Spatial Computing

Abstract:

Getting started with Spatial Computing can be a daunting task. A common perception is that immersive technology is a hype or solely useful for gaming. However, there are many use cases that have shown the potential for enterprise. While many industries such as manufacturing, architecture, medical, and marketing have clear use cases, the corporate and office side is often forgotten. This paper will look at Spatial Computing for offices. The next computing platform will be reality, and the enterprise must be ready.

Definitions:

- **Virtual Reality (VR):** An experience that gives the user the sense of presence, or the psychological feeling of 'being there'. This allows the user to treat the virtual experience as something that is real. Virtual Reality is commonly experienced with a head mounted display (HMD) that allows the user to walk inside a virtual environment.

- **Augmented Reality (AR):** A mix of digital content placed on the real world. Can be viewed using glasses or a handheld device. AR allows digital content, such as instructions or an overlay of a model to be placed on the real artefact.

- **Mixed Reality:** A more powerful form of augmented reality. The digital content placed on the physical world reacts more like how one would expect. This means, when a person or an object obstructs the view of the camera that is placing the content into the real world, the content is hidden from view until the obstructing object is removed.

- **Spatial Computing**: VR and AR do not stand alone, rather they are on a spectrum, this is commonly referred to as XR or Spatial Computing, in this paper the latter will be used.

- **DOF:** Degrees of Freedom. Typically 3 DOF or 6 DOF. In the most basic sense, 6 DOF allows the user to walk around a physical space and interact with their hands (controllers) in the virtual environment. When the user walks one step forward, their camera viewport shifts by that much. In 3 DOF the player can look around the virtual environment and use a controller but they cannot physically walk around a space, and do not have the hand presence to interact with the environment.

- **FOV:** Field of View.

Introduction

With the start of the virtual reality revolution in the 1960s, the field has grown commercially with the release of the Oculus Rift in 2010. Until recently, VR was difficult and expensive to set up and maintain, but in 2018 the first standalone headsets (those that do not require a high powered PC to run) were manufactured, and gained popularity when Walmart obtained a million units to train employees (STRIVR). While augmented reality is still behind in terms of its technology, it is likely to have more use cases in the near future because it will not isolate a user from the real world, and will still allow interaction with the physical space around the user.

The technology is changing at a fast pace, but now is the perfect time to get into Spatial Computing. With immersive technology, enterprises will be able to increase productivity and processes.

Benefits

In most industries that have adopted spatial computing thus far, the greatest benefits have been from virtual assistant, upskilling, and training applications. The use case for VR in manufacturing and for expensive training scenarios is an excellent use case. Bell Helicopters cut their production time from 5-7 years to 6 months (HTC, 2018). Boeing uses Augmented Reality when engineers were installing electrical systems on airplanes which have a 90% in the quality of installation and a 30% reduction in time taken to do a job (Boeing, 2018). Welsh Water uses AR to give employees on the field real time information about how to fix a pipe to increase safety, and to ensure there are fewer mistakes. Nestle uses immersive technology to allow newly hired employees to virtually meet their team, and to be virtually immersed in an environment so they can see what the office is like to ease the transition into work.

In many industries, Virtual reality is used for training to improve efficiency, empower employees, and reduce costs. Lloyds Banking Group has reported that it saved £127,000 using VR for one training course in its first year (Make Real). Other companies could benefit from virtual classrooms like this as well. Often training requires flying in a specialised trainer, and sometimes requires employees to travel to a training location as well. Using VR or AR for training would allow these travel costs to be eliminated. The same goes for meetings, or needing expert assistance in a remote location.

Looking to the future where AI is usable for Spatial Computing experiences, there are more possibilities for training. With AI, there would be no need for a specialist, rather there could be a recording of someone teaching, and AI dirven agents can recognize people's questions and behaviours in order to respond to the particular situation.

Issues of Spatial Computing

One of the biggest concerns of using spatial computing is scalability. The technology is not quite ready for widespread adoption. The hardware can be heavy and cumbersome, and the displays are not at a point where they can be used for multiple hours without a break. The time to set up a headset is getting much faster with standalone VR headsets such as the VIVE Focus, Oculus Go, and Oculus Quest. With Augmented Reality, the solution with the least friction is using a mobile device such as a phone or tablet, however if an experience requires the use of hands, or requires higher fidelity and more compute power, an AR headset is necessary. Currently the best AR headset is the Hololens 2 which costs $3,500. There are many competitors in the AR headset market, and soon the price will be much lower, but there will be multiple iterations to figure out the user experience.

