technology also makes use of sensors outside a headset to provide a more immersive experience. VR headsets like the HTC Vive and Oculus Rift track different body movement in order to allow the user to be able to look around and interact with virtual items. The image processing needs to be done at around a 60 frames per second for the user to be able to move their head naturally. Several companies currently working on VR technology are now also attempting to track eye

movements within their headsets. This will allow the images displayed on screen to appear even more realistic as the image will automatically focus based on where the user is looking.

Currently on the market there are three categories of VR headsets available:

1. **Headsets for Gaming Consoles and PC:** this grouping of headsets relies on the extra computing power of gaming consoles and personal computers. Since they are tethered to a computer system, more peripherals can also be connected and integrated into the VR experience like handheld controllers, motion trackers, eye tracking glasses, glove controllers and treadmills.

2. **Standalone Headsets:** these are wireless headsets that do not need to be plugged into a computer or smartphone to work. All of the necessary technology is packed into the device; the computing hardware, motion tracking, controller connectivity, and the operating system itself.

3. **Mobile Headsets:** these headsets are powered by smartphones that are VR enabled, where the smartphone acts as the screen. These are essentially just headgear that keep the phone in place on the wearer's head and they optimize the wearer's field of view for VR. Some may add more tracking capabilities to the smartphone and be made of high quality materials, and others like Google Cardboard are the bare essentials to make the concept work.

AR technology deploys a virtual image over real-world objects. The system receives input from the camera or other input devices. There are generally three approaches which AR technology makes use of. Simultaneous Localization and Mapping (SLAM) is a set of algorithms tasked with solving complex localization and mapping problems. This technology localizes sensors with respect to their surroundings. It uses this data to map the structure of the immediate environment and allows applications to incorporate real world information into the graphics generated on screen (i.e. the Ikea Place app that generates proportional examples of furniture onto a user's living space).

Recognition based or marker based AR is another approach to the design of AR systems. The camera of the device identifies visual markers using either, QR/2D code or natural feature tracking markers. When the device senses a marker it places the virtual image at that position. It uses these markers to determine orientation and position of the marker image.

Lastly, location based AR is another technology that utilizes GPS, digital compass, velocity meter, and accelerometer as inputs to determine orientation and position of the virtual image. This is a popular approach to AR technology as smartphones already have the necessary infrastructure to provide all these inputs. Simply put, there are two ways in which augmented reality can be viewed:

1. **Augmented Reality Glasses:** all of the processing power and projecting technology is packed into the glasses. 3D augmentations are superimposed into the wearer's direct line of sight (i.e. Google Glass).

2. **Smartphones:** the user must view reality through the screen of their phone where the computer graphics are then applied.

Industry Use

AR and VR technology has a wide variety of applications from both commercial and business standpoints and more possibilities are being explored constantly. The global AR market is expected to grow to $60.55 billion (USD)[1] by 2023 and the VR market is expected to be $44.7 billion by 2024[2]. Within the workplace, several companies are experimenting with virtual workstations. The Virtual Desktop app capable of being used on the Oculus Rift and HTC Vive is designed to provide users with a virtual Windows Desktop that can be physically interacted with in virtual reality.[3] On the AR side, a company called Meta is testing the use of an interactive holographic workstation to replace desktop computers. Users can instead use a 3D environment to store, display, and interact with virtual objects and other documents. [4]

For general use, Google Translate running on a smartphone can be used in AR mode to translate speech and text. When using the camera on a smartphone the Google Translate application can process an image with text written in one language and translate it to another. Another sensory modality of AR is provided by Google in the form of natural language translation. A recent update has enabled all Google Assistant optimized headphones and Android phones with the ability to do live audio translations.[5]

The process of prototyping is undergoing a major shift towards using AR and VR to explore and test new prototypes in a cost-effective way. The benefit of these technologies is that it allows all interested parties (engineers, assembly line workers, customers, management, marketers, safety regulators, etc.) of a project to come together and interact with a model before it goes into production. For example, the tech firm Finger Food created an AR solution for the truck manufacturer Paccar, which could be seamlessly integrated into their design workflow.[6] It allows the user to view and interact with full scale models of trucks and to test various physics simulations on the models in real time. Another example is the global architecture firm IA (Interior Architecture) who is using InsiteVR to build models of their designs.[7] This also allows clients of the company to “tour” the designs and give input before designs are finalized. Ford is another company using VR technology to help its engineers when designing elements of their vehicles. Audi has taken this technology to the consumer allowing customers to view, configure, and customize certain elements of their vehicles.

