iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VII **Month of publication:** July 2021

DOI: https://doi.org/10.22214/ijraset.2021.37098

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VII July 2021- Available at www.ijraset.com

Augmented Reality

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Abstract: Augmented Reality (AR), which blends virtual information with the real environment in real-time performance, is constantly evolving and becoming more sophisticated and robust. It is critical to ensure that the augmented reality system is accepted and successful. This paper primarily discusses the current state of AR applications and the various fields in which AR is being used.
Keywords: Augmented Reality, Mixed Reality, Virtual Reality

I. INTRODUCTION

Augmented Reality(AR) is an artificial environment created through the combination of real-world and computer generated data. It is a combination of a real scene viewed by a user and a virtual scene generated by a computer that augments the scene with additional information. An AR system adds virtual computer-generated objects, audio and other sense enhancements to a real-world environment in real time. Augmented reality (AR) is gaining popularity as a technology enabler in a variety of disciplines, including education, design, navigation, and medical. It increases the user's perceptions such as vision, hearing, touch, and smell by combining virtual information with the real world in real-time performance. Augmented reality is a technique that uses computer vision-based recognition algorithms to add sound, video, images, and other sensor-based inputs to real-world items via your device's camera. It's an effective approach to produce real-world data and present it in a dynamic manner, allowing virtual elements to blend in with the actual environment. Augmented reality displays superimpose data in your field of view and can transport you to a new universe in which the real and virtual worlds are inextricably linked. It's not just for computers or mobile phones. A fantastic example is Google Glass, a wearable computer with an optical head-mounted display.

One of augmented reality's key goals, amidst the expansion of data collecting and analysis, is to highlight certain elements of the physical environment, raise comprehension of those qualities, and generate sensible and accessible knowledge that can be used to real-world applications. Big data may help organisations make better decisions and acquire insight into consumer purchasing habits, among other things.

II. LITERATURE REVIEW

AR brings the real and virtual worlds together in real time, supplementing the real world with computer-generated virtual items. AR is defined as a technology that combines real and virtual things in a real world, aligns real and virtual objects with each other, and allows for real-time interaction, according to one of the most widely accepted definitions. Milgram's mixed reality continuum is a taxonomy of how actual and virtual elements can be merged, as shown in the diagram below. From a wholly real to a completely virtual environment, the continuum spans. Mixed reality can be characterized as a condition in which real and virtual items are mixed together, based on this continuum. Because AR integrates virtual things in the user's real environment, allowing interaction with virtual content, it might be regarded a mixed reality technology with more reality. In the instance of mobile AR, the technique entails the use of a smartphone camera to integrate digital features to the actual world. Virtual reality is distinct from augmented reality in that it shuts out the actual world and immerses the user in a digital world using a virtual reality headgear.

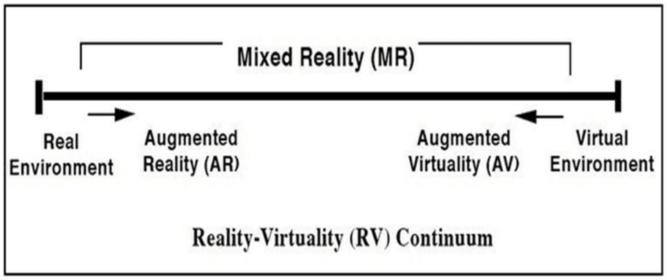

Fig. 1. Milgram's Mixed Reality Continuum

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III. TYPES OF AR

A. Marker-based AR

Marker-based AR works by triggering an enhanced experience with the usage of markers. The markers, which are frequently constructed with distinctive patterns such as QR codes or other unique motifs, serve as technological anchors. When an augmented reality programme recognises a physical marker, digital material is superimposed on top of it. Augmented reality using markers is frequently utilised in marketing and retail. Consider talking business cards and moving brochures.

In this case, marker-based AR is being utilized in a person's house for retail reasons. Imagine being able to preview how your new bathroom vanity will appear before you purchase it. You can also use this app to swipe through several sink alternatives to determine what looks best in your area.