For augmented reality, some design considerations are the weight of the headset, the use of peripheral devices (such as a keyboard), gaze tracking, hand tracking, and displaying content in a non-distracting way. For virtual reality, the user experience, especially with using hand tracking and no controllers, needs more improvement. This can clearly be seen when trying to

use a mouse and keyboard in the virtual environment. While there are some hypothetical solutions such as Bluetooth keyboards, this relies on the user being able to touch type. However, with augmented reality, this is less of an issue, and with the advancements in finger tracking and VR peripherals this is unlikely to be an issue for much longer.

In addition to this, it is necessary to ensure that all headsets are regularly cleaned and sanitized. If using VR, the ideal play space is at least 2 meters by 2 meters for a 6 DOF headset for interaction. This may require having a dedicated room for VR headsets. With augmented reality, the space issue goes away, however AR has limited field of view (40-50 degrees rather than the human FOV of 120-180 degrees).

Finally, there is a growing skills gap when companies are looking to use Immersive technology solutions (Immerse UK report, 2019). Of course, this is not surprising given the infancy of the industry. The skills gap can quickly be closed by training employees and investing in research about the use cases and best practices and encouraging employees to become experts in Spatial Computing.

Use Cases

Communication and Collaboration

A common problem in the industry is holding meetings across distributed teams. 60-80% of people find that meetings are inefficient. 69-73% of employees do other work in meetings. A survey by Muse found 92% of respondents multitask during meetings, 69% of these checked email, 49% did unrelated work, 41% multitasked often or all the time (Highfive, Muse Editor, Perlow et al. 2017). While holding a meeting in a boardroom is very helpful to make sure that all the members of the team are focused and concentrating, it is increasingly difficult to hold these meetings when enterprises are becoming more globalised. In today's workplace, many meetings are done as conference calls with remote participants. This can make it easier for participants to multitask, and lose important information that is given by body language. Of course, one solution to this is to have all locations book a room, but 73% of meetings only have 2-4 people and on average, people spend 30 minutes looking for rooms in the era of increasing meetings, fewer, and smaller conference rooms (Shellenbarger, 2014). VR rooms will still require some setup, there is significantly less friction to have meetings as the size of the room can grow or shrink depending on the number of participants, and it is possible to use a VR or AR headset sitting at a desk.

Thinking of teams following agile methodologies XR meeting rooms could be very beneficial. It will allow more cohesive standups, sprint planning and retrospective sessions where everyone can be in the same room virtually. The virtual environment would allow for having a common sprint board so that everyone is looking at the same version, it would allow anyone, regardless of their location to write on the same whiteboard or move tickets around. VR allows all participants to have the sense of being there, and allows distributed teams to be virtually co-located building stronger relationships within the team. For people working in the office, having

AR headsets to talk with one member working from home (who uses a VR headset for the room) would allow for a more cohesive experience than talking to a 2D image on a screen, or even worse, over telephone without any videoconferencing.

Training and Education

In many different industries, the biggest ROI with spatial computing is through workforce training. Walmart has been using VR since 2017 with over 1 million employees going through VR training, and have reported that there is a higher retention rate of information, higher employee satisfaction, adn higher test scores (Tuchscherer, 2019, STRIVR). Currently, the state of VR for training is excellent for manual tasks, things that happen in the real world and involve interaction. VR is good because it allows repetition of tasks that are dangerous, happen infrequently, are impossible, or that are expensive. At the moment, there is a lot of research going into how to create training for use cases for enterprises. While virtual representations of people, the avatars, in virtual environments are not quite realistic, there are many studies about the virtual environment being treated like a real environment. Because of this, there are noted changes in people's behaviours using a virtual experience. The technology and software is still a bit behind to have truly realistic experiences with avatars and it will be a few years before this to be able to happen due to the nascence of AI, ML, and the riggin and animations of characters at a high frame rate in a virtual environment.