Education and training are also starting to change thanks to the adoption of AR and VR. Through VR, trainees can be immersed in a training environment where they can get hands-on practice without the possibility of real life mistakes. The aviation industry has been using simulation technologies for decades, but now with the relative ease of access to those technologies more sectors are adopting AR and VR for training purposes. For example, the forklift training company certify.me created a VR app for certifying new forklift operators where trainees are presented with a variety of virtual scenarios that demonstrate what to do and what not to do.[8] NASA has a mixed reality space where astronauts in training are immersed in a VR simulation while also being in a 1:1 physical space where they can walk around and touch real objects presented to them in the VR environment.[9]

Repair and construction work have also been augmented. Recently, some AR solutions have been created to help workers make effective repairs. For example, Boeing engineers are now equipped with glasses that overlay instructions and the proper placement of wires over a physical object that is being repaired.[10] The glasses are also equipped with a camera that lets a supervisor view the work being done and give live

feedback. The adoption of AR has reduced production time for Boeing by 25% and lowered error rates to practically zero. The construction industry is also adopting a mixed reality approach for completing construction projects. A recent development is an augmented reality app for construction workers that super-imposes the 3D mockup of a construction project over the real environment being built.[11] This has helped with accurately finishing projects with fewer interpretation errors, as opposed to the traditional method of comparing the worksite to a two dimensional architectural plan. Augmented reality is also well suited for the itemization of tasks, in the sense that all of the steps of a process or a task are neatly overlaid on a wearer's field of view, until the item is completed properly. For example, AR has been used to help workers navigate large and complicated warehouse layouts to locate packages they need to find to complete an order.[12]

AR and VR are providing marketers with novel spaces and new formats for creating campaigns. Many business have developed AR solutions that let consumers "test drive" products before they are purchased, like trying on clothes, glasses, and hairstyles. Ikea, for example created the Ikea Place app that lets users see how a virtual piece of furniture would look inside their home at full scale.[13] There is also a shift towards making advertisements more interactive and immersive as they will leave a longer lasting impression on the audience, as opposed to traditional advertising efforts. To promote the horror franchise "Saw" a VR mini-game was created where users needed solve a puzzle within an interactive room.[14] Biometric data from that group was compared with a control group that only saw a trailer in VR, and it revealed that the VR room left a longer lasting impression. Within a VR environment, biometric data can be measured in real time which lets marketers know how effective a campaign really is.

Entertainment is still one of the largest uses for AR and VR. The explosive and sustained popularity of Pokémon Go (a mobile game AR application with 147 million monthly users[15]) proves there is a large base of users who are open to using the technology. VR games come in all shapes and sizes and the market is projected to hit 22.9 billion by 2020[16]. VR as a medium is also being explored for the film industry and it is said to improve empathy and it can be used as a teaching tool. Even in the world of law, Bloomberg Law speculates that VR might be incorporated into the courtroom, so that evidence can be better understood in an immersive environment.[17]

Use cases have also been explored in the medical field. Since medical practitioners rely heavily on visual information, AR and VR is well placed to help them visualize tasks. One such creation is a handheld device developed by Accuvein that reads the heat signature of a patients veins and projects an AR map of the underlying vasculature onto their skin.[18] This has increased the likelihood of finding a vein on the first try by 3.5 times for those using the machine. A patient's information can also be used to pre-plan surgeries in VR, their CT and MRI scans can be used to recreate a digital body that can be explored in detail in VR.[19] Similarly, those same scans can be super-imposed onto the patient in real-time to guide doctors to the problem area before a surgery and have a better idea of what they are targeting under the patient's skin.[20]