B. Markerless AR

Marker-less AR is more adaptable than marker-based AR since it lets the user to place the virtual object where they want it. You may experiment with various styles and places entirely digitally, without having to change anything in your immediate environment. Markerless augmented reality uses the device's hardware, such as the camera, GPS, digital compass, and accelerometer, to collect the data required for the AR programme to function.

The virtual automobile in this case may be placed wherever, independent of the surrounding surroundings. You can personalise the Mustang, modify and rotate the perspective, and read more about the product.

C. Location-based AR

Digital material and the experience it produces are tied to a specific location with location-based AR. The items are laid up in such a way that they appear on the screen when a user's location matches a predefined point.

Pokemon Go, the game that popularised augmented reality, is an example of location-based AR. The programme uses your smartphone to bring virtual Pokemon into our reality, and players are urged to find as many of the characters as they can.

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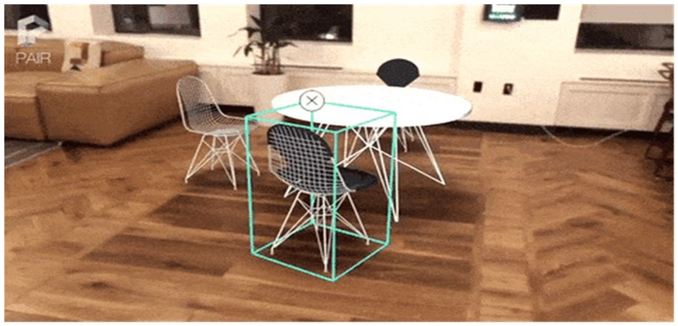
D. Superimposition AR

Superimposition AR detects an object in the real world and improves it in some way to offer a different perspective. This might be as simple as replicating a piece of the item or as complex as rebuilding the complete entity.



The chair is duplicated, rotated, and put in a different spot around the table in this example. With this technology, the user may select if they want four chairs and a little elbow room or whether they can easily sit six at the same table.

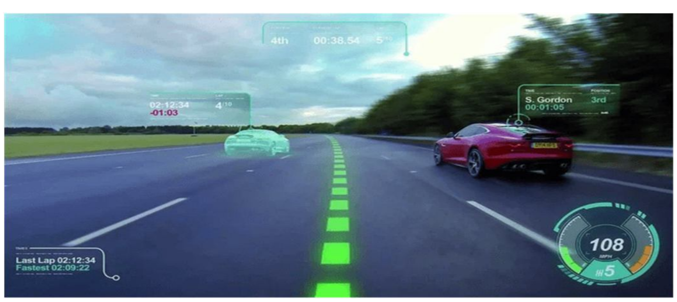
E. Projection-based AR

Projection-based augmented reality is distinct from other forms of markerless augmented reality. To put it another way, you don't need a mobile device to see the information. Instead, light projects computer visuals onto an item or surface, allowing the user to interact with them.

Projection-based AR is used to generate 3D things that the user can interact with. It may be used to demonstrate a prototype or mockup of a new product, as well as disassemble each component to better demonstrate its inner workings.

F. Outlining AR

When the human eye is unable to distinguish borders and lines, Outlining AR can assist. To comprehend a user's immediate surroundings, augmented reality employs object recognition. Consider driving in low-light situations or viewing a building's construction from the outside.



This example of outlining AR informs the motorist of the exact location of the lane's centre to keep them safe. Parking your automobile and having the limits drawn so you can see exactly where the parking spot is are examples of similar usage.

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IV. AR COMPONENTS

A. Scene Generator

The scene generator is the hardware or software that renders the scene. Rendering is not now one of the key issues in AR because just a few virtual objects need to be created, and they don't always need to be realistically displayed to satisfy the application's needs.

B. Tracking System

Because of the registration issue, the tracking system is one of the most essential challenges for AR systems. The illusion that the two worlds coexist will be jeopardized unless the objects in the real and virtual worlds are appropriately aligned with regard to each other. Many applications in the industry, particularly in medical systems, necessitate precise registration.

