Virtual and Augmented Reality

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This article will share with you the latest information about two powerful and interconnected technologies: Virtual Reality and Augmented Reality.

For many readers, the two terms may look to be identical but they are not. They are in fact dual of each other.

Virtual Reality describes generally an “artificial” digital or numerical universe in which we are plunged. The “3D games’ that appeared in the 80’s and the 90’s are a perfect example of that virtual reality.

In Virtual Reality, the user (or the “player” if we refer to a game) is immersed into a simulation of reality, which tries to be as realistic as possible in terms of sounds, images, video and atmosphere. This always involves a three-dimensional experience, e.g the user can “move” using some mechanical controls, inside the virtual reality along three axes. Two-dimensional virtual systems which do not involve a third dimension are no different than going to a movie theater or watching a video on a screen.

To the opposite, in Augmented Reality, the user *embeds* virtual elements into his/her real world. So, augmented reality appears as dual from virtual reality. Typically in augmented reality, sensors or other sources of information send data which are displayed to the user via a visual interface or sounds or other ways. The way these data are displayed in the real world of the user means that they often interact with it and that they can “superpose” themselves to the vision of the user for instance. A typical example are 3D glasses which superimpose 3D computer generated images to the natural vision of the user.

An overview of the technologies involved with both virtual and augmented reality

Virtual Reality (VR)

Virtual Reality is older than Augmented reality. It really started in the 80's with personal computers and the development of graphical user interfaces. As we mentioned the main (if not only) usage was gaming. Games such as Wolfenstein 3D, released in 1992, pioneered the first person shooter games using a realistic 3D engine (for the time), allowing a player to move and interact in a 3D universe by using a personal computer and the mouse and keyboard to control the interaction with the virtual reality. Such games, the first-person-shooters, gave the impression to a player that he or she was 'really' physically present inside the virtual universe of the game. Wolfenstein3D was followed by many many others, always and continuously improving the 3D engine, making it more and more realistic with the time. With the continuous increase in chip computing power and in video computing power, games using virtual reality, especially first-person shooters, became extremely realistic, with engines able to simulate a vast amount of 'natural' physical phenomenons, such as gravity, sunlight, fog, etc… Besides, the development of artificial intelligence allowed the player to create characters with which the player can interact and that gives the impression to be autonomous, increasing the appearance of reality in the artificial world of the game.

While the simulated worlds and the gaming engines became more and more developed, the way the player could interact with these virtual worlds became more and more subject to improvement. A wide range of devices were developed to allow mechanical interaction with the virtual world: joysticks, racing steering wheels, pedals, buttons etc… The virtual reality vision glasses were also developed. They were especially simple: a panoramic screen installed directly on the surface of immersive glasses. With such a system, user vision was fooled into the realistic impression that he or she was really inside the virtual universe and interacting really with it.

At first such 3D vision glasses were developed for niche areas such as attractions in fun fairs or scientific research with molecules but recently they reach a level of maturity which allows the general public to buy them for an affordable cost.

3D vision glasses use the natural motion of the body to control the virtual world. For instance if a user rotates the head, the glasses will trigger the adequate rotation and so they act as a controller in the same way as the mouse or the keyboard.

For now the 3D vision glasses are not able to provide a “fluid” experience because there is a significant delay between the movement of the body and the adequate reaction of the graphical engine. The engine reacts very fast to the movement of the body but for our user experience this is not fast enough and then users may experience nausea and sicknesses, similar to the sea or motion sicknesses.

The fact that user experience is not good in such cases involves the very limit of such technology and its limitations.

Among several applications other than gaming, Virtual reality technologies have created interest for fitness, military training and simulation for crews. Another area of application is e-learning and remote working.

The technologies used by Virtual Reality are not new. In fact they existed decades before but were much too expensive to produce commercial products. VR glasses simply use motion sensors which update information to microcontrollers, which in turn are converted into motion information for the virtual reality engine.

Augmented Reality (AR)

Augmented Reality started really with the Augmented Reality Google glasses headsets in the 10’s. Such glasses could display a continuous feed of information on the glasses, superposing the information to the natural vision of the user. This information varied and depended on many sensors: location (obtained by GPS) , weather, speed, motion etc…

The price of the first versions were important and there was not an important market for it, except for maybe a few ‘geeks’ and hightech users.

With time, augmented reality started to find its way, allowing traders to immediately visualize ‘real-time’ information and act faster than by looking at the screen of their computers or smartphones.