Canadian Government Use

The GC has invested $9.5 million in AR technology developed by Vancouver-based software company NGRAIN.[21] The software company has developed an interactive 3D AR platform for aerospace company Lockheed Martin. Lockheed Martin uses this interactive platform as a tool to perform maintenance on

fighter jets like the F-35 and F-22. The company reports reduced maintenance time and less errors. The Canadian Military is also investing in VR, they have recently purchased a mixed reality simulation to train helicopter operators in the use of a hoist system.[22] This and other projects like it reduce the training costs associated with hands-on jobs, where no costly accidents can happen and learners are allowed to learn from their mistakes in a risk-free environment.

The GC has also been investing in AR and VR as tools of education and entertainment. Through the Build in Canada Innovation Program, $482,000 was awarded to Motive.io to develop a location based AR experience that takes users through Ottawa's cultural heritage.[23] Although there is no substantial research yet to support the claim that immersive VR experiences increase empathetic responses, many projects are being developed with that goal in mind. The Social Sciences and Humanities Research Council (SSHRC) helped fund a VR Residential School that takes viewers into a world crafted by survivors and researchers, it's hoped that the project will eventually be adopted as a teaching tool for high schools.[24] Even the Parliament of Canada has been turned into an interactive augmented virtuality environment, this time by partnering with Carleton University to create a virtual tour of the Senate where users can walk around the building and click on points of interest to learn of their historical significance.[25]

The Canadian Military stands to benefit the most from the use of AR and VR technology, given their needs for logistics management, training solutions, and personnel management. At present, the military mainly uses those technologies for training purposes. Some simulations are entirely based in VR, and some have real physical equipment that can be "used" in a VR environment. Bluedrop, a performance learning and IT consulting and development firm, has designed both types of training programs, and one of their mixed reality simulations in particular integrates a real CH-47 Chinook helicopter fuselage into a virtual training program.[26] The Canadian Armed Forces has more than 230 simulators in 125 locations across Canada, and not included in this count is the number of Navy and Airforce simulators.[27] Military therapists have also explored the use of VR to treat post-traumatic stress disorder in soldiers, as a way for them to safely explore the source of their trauma and move past it.[28] Through the Innovation for Defense Excellence and Security program, a few projects involving AR and VR have received funding from the Department of National Defense. Categories include cognitive performance enhancement, Resilient Non-GPS Based Positioning Navigation and Timing, and understanding and addressing PTSD.[29]

Possible Implications for SSC

Value proposition

SSC should consider the positive impacts that AR and VR can have on the Department. For the Department to benefit from AR and VR technologies, very specific projects and use cases may be considered before applications are developed. Projects should not be launched simply for the sake of innovation but because they fulfill business objectives and requirements. The Department could lead by example for other departments by adopting AR and VR solutions that have already been developed and promote those solutions.

The Government of Canada (GC) can provide better services to citizens and other departments through the use of AR and VR technology. The government can provide a clearer vision of its planning and

documentation. For architectural projects, for example, virtual tours of proposed sites and renovations can be given to citizens and other stakeholders. The same concept can also be used in courtrooms to help explain evidence in a convincing and immersive way. Policy and documentation can now become more interactive in the world of AR and VR technology.