C. Display

AR technology is still in its early stages of development, and solutions are dependent on design considerations. HMDs make up the majority of AR display devices (Head Mounted Display).
When it comes to merging the actual and virtual worlds, there are two main options: optical and video technologies. Depending on parameters such as resolution, flexibility, field-of-view, and registration procedures, each of them has various trade-offs.

V. AR DEVICES

A. Optical see-through HMD

The virtual environment is seen directly over the real world in Optical See-Through AR, which uses a transparent Head Mounted Display. Optical combiners are placed in front of the user's eyes to make it operate. These combiners are somewhat transmissive, allowing the user to see the real world via them. The combiners are also somewhat reflective, so virtual pictures bounced off them from head-mounted monitors are visible to the user.
The many augmented medical systems are prime instances of an Optical See-through AR system. There are presently no general-purpose see-through HMDs available. The alignment of the HMD optics with the real environment is one challenge with Optical See-through AR. A good HMD enables for changes to meet the user's eye position and comfort. When it's not in use, it should be simple to move out of the way.

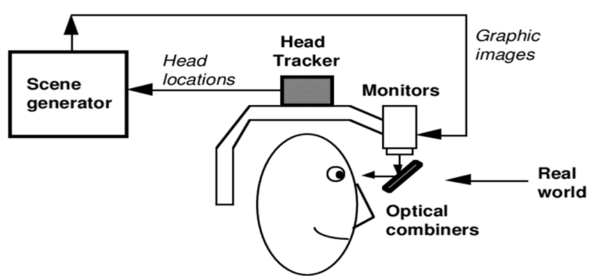

Fig. 2. Optical See-Through

B. Video see-through HMD

In Video See-Through AR, an opaque HMD is used to display integrated video and view from the HMD's cameras.
This method is a little more complicated than optical see-through AR because it necessitates precise camera placement. Video composition of the actual and virtual worlds, on the other hand, is significantly easier.

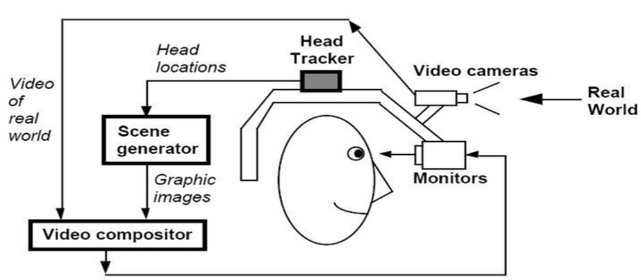

Fig. 3. Video See-Through

C. Monitor Based

Monitor-based AR uses merged video streams as well, but the display is a standard desktop monitor or a hand-held device. It's the simplest AR setup because it doesn't require the use of a head-mounted display. Princeton Video Image, Inc. has created a method for combining graphics with live video feeds. In American football games, their work is frequently visible as the first down line. It's also utilized to incorporate commercial logos into various broadcasts.

VI. KEY TECHNOLOGIES OF AR

A. Intelligent Display Technology

According to relevant statistics, humans receive more than 65 percent of their knowledge through their own eyes, which has evolved into the most intuitive way for humans to engage with the actual world. Augmented reality becomes a possibility with the advancement of intelligent display technology, which is pushed to new heights by the many types of display devices created using intelligent display technology. There are three primary kinds of display devices that play a significant role in the area of AR technology nowadays. In 1968, the first helmet display (HMD) was introduced. Professor Ivan Sutherland's optical perspective helmet display allows users to superimpose basic visuals created by computers on real-world situations in real time. Optical perspective helmet-mounted display and video perspective helmet-mounted display are the backbone of helmet-mounted display in subsequent development. Second, portable device display, based on augmented reality technology, handheld device display is extremely light, tiny, especially with the popularity of smart phones, through video viewpoint to show using augmented reality technology. Third, additional display devices, such as PC desktop displays, convert real-world scene data collected by the camera into a three-dimensional virtual model created by the computer, which is then presented on the desktop display.