Athletes, soldiers and a category of people that needed to visualize information without having the possibility to consult a computer/smartphone screen found in Augmented Reality a very helpful system.

Here, Augmented reality acts no more no less than a personal computer dashboard.

It is interesting to notice that Augmented Reality was first introduced by … Virtual Reality. The characters in games typically use such systems while they are fighting or making their ways through obstacles. The concept was therefore extracted from virtual reality to be put inside our physical world.

As per 2020, Augmented Reality is supposed to be the next revolution for armies and polices all over the world, allowing them to get continuous information from the other soldiers or from the command center, such as the enemy position, the status of weaponry, or any additional information available through lasers, lidars or radars equipping their suits.

VR and AR as a Computer User Interface

Operating Systems and softwares in general can make use of such technologies to provide new ways of man-machine interfaces.

Windows Mixed Reality

Windows have developed a “mixed” reality system available in some Windows 10 editions, and which provides holographic and mixed reality experiences with compatible head-mounted displays.

The mixed reality interface is a hybrid system with pieces belonging to VR and pieces belonging to AR. The devices used are typically the Microsoft HoloLens glasses.

Windows also maintains the Mixed Reality portal, which provides applications making use of the microsoft mixed reality technology.

Apple Augmented Reality

IoS claims to be the largest platform for AR development. Several useful information can be found on their official website. IOS ,same as Windows, provides SDK to enable developers to create AR interfaces for their platform.

Typical applications are in education.

Note that IoS AR is not based on headsets but on the IOS devices themselves.The sensors are worn by users (Lidar sensors for example) but the final display is on the AR device which is usually a tablet or a smartphone.

Google Augmented Reality

Google pioneered AR. Same as Apple, Google proposes Android-enabled AR applications. Google provides a lot of LIDAR and UWB radar detection systems throughout the project SOLI.

This is one of the most innovative AR sensors actually offered by Google.

Magic Leap Spatial Computers

Magic leap offers what they name as ‘spatial computers’, e.g. computers with an operating system which are primarily focused on Augmented Reality. They are not SmartPhone based systems and can be compared with Microsoft Hololens systems but they offer richer and more complex AR experience.

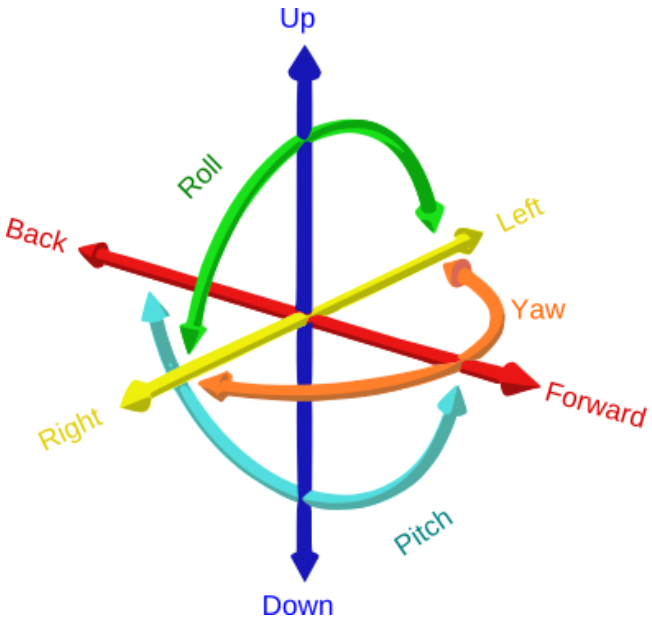
An Overview of the Available HeadSet products for VR and AR

3DOF and 6DOF

These terms refer respectively to three-degree of freedom and six-degree of freedom.
They are important to understand the difference between the 3D VR headsets.

The Six degrees of freedom (6DoF) relates to the freedom of movement of a rigid body in three-dimensional space.

These describe *independent asynchronous* movements which can be performed independently of each other and not sequentially.



They are represented in the above picture.The three translation movements (right/left, up/down and forward/back) are the most obvious. The three other movements corresponds to rotations along each translations axis:

- A *roll* consists of a rotation through the forward/back axis. For example the user moves forward like crawling in a tunnel and rotate his body along that tunnel
- A *yaw* is a rotation along the up/down axis. This can be visualized by a user climbing rectangular stairs for instance and rotating by 90 degrees to follow them.