Additionally, AR and VR technology can accommodate the accessibility needs of GC employees and citizens interacting with the GC. AR and VR are part of a suite of technologies known as Adaptive Computer Technology (ACT), which aids in providing assistance to those with sensory, mobility, dexterity and learning disabilities who work on or communicate through computers. AR and VR can reduce the barriers presented by the standard computer interface and can offer new and adaptive ways for GC employees and citizens to interact with GC information and data.[30]

The use of AR and VR technology can also aid and support public safety and emergency services. For example, if emergency vehicles are fitted with AR Head-Up windshield displays this could help with route navigation, allowing responders to find the quickest route and obtain traffic information in real-time. Location based AR technology could also allow first responders to gain insight on dangers and hazardous conditions around them. Through the Innovative Solutions Canada program, a current challenge open to the public is the creation of a heads up and hands free solution for supporting firefighters in the field.[31]

In general, AR and VR technologies are well suited for tasks that rely heavily on visual elements. The industry is not yet mature (see Appendix A) so not all potential use cases have been explored, or even discovered. At present, AR business use cases include the itemization of tasks, remote work support (a supervisor can see and comment on what a worker is doing if a HDM has a camera), performance dashboards for Internet of Things (IoT) enabled devices, guiding precision manual labor (i.e. repair, assembly, construction), prototyping, and for overlaying medical information on a patient.

Similarly, not all use cases have been uncovered for VR but there are many existing business solutions. A strength of VR is that it lends itself well for immersive experiences since the entire field of view is replaced with a virtual world. Video games and 360̊ videos are very popular for consumer use and can be easily transformed for business use. Mixed reality practice simulations are being adopted to replace high-risk training scenarios since there is less risk of injury and equipment damage. Undergoing training in VR helps learners retain information since they are being completely immersed into a practice scenario where they can physically interact with virtual objects (as opposed to learning in a classroom). Prototyping and virtual tours can also be done in VR.

As a communications service provider, SSC is well suited to become a provider of AR and VR equipment for other partnered departments. The Department could also lead the development of AR and VR solutions on an on demand basis for other departments.

Challenges

Prolonged use of AR and VR gear has not been extensively studied, and there could be unknown risks that have yet to be uncovered, such as health risks to employees etc. The use of AR and VR in the form of wearable technology in the workplace could also provide further challenges. Although the technology can increase connectivity among employees and simplicity of user interfaces, AR and VR technology could also

cause employees to lose focus on the task at hand when working using the AR and VR technology. This challenge could be expected to diminish as AR and VR technologies become more commonplace.

AR and VR technologies are great for the immersion factor, however being disconnected from the physical world while still being physically present within it can make users "blind" to the environment around them. According to a study from Purdue University done in Tippecanoe County (US), the popular AR game Pokemon Go has been linked to two deaths and has caused an increase in car accidents near "PokeStops" (real world locations with in-game components) since users are playing the game while driving or walking.[32] There is also anecdotal evidence of VR headset wearers forgetting their surroundings and tripping over physical objects within a room, falling out of chairs, and even hitting other people around them. Developers will need to consider elements of special awareness when designing solutions and how liability laws may affect them.

Another issue for AR and VR is that of interoperability between devices. For mobile devices, there are a number of platforms from which to access VR applications but not all platforms are available on all devices. iPhone and Android users are limited by what they are able to download from their respective application stores. AR headsets are not limited by their hardware like smartphones, but applications must live within a platform for them to function and there are many platforms to choose from on the market. An AR platform in this context is similar to an operating system for the headset, where developers can create solutions that run on the platform.

Lastly, standard AR and VR solutions may not be suited for those with sensory, mobility, dexterity, and learning disabilities. Individuals who may benefit from ACT would need to be properly assessed and outfitted with tools and technology that appropriately addresses their unique needs. A standard off-the-shelf corporate AR and VR solution may improve the ease of work and productivity of able-bodied employees, but it may not adequately address the needs of those requiring sensory, mobility, or learning aids. The AR or VR solution may require adaptation and modification to fit each end user, which will require additional resources and expertise in resolving.

Considerations

In the realm of AR and VR technology, the question of data ownership will be a very important issue to consider, given that data created from the use of AR and VR (user profiles, biometric data, sentiment response, eye tracking, etc.) presents a number of privacy and security concerns. If applications are created by outside companies, there is the potential for information to be collected by those providers and SSC will need to be very clear about who can access that information and for what purposes. Clarification will also be needed as to whether or not SSC can collect that data in the first place, SSC may need to anonymize all AR / VR data or simply not collect it. Moving forward, SSC has the potential to use AR and VR solutions but the Department needs to carefully look at the business problem that needs to be solved and if the technology is an appropriate choice to solve that problem.