Diversity and Inclusion

Often named the empathy machine, VR has the potential to place users into someone else's shoes. Stanford has done extensive research on virtual avatars and the effects on people's behaviours. Depending on the way the experience is set up, the result is that VR does change people's behaviours, and that people will respond emotionally to an experience. This is particularly useful for cases for people with neurodiversity and will be starting a new job at a company, allowing managers to practice handling different behaviours and attitudes of employees, or allowing people to practice empathy in difficult situations.

There are many companies starting to utilize VR for training use cases, such as Lloyds Banking Group, Verizon, and Walmart. Each have been buying third party software which can be configured to specific use cases for the enterprise.

The most popular way of creating these use cases is done by placing a user in an avatar that does not look like them. In these experiences, it is possible to have the user experience discrimintation, what it is like to be someone of a different gender, race, religion, or ability. This relies on the 'Proteus Effect' or that our behaviour in the real world is affected by how the avatar looks in the virtual world (Yee and Bailenson, 2007). For example, if the user wears an avatar that is tall in the VR experience, they will rate themselves as having more confidence once they are outside of the virtual experience compared to someone who was in an avatar that was shorter. This is a method intensively studied by researchers at the Stanford Virtual Human Interaction Lab, who have found that placing people in different avatars contributes to behaviour in the physical world. In order to create an experience like this, it is helpful to start in front of a

virtual mirror. THis way the user is able to see how the avatar acts, and see themselves embodied as someone different. After this, it is necessary to create a scene in which the user can interact and talk with someone, or have an external actor do something to them.

Another technique is called ‘body-swapping’ (Slater, 2019). In this use case, the user is able to see what it is like to interact with them. They first play a helpful character in a scene, for instance a manager talking with an employee about depression. Then the roles are swapped, and the manager is able to see what it is like to talk with them.

Both of these techniques are useful and important in the current state of the technology, but it is also important to look to the future. There has been work on the convergence of AI, ML, avatars, and the immersive technology, and once this happens the virtual experiences will be far more transformative. A concern with the D&I use cases at the moment is that it is very difficult to rig and animate virtual characters to avoid feelings of unease and discomfort for users. THis is known as the uncanny valley. Humans are very good at knowing how other humans like characters should behave and act. When a virtual human does not act according to this idea, it causes feelings of unease and discomfort. It is often advised not to use virtual characters in such use cases in order to enhance the experience. This could be by using motion capture to tape real life actors and place them in the virtual experience, or by creatively designing the experience so that it is not necessary to interact with another person. However, once this limitation is overcome, the experiences will have the opportunity to become much more realistic and be far more valuable.

Working from Home

By far one of the most difficult use cases, but one that would be a competitive advantage for many industries. For this use case, take the example of a computer programmer. Many developer jobs are starting to be advertised as having flexible working as a competitive advantage in the workplace. One of the major disadvantages of working from home is that many homes do not have similar equipment to the workplace. Multiple monitors, teleconferencing, not having a quiet working space, not having a desk, not being in the same meeting rooms are all some of the hurdles that employees working from home face.

Using VR HMD or AR glasses would allow employees working from home to have multiple monitors in a virtual environment, and could allow them to be present in virtual meetings. Of course, this would mean that inside the meeting room there were cameras, or every participant had a headset.

Virtual Assistant

The virtual assistant can be used in different ways. In manufacturing, virtual assistants are used for on the job use cases, to help employees figure out where to place wires or what to do next in fixing a piece of equipment. More generally, a virtual assistant, either a virtual AI or an expert

located anywhere in the world, is able to assist the end user. Having a virtual representation of a person can be more effective than a chat bot or faceless automated system.

Up to Date Information

A powerful use of augmented reality is getting up-to-date information when and where it is needed. Because the information is contextual and placed spatially, it can provide relevant updates. This could be particularly helpful for a business person travelling to a different location, they would be able to point their phone at the newspaper and see the latest information. For employees, this could help them make more informed decisions throughout the day based on relevant information.

Another use case of this would be in data visualisation, this could be beneficial for developers to visualize code bases, to create diagrams of systems, or for data analysts to find new perspectives on the data and more solid understanding what the data means.

Where to Begin?