- A *pitch* is a rotation following left/right . think of someone sliding a wall by the left than suddenly falling back, rotating their body

Of course in normal life, the 6 degrees of freedom are rarely applied optimally except by dancers, sportsmen or acrobats.

3DOF is, in terms of VR, the ability to only perform rotational movements: yaws, rolls and pitches.

To continue our study, modern VR headsets are streamed into three different categories: Mobile (wireless) , Wired (using a cable), or autonomous.

Wireless Mobile VR headsets

Mobile VR headsets are just basic headsets equipped with a pair of lenses which will connect to the smartphone. The lenses will divide the screen into two images, right and lef and this will turn the smartphone into a VR device.

Such mobile headsets are not expensive (typically around 100$) Since all the processing is performed on the smartphone, there is no need for any cable connection and the system works in wireless mode.

Such ‘cheap’ VR Headsets are not truly VR. They usually offer three-degrees-of-freedom (3DOF) motion tracking but they won’t process the position of the user, meaning that the user will not move synchronously to his real position.

Here are some Wireless mobile headset products:

- Samsung Gear VR
- Google Daydream View
- Nintendo Labo VR Kit
- Qualcomm-Compatible XR Viewers

Wired (dependant) VR Headsets

Wired VR headsets are connected to a PC or a game console by a cable. In fact some may not need a cable, but in all cases these headset cannot function without additional hardware nearby. They usually provide 6 degrees of freedom and as such allow the user to have a ‘real’ VR

experience. Of course they are more expensive than the mobile ones. From 500$ to 1,000$ in general.

Such VR systems offer either external sensors or outward-facing cameras on the headset to provide the full 6DOF movement tracking.

Since the headsets have a dedicated display, the image fluidity and fidelity is considerably higher than the mobile ones.

Here are some Wired VR headsets products:

- Oculus Quest VR headset
- Nintendo Labo VR Kit
- Sony PlayStation VR headset
- HTC Vive

Autonomous VR Headsets

Autonomous VR headsets do not need additional hardware to function. They are often an intermediary choice between the mobile and wired versions. The good point is that the user does not need another computer connected to it and so have a lot of leeway to experience VR. The bad point is that the embedded system inside the headset cannot certainly provide the same processing power as the lastest Pentiums and NVidia GPU processors that the wired/dependant VR headsets use. There is therefore a trade-off between independence and performance here. Some of the headsets offer 3 degrees of freedom and some offer 6 degrees of freedom.

Here are some Autonomous VR headsets products:

- Oculus Go
- Oculus Quest
- Lenovo Mirage Solo With Daydream

An overview of AR headsets

AR headsets are usually less expensive than VR ones.

AR headsets have transparent lenses which allow users to look at the surrounding environment, rather than completely replacing their vision with a computer-generated image

AR generated images are designed to complement and interact with the user environment, not to replace it.

AR Products can be very expensive: a Magic Leap One headset costs around $2,300 and the HoloLens 2 is expected to cost around $3,500.

Pro and Cons of AR and VR

AR and VR are very controversial technologie and their need and use are very debatable in many areas. They still stay in ‘niche’ areas where the biggest applications are in gaming.

They, of course, represent a futuristic way of interfacing computers but, let us face it, they can be so ‘freaky’ that they can even discourage the most enthusiastic geeks. After all, who is going to wear these awful huge glasses which costs a lot of money? They are certainly very novel and entertaining but … do we really need them?

Besides this, there are still unknown effects that can produce disorientation and confusion over several users, not to mention serious psychiatric problems and as such their usage should be restricted to very specific domains like for example people working in extreme conditions : astronauts, firefighters, pilots, police squads, soldiers and who cannot really afford to get visual information thought computers while they are on duty.

Using VR in gaming is certainly very promising but one certainly should take care of what sort of games will be published for VR. Playing ultra-violent and ultra-realistic games with VR can certainly cause strong psychiatric damages to users and as such, these devices may need medical authorization before they are released on the free market.

One “good” application is for fitness and sport rooms where they can allow users to outperform by creating a stimulating environment.

Conclusion

AR and VR devices are certainly going to revolutionize the way we interact with computers. They still are at the beginning but they look very promising.

As we underlined, some use can be dangerous and may need control and regulations.

Whatever AR and VR will become and how they will develop, we should never forget that they will neve outperform or be better than our good old physical world!

We hope that we gave here the reader a general tour of AR and VR technologies.