The adoption of AR and VR systems present several challenges. Due to the current lack of low-cost hardware capable of running AR based applications, most AR solutions are designed as mobile apps. This is because a mobile device can track all the necessary information for a properly function application, but it comes with computational limitations since it is all contained within a small device. Location-based AR

applications are currently the only type of AR application available for use on mobile phones. This is because Recognition-based and SLAM technology is much too computationally intensive for a smartphone. Since Location-based software requires only GPS it is a viable approach. As the need for more complex AR and VR applications grows so will the computational demands. Smartphones alone will not be able to handle these new complex demands. SSC will need to carefully consider project goals when deciding on whether the Department should create a VR or AR application, and on what kind of hardware it should run on. Scalability is another consideration for SSC, that is, the ability to grow a project's infrastructure and capabilities to let more people use it at the same time. A project's eventual growth in terms of scalability and deployment will need to be considered right at the start its development.

SSC should consider working through its Accessibility, Accommodation and Adaptive Computer Technology (AAACT) team to pilot AR and VR solutions to those with sensory, mobility, and learning needs.[33] SSC could engage with employees who have requested assistance from AAACT and collaborate with them to test various technologies in order to assess whether or not they reduce the barriers to work for those with impairments.

Given that the AR and VR markets are not yet mature and that more advancements are projected, SSC senior management should proceed with caution as it relates to the procurement of AR and VR. Additionally, caution is advised regarding the hype surrounding the promises of immersive technologies. What is depicted in popular films such as "Ready Player One" has already inflated the expectations of consumers and does not accurately reflect the business reality and utility of AR and VR today.

Given that these technologies generate a lot of data while they are being used, as the IT infrastructure provider for the GC, SSC should ensure that it is well equipped to handle the additional bandwidth usage of large scale deployments.

Since AR and VR are technologies that are still being refined, SSC will need to make investment/procurement decisions within a relatively short timeframe. Depending on the project scope, availability of funds, and availability of personnel the Department will need to consider how it will develop AR and VR solutions. These solutions will require specialized knowledge which is highly sought after in the tech world and hiring personnel could be a competitive endeavor. Taking this into account, having an in-house team for creating AR and VR applications may not be feasible unless there is a lot of demand from other departments. The Department at this time should consider contracting in the short term (the next 5-10 years), since the talent pool, technologies, and business use cases are not at an adequate level of maturity.

References

[1] Markets and Markets. (July, 2017). *Augmented Reality Market by Offering, Device Type, Application, and Geography.* MarketsandMarkets Research Private Ltd. Retrieved on 13-February-2019 from: www.marketsandmarkets.com/Market-Reports/augmented-reality-market-82758548.html?gclid=EAIaIQobChMI_J60r6_Q4AIVCZ7ACh3BuQ4tEAAYASAAEgLvq_D_BwE.

[2] Markets and Markets. (January, 2019). *Virtual Reality Market by Offering, Device Type, Application, and Geography.* MarketsandMarkets Research Private Ltd. Retrieved on 13-February-2019 from: https://www.marketsandmarkets.com/Market-Reports/reality-applications-market-458.html?gclid=EAIaIQobChMIu-Cf_6_Q4AIVx7fACh3etwIAEAAYASAAEgK9RvD_BwE

[3] Heaney, David. (November 29th, 2018). *Virtual Desktop (Mobile) Review: The Best Way to Access Your PC From Occulus Go.* UploadVR. San Francisco, USA. Retrieved on 13-February-2019 from: https://uploadvr.com/virtual-desktop-oculus-go-review/

[4] Wang, Selina. (July 18th, 2017). *This Startup Wants to Replace Your Office With 3d Holograms.* Bloomberg L.P. New York, USA. Retrieved on 11-February-2019 from: https://www.bloomberg.com/news/articles/2017-07-18/this-startup-wants-to-replace-your-office-with-3d-holograms