The world of spatial computing has a lot of opportunity, as well as a lot of confusion. After finding a use case, one of the most difficult questions is what type of experience to build. Should it be 3DOF, 6DOF, VR, AR, 360 Video, interactive, realistic, stylized? Unfortunately, there is no one size fits all approach, and what works well for one use case may not work well for another.

Fragmentation of VR

Virtual reality comes in many different forms. In terms of headsets there is 3DOF and 6DOF. In the most basic sense, what separates the two is that 6DOF allows the user to walk around a physical space and interact with their hands (controllers) in the environment. When the user walks one step forward, their camera viewport shifts by that much. In 3DOF the player can look around the virtual environment and use a controller but they cannot walk around a space, and do not have the hand presence to interact with the environment.

3DOF headsets are less expensive than 6DOF and the two most popular options for enterprises are the £15 Google cardboard (needs a phone to operate) and the £199 Oculus Go (stand-alone with a controller).

The 6DOF headsets have recently made a leap forward with the Oculus Quest which is a stand-alone headset priced at £399. Most other headsets are more expensive, (ranging from £399-40,000) and rely on a computer with a powerful GPU. These headsets allow higher visual fidelity and larger field of view, but for most companies, the cost of these headsets is not worth this trade off.

In terms of experience fragmentation, there are interactive experiences and 360 videos. 360 videos are great for either 3 or 6DOF systems, and less expensive to create, but if the video is incorrect, the price doubles as the video will need to be shot again. Interactive experiences are more like traditional game play. They rely on 3D modelled content and the rigging and animation of characters. While these are more expensive upfront, they tend to have reusable assets and do not cost as much to redo if something in the experience is wrong.

AR Fragmentation

AR is either using eyeware or a handheld device such as a tablet or phone. When using a handheld device it is necessary to hold the device up and point to have the digital content appear. AR glasses are not ready for commercialization but for use in industry, specifically in architecture and manufacturing, they have been proven to be useful since Google Glass came out in 2013.

Spatial Computing Fragmentation

There are two main methods to deploy a Spatial COmputing experience, as web application or as a native application. Currently, a native application is more common than a web application, but it is likely to change in the next few years.

At the moment, WebXR is in its infancy, but some browsers have started supporting it and in the next few years it is likely to be a big market as it is the easiest way to use an experience with a headset or without. It is also beneficial because it is easier to deploy a website to many users, rather than ensuring each headset is up to date with the latest application.

Native applications are more polished, are more powerful, and extensible. They require specific development tools, such as Unity or Unreal game engines. These typically require a user to have a headset, adn are more difficult to maintain than a web page. With native applications, other considerations such as whether it should be mobile phones, 3 DOF headsets, 6 DOF headset, AR Headset must also be considered to optimize the experience for each device.

Realistic versus stylized environments

There is an ongoing debate about whether using realistic or stylized virtual environments is better for virtual reality experiences. There has been research showing that stylized environments are preferred with realistic interactions (Svee, 2019), however, this depends on the user base and the use case. Most users are expecting AAA game studio quality, and this is not always possible. With virtual meetings, as long as the avatar is human-like and behaves like a human, that is enough for the user to believe in the experience, and treat it as being real (Blascovich et al. 2002). The same is true for stylized environments. As long as the environment acts and can be interacted in an expected way, then the user will treat the experience as being real.

Conclusion

Now is the time to get started in Spatial Computing. Let developers experiment in technology, create new use cases, and have reality become your next computing platform.

There is a stigma that Spatial Computing is for video games, but as has been stated, there are many use cases within an office setting. There are things to consider before adopting but given the potential, it is time to start looking into the technology. All industries can benefit from the communication and collaboration use cases as well as training. This is because having a head mounted display, and allowing the user to be present inside a room where they can respond to certain situations can translate better into real world scenarios than watching a video or reading text from a computer screen.

When training for situations that are rare and dangerous, virtual reality is the medium to perform in without needing to spend the money to create the situation, and with no risk to the employee. In these circumstances, instead of having one chance to try a scenario in a classroom setting, the employee can try multiple times in virtual reality with no harm to them.

Enterprises would benefit in the technology by using it for communication, collaboration, training, education, diversity, inclusion, working from home, virtual assistant, and getting the most recent data to help employees perform in their role or assist consumers. The next computing platform is reality, and the enterprise must be ready.

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