B. 3D Registration Technology

3D registration technology is one of the most important technologies in the augmented reality system because it allows virtual pictures to be correctly placed in the actual world. There are two phases in the primary flow of 3D registration technology. Determine the connection between the virtual picture, the model, and the camera or display device's direction and position information first. Second, the virtual rendered picture and model are projected precisely into the actual world, allowing the virtual image and model to be blended with the real world. There are several methods for 3D registration, including hardware tracker registration, computer vision registration, wireless network registration, and mixed registration, the latter two being the most common. It establishes a reference point for three-dimensional registration technology based on computer vision, allowing the camera or display to determine the direction and location of the real scene.

C. Intelligent Interaction Technology

Intelligent interactive technology is intertwined with intelligent display, 3D registration, ergonomics, cognitive psychology, and other fields. Hardware device interactions, location interactions, tag-based or other information-based interactions are all examples of intelligent interactions in AR systems. Augmented reality now not only superimposes virtual information over real-world situations, but also allows users to interact with virtual items in those settings, thanks to advancements in intelligent interaction technology. This interaction is focused on humans giving precise instructions to the virtual item in the environment, and the virtual object may provide feedback, allowing the augmented reality application's audience to have a better experience.

VII. AR DEVELOPMENT TOOLS

A. Foreign AR SDK

Apple's augmented reality development tool, ARKit, was released in 2017. This set of technologies allows developers to create augmented reality apps for iPhones and iPads. ARKit assists developers in creating AR applications that allow two devices to share the same virtual things, enhancing the AR experience. Google's software framework for creating augmented reality applications, ARCore, is similar to Apple's ARKit. It can use improvements in cloud software and device technology to bring digital items into the physical world. Motion capture, environment perception, and light source perception are the three major functionalities.

Vuforia is the most popular SDK at the moment. The core identification feature is compatible with iOS, Android, and Windows Phone, and multiple SDKS are available depending on the platform. Depending on your demands, you may use Android Studio, Xcode, Visual Studio, or Unity as a development tool.

The Wikitude SDK reconstructs its proposals utilising an image recognition and tracking development framework as well as geolocation technologies, such as image recognition and tracking, 3D model rendering, video overlay, and location-based AR. Wikitude introduced SLAM technology in 2017, which allows for object detection and tracking as well as unmarked real-time tracking.

B. Domestic AR SDK

It's difficult for domestic developers to use a foreign AR SDK to suit their demands. Language hurdles, inadequate technical assistance, delayed technical support, and no results are among the most significant challenges. Domestic AR SDK provides several advantages in terms of localisation. Baidu AR, NetEase Insight AR, Vision+EasyAR, Liangfengtai HiAR, Tianyan AR, Taixu AR, and Magic AR are the most popular AR SDKs. Baidu announced the formal launch of the augmented reality Lab (AR Lab) on January 16, 2017. DuMix AR 3.0 from Baidu provides technology developers with cutting-edge technological features like as intelligent perception, virtual rendering, human-computer interaction, and fast and flexible engineering development techniques.

Insights from NetEase AR clients (AR content browsers), AR SDKs (Internet application engines), and AR game engines (AR GAME PLUGIN) can efficiently connect high-quality AR content developers and use situations to deliver high-quality to consumers. EasyAR is a simple, easy-to-use, and efficient SDK with desirable features and strong capabilities that developers have long desired, such as dynamic target recognition loading, H.264 hard decoding, recording screen function, and over 1000 local target recognition.

VIII.INTERFACES AND VISUALIZATION

AR research has broadened in breadth during the last five years. Researchers are thinking about how users will interact with and operate AR apps, as well as how AR displays should convey information, in addition to the core enabling technologies.