[5] Google. (2019). *What are Google Pixel Buds?*. Google. Retrieved 11-February-2019 from: https://support.google.com/googlepixelbuds/answer/7545575?hl=en&ref_topic=7544331

[6] Finger Food. (2019). *Paccar: Fundamentally changing big industry with big technology*. Finger Food Studios. Port Coquitlam, British Columbia. Retrieved 11-February-2019 from: https://www.fingerfoodstudios.com/case-study/paccar/

[7] InsiteVR. (2019). *VR Meetings for Architecture, Engineering, and Construction*. InsiteVR. 2019. Retrieved 13-February-2019 from: https://www.insitevr.com/

[8] CertifyMe.net (September, 2016) *Virtual Reality Training: New Forklift Training Video in VR* Certifyme.net. Retrieved 15-February-2019 from: https://www.certifyme.net/virtual-reality-training/

[9] Kolodny, Lora. (2017). *Nasa is using a mixed reality space station to train astronauts*. TechCrunch. Retrieved 15-February-2019 from: https://techcrunch.com/2017/03/26/nasa-is-using-a-mixed-reality-space-station-to-train-astronauts/

[10] Upskill. (2019) *Upskill and Boeing: Reinventing aerospace manufacturing and supply chain management*. Upskill. Retrieved 15-February-2019 from: https://upskill.io/landing/upskill-and-boeing/

[11] Lorek, Sarah. (January 30th, 2018) *Mixed Reality in Construction Gets Real with Trimble's Hololens Hard Hat*. Constructible. Retrieved 13-February-2019 from: https://constructible.trimble.com/construction-industry/mixed-reality-in-construction-gets-real-with-trimble-hololens-hard-hat-video

[12] Porter, Michael, et al. (November-December 2017) *A Manager's guide to Augmented Reality*. Harvard Business Publishing. Retrieved 11-February-2019 from: https://hbr.org/2017/11/a-managers-guide-to-augmented-reality

[13] Dasey, Daniel. *Try Before you Buy: Ikea Place Augmented Reality*. Ikea. Retrieved 15-February-2019 from: https://highlights.ikea.com/2017/ikea-place/

[14] D'Angleo, Matt. (December 5th, 2017). *How Virtual Reality is Impacting the Ad Industry*. Business.com. Retrieved 27-February-2019 from: https://www.business.com/articles/virtual-reality-advertising-augmented/

[15] Philips, Tom. (June 27th, 2018). *Pokemon Go Active Player Count Highest Since 2016 Summer Launch.* EuroGamer. Retrieved 27-February-2019 from: https://www.eurogamer.net/articles/2018-06-27-pokemon-go-player-count-at-highest-since-2016-summer-launch

[16] Statista. (2015). *Virtual Reality video gaming sales revenue worldwide from 2015-2020*. Statista. Retrieved 29-Fabruary-2019 from: https://www.statista.com/statistics/499714/global-virtual-reality-gaming-sales-revenue/

[17] Kaufman, Bruce. (November 16th, 2017). *The Next Frontier for Virtual Reality: Courtrooms.* Bloomberg BNA. Retrieved 20-February-2019 from: https://www.bna.com/next-frontier-virtual-n73014472186/

[18] AccuVein. (2015). *AccuVein Vein Visualization: The Future of Healthcare is Here*. AccuVein. Retrieved 18-February-2019 from: https://www.accuvein.com/why-accuvein/ar/

[19] mVR Division. *Surgical Navigation Advanced Platform*. Surgical Theater LLC. Los Angeles, California. Retrieved 18-February-2019 from: https://www.surgicaltheater.net/plan-navigate/

[20] Microsoft Reporter. (February 8th, 2018). *Surgeons use Microsoft HoloLens to see inside patients before they operate*. Microsoft. Retrieved 20-February-2019 from: https://news.microsoft.com/en-gb/2018/02/08/surgeons-use-microsoft-hololens-to-see-inside-patients-before-they-operate-on-them/