A. User Interface and Interaction

Most AR interfaces used to be based on the desktop metaphor or leveraged designs from Virtual Environments research until recently. The utilization of diverse designs and physical interfaces is a major trend in interaction research, especially for AR systems. Heterogeneous methods blur the lines between real and virtual worlds, including elements from each. The use of actual, physical items and tools is emphasised in tangible interfaces. Because the user of an AR system sees the actual world and frequently want to interact with real items, it is acceptable for the AR interface to have a physical component rather than being purely virtual.

In one such interface, the user manipulates furniture models in a prototype interior design programme using a real paddle. The user may pick pieces of furniture, drop them into a room, push them to the appropriate positions, then crush them out of existence to remove them using various actions such as pushing, tilting, swatting, and others. The Studierstube Personal Interaction Panel (PIP), numerous game apps, and Sony's Augmented Surfaces system are further examples. The Studierstube PIP is a user-held blank physical board on which virtual controls are created. The interface's tactile nature facilitates interaction with the controls. Several AR gaming devices were developed by the Mixed Reality Systems Lab. Two players played a hockey game with the AR2 Hockey system by manipulating a real item that represented the user's paddle. Users modify data using a range of real and virtual methods in Sony's Augmented Surfaces technology. Both projective and portable displays are used to present data to users. When a real camera model is put on top of a projection of a top-down view of a virtual room, it creates a 3D depiction of the room from that camera's perspective. Researchers have begun to investigate collaboration in diverse settings. The Studierstube and MARS systems, for example, allow co-located and distant users to collaborate while engaging with AR, VR, and desktop displays. Another example of cross-paradigm collaboration is mobile warfighters cooperating with troops in a virtual reality military simulation. Alternatively, the Magic Book interface allows one or more AR users to enter a VR environment shown on the book's pages; once inside the immersive VR world, the AR users see an avatar appear in the environment depicted on the book page. When the user descends into the VR reality, the Magic Book requires the display to fully hide their view of the world.

B. Visualization Problems

Due to the nature of AR technology or displays, researchers have begun to address issues with showing information in AR displays. Work has been done on displaying registration failures and preventing vital data from being hidden due to density issues.

1) *Error Visualization:* In some AR systems, registration errors are significant and unavoidable. For example, the measured location of an object in the environment may not be known accurately enough to avoid visible registration error. In such circumstances, one strategy is to rendering an item is to show the region in which it exists graphically. Based on the object's location on the screen,errors in measuring and tracking are predicted. This ensures that the virtual representation is complete at all times.
2) *Data density:* If a huge amount of virtual data is added to the actual environment, the display may become crowded and illegible. The distribution of data on the screen varies based on the user's real-world perspective. Julier employs a filtering approach based on a spatial interaction model to keep critical information visible while reducing the quantity of data presented. To evaluate whether or not each object should be presented, the framework considers the user's objective, the importance of each object in relation to the goal, and the user's position.

C. Advanced Rendering

Virtual augmentations should, in theory, be indistinguishable from real-world items. In real life, such high-quality representations and compositions are not possible.

Researchers have started looking at the issues of removing actual things from the environment (a.k.a. Mediated Reality) as well as more lifelike depiction (although not yet in real time).

1) *Mediated Reality:* The challenge of eliminating real things entails more than just collecting depth information from a scene, as previously mentioned in the section on tracking; the system must also be able to separate specific items in that environment. Lepetit presents a semiautomatic approach for using silhouettes to identify items and their positions in a scene. This allows virtual items to be added and actual ones to be removed without requiring a 3D reconstruction of the environment.
2) *Photorealistic Rendering:* The ability to autonomously gather environmental lighting information is a critical need for enhancing the rendering quality of virtual objects in AR applications. A method that employs ellipsoidal models to predict lighting parameters and Photometric Image-Based Rendering are two examples of work in this field.