[21] Market Wired. (June 26th, 2013). *Harper Government Supports Market-Leading Canadian SME*. Yahoo Finance. Retrieved 22-February-2019 from: https://finance.yahoo.com/news/harper-government-supports-market-leading-180734827.html

[22] Burke, David. (April 10th, 2018) *Fear makes virtual training lessons stick in Nova Scotia's thriving VR industry*. Canadian Broadcasting Corporation. Retrieved 20-February-2019 from: https://www.cbc.ca/news/canada/nova-scotia/virtual-reality-business-technology-nova-scotia-1.4609172

[23] Public Services and Procurement Canada. (November 20th, 2017). *Government of Canada supports BC augmented reality startup through Build in Canada Innovation Program*. Published by Cision Canada. Government of Canada. Retrieved 22-February-2019 from: https://www.newswire.ca/news-releases/government-of-canada-supports-british-columbia-augmented-reality-startup-through-build-in-canada-innovation-program-658845663.html

[24] University of Manitoba. (September 12th, 2018). *Launch of a virtual reality Canadian Residential School*. University of Manitoba. Winnipeg, Manitoba. Retrieved 20-February-2019 from: http://news.umanitoba.ca/launch-of-a-virtual-reality-canadian-residential-school/

[25] Senate of Canada. (March 1st, 2017). *Senate Virtual Tour*. Government of Canada. Retrieved 6-February-2019 from: http://tour-ext.sencanada.ca/tour/index.html and https://sencanada.ca/en/sencaplus/how-why/the-senate-virtual-tour-your-digital-admission-to-the-red-chamber/

[26] Arellano, Nestor. (August 26th, 2019). *VR, gaming technology and training the future soldier*. Vanguard Canada. Retrieved 6-February-2019 from: https://vanguardcanada.com/2016/08/26/vr-gaming-technology-training-future-soldier/

[27] Boutilier, Alex. (January 1st, 2015). *Canadian Forces expand virtual reality training capabilities*. Toronto Star Papers. Toronto, Ontario. Retrieved 8-February-2019 from: https://www.thestar.com/news/canada/2015/01/01/canadian_forces_expand_virtual_reality_training_capabilities.html

[28] Madigan, Jennifer. (December 19th, 2017). *Virtual reality simulation and neurofeedback to help PTSD*. Blueline, Annex Business Media. Toronto, Ontario. Retrieved 8-February-2019 from: https://www.blueline.ca/news/features/virtual-reality-simulation-and-neurofeedback-to-help-ptsd-5076

[29] Department of National Defense. *IDEas Recipients*. Government of Canada. Retrieved 8-February-2019 from: https://www.canada.ca/en/department-national-defence/programs/defence-ideas/past-opportunities/ideas-recipients.html

[30] Shared Services Canada. (April 3rd, 2019). *Accessibility, Accommodation and Adaptive Computer Technology (AAACT)*. Government of Canada. Aaact-aatia@ssc-spc.gc.ca. (819) 994-4835. Retrieved 03-May-2019 from: https://www.canada.ca/en/shared-services/corporate/aaact-program.html

[31] Innovation, Science and Economic Development Canada. (2018). *Head Up Hands Free Firefighting*. Government of Canada. Retrieved 8-February-2019 from: http://www.ic.gc.ca/eic/site/101.nsf/eng/00056.html

[32] Sharwood, Simon. (November 27th, 2019). *Pokemon Go Caused Hundreds of Deaths, Increased Crashes.* The Register. International. Retrieved 27-February-2019 from: https://www.theregister.co.uk/2017/11/27/pokemon_go_caused_car_accidents_and_deaths/

[33] Shared Services Canada. (April 3rd, 2019). *Accessibility, Accommodation and Adaptive Computer Technology (AAACT)*. Government of Canada. Aaact-aatia@ssc-spc.gc.ca. (819) 994-4835. Retrieved 03-May-2019 from: https://www.canada.ca/en/shared-services/corporate/aaact-program.html