D. Human-Factors Studies and Perceptual Problems

Human factors, perceptual studies, and cognitive science research may all aid in the development of effective AR systems in a variety of ways. Drascic talked about 18 major design challenges that have an impact on AR displays. Implementation mistakes, technological challenges (such as vertical misalignment in picture frames of a stereo display), and basic design constraints in existing HMDs are among the issues. Rolland and Fuchs examined the various human variables in relation to optical and see-through HMDs for medical purposes in depth. Among the most important factors are:

1) *Latency:* More registration mistakes are caused by delay than by all other factors combined. Delay, moreover, can impair work performance. A statistically significant change in the performance of a job to guide a ring across a bent wire may be made by delays as little as 10 milliseconds.
2) *Depth Perception:* Because numerous elements are involved, accurate depth perception is perhaps the most challenging form of registration to obtain in an AR display. As previously stated, certain problems (such as the accommodation-vergence conflict or the fact that poor resolution and dark screens make an item look further away than it is) are being addressed through the design of new displays. Other issues can be overcome by appropriately depicting occlusion. The position of the eyepoint is also important. The eye's centre of rotation gives the highest position accuracy, while the centre of the entry pupil yields greater angular accuracy, according to an examination of alternative eyepoint positions to employ in generating an image.
3) *Adaptation:* User adaption to augmented reality technology might have a detrimental influence on performance. In a video see-through HMD, one research looked at the impact of vertically shifting cameras over the user's eyes. The individuals were able to adjust to the displacement, but when the HMD was withdrawn, they had a significant overshoot in a depth-pointing test.
4) *Long-Term Use:* Uncomfortable AR displays may not be acceptable for long-term use. Biocular displays (in which the same picture is displayed on both eyes) were found to produce substantially more discomfort, both in terms of eye strain and tiredness, than monocular or stereo displays, according to one research.

IX. DIFFERENCE BETWEEN AR AND VR

The phrases "virtual reality" and "augmented reality" are frequently used interchangeably. AR apps and games, such as Pokemon Go, and VR headsets, such as the Oculus Quest or Valve Index, are still popular. They sound similar, and as technology advances, they begin to blend together. However, they are two distinct concepts with qualities that distinguish one from the other.

A. Virtual Reality

VR headsets completely obliterate your vision, giving you the illusion of being somewhere else. When worn, the HTC Vive Cosmos, PlayStation VR, Oculus Quest, Valve Index, and other headsets are opaque and shut off your surroundings. You might assume you're blindfolded if you put them on when they're switched off. However, when the headsets are turned on, the lenses refract the LCD or OLED displays within to fill your field of vision with whatever is being projected. It could be a game, a 360-degree film, or simply the virtual area created by the platform's interfaces. The outside world is replaced with a virtual one, and you're transported to anywhere the headset wants you to go.

Virtual reality exceeds your surroundings in both games and apps, transporting you to other locations. It makes no difference where you are physically. You can sit in the cockpit of a starfighter in games. You may virtually tour distant sites as though you were there using apps. Virtual reality offers a plethora of possibilities, many of which involve replacing everything in your environment with something else.

B. Augmented Reality

Rather than replacing your eyesight, augmented reality augments it. AR glasses, such as the Microsoft HoloLens and other enterprise-level "smart glasses," are transparent, allowing you to see everything in front of you as if you were wearing a pair of cheap sunglasses. AR displays may range from basic time overlays to holograms hovering in the midst of a room. On top of whatever the camera is looking at, Pokemon Go puts a Pokemon on your screen. Meanwhile, smart glasses like the HoloLens and others allow you arrange floating app windows and 3D décor around you digitally. When compared to virtual reality, this technology has a significant disadvantage: visual immersion. AR applications only appear on your smartphone or tablet screen, and even the HoloLens can only display pictures in a limited area in front of your eyes, but VR totally covers and replaces your field of view. The potential for augmented reality are virtually endless. For years, phone-based AR software has recognized surroundings and provided additional information about what it sees, such as real-time text translation or pop-up restaurant reviews as you look at them. Dedicated AR headsets, such as the HoloLens, can go much farther, allowing you to put several programmes as floating windows in virtual space. AR is now only accessible on cellphones, and it lacks the vision-augmentation capabilities of enterprise-level AR screens. As a result, until a consumer AR headset is produced, AR will remain highly restricted.

X. AR CLOUD

Cloud computing was made feasible because to a lot of early grid computing research. Since 2007, cloud computing has grown in popularity. In 2010, Gartner named cloud computing as one of the top ten IT industry strategic technologies. Cloud computing will grow over the next several years and become an essential element of mainstream computing.

The AR cloud represents the whole world's digitalization. With the advent of AR cloud, Charlie Fink predicted that the entire world will become a Shared space screen, allowing numerous users to participate and collaborate in real time. The present AR experience is similar to a standalone game that necessitates connectivity, cooperation, and sharing. The AR cloud is frequently referred to as the development of search, and many people will be seeking for surprises in the AR world in the future.

The implementation of AR cloud necessitates a real-world 1:1 data set (creating a data set that is consistent with the real world, including real-world position coordinate information, scene visual features, and can be updated and expanded in real-time changes), the ability to quickly locate (the terminal device should be able to access this cloud from any location with a network, and can quickly and accurately locate), and the ability to quickly and accurately locate (the terminal device should be able to access this cloud from any location. Through the device's GPS, gyroscope, accelerometer, electronic compass, and camera visual information, get point cloud and picture upload to the cloud, match the point cloud in the cloud, and return position information), as well as interactive virtual content and multiplayer online engagement. As a result, the virtual world can have many versions, similar to how there are various gaming servers, and players can choose and choose according to their preferences. You may use the AR cloud for a variety of applications in both the physical and digital worlds (transportation, energy, health, social, entertainment, and so on).

However, several issues must be addressed in order to use AR cloud, such point cloud storage, network latency, lost lines, and user experience (UX). Other key skills are lacking, such as the need for more natural and intelligent voice interaction, AI technology to deal with or generate large amounts of data, low latency 5 G networks, block chain to encourage people to create and trade AR virtual content, the Internet of Things to provide more data in the real world, and a collaborative AR cloud.

XI. APPLICATIONS

Entertainment, education, health, engineering, and manufacturing are just a few of the sectors where Augmented Reality technology might be used. With the spread of this technology, new potential areas of use are likely to emerge.

A. Education

AR can enable teachers to display virtual illustrations of ideas and integrate game aspects to give textbook material assistance, making classroom instruction more exceptional and engaging. Students will be able to learn and memorize information more quickly as a result of this.

B. Architectural Designing

In building and architectural projects, augmented reality entails combining mobile devices and 3D models to show a 3D model of a proposed design onto an actual environment. Aside from visualization, augmented reality offers a slew of design and construction applications. It may be used for design analysis to find conflicts in your final model by visually walking through it.

C. Marketing

Augmented reality (AR) is a growing trend in marketing and sales that allows businesses to provide clients with new experiences while utilizing the convenience of their mobile devices. Consumers connect with businesses and make purchasing decisions through mobile, which has become one of the most important media kinds. When it comes to boosting sales and enhancing brand value through mobile devices, AR provides you another tool in your toolbox.

D. Gaming

The integration of game visual and audio material with the user's environment in real time is known as augmented reality gaming (AR gaming). Unlike virtual reality gaming, which frequently necessitates the use of a separate room or limited space to create an immersive atmosphere, augmented reality gaming makes use of the current environment to create a playing field inside it. Smartphones, tablets, and portable gaming systems are commonly used to play AR games. One of the finest examples of this is Pokemon Go.

E. Military Training

The military has been utilizing cockpit displays that display information to the pilot on the cockpit glass or the visor of the flying helmet. This is an example of augmented reality. The actions of other units participating in the exercise can be imaged by providing military troops with helmet mounted visor displays or a special purpose rangefinder.

During a training segment, for example, a display equipped soldier may observe a simulated helicopter ascending beyond the tree line while staring towards the horizon.

F. Medical

Because imaging technology is so widely used in the medical profession, it's no surprise that it's one of the most significant domains for augmented reality systems. The majority of medical applications are concerned with image-guided surgery.

The surgical team may use augmented reality to view the CT or MRI data accurately recorded on the patient in the operating room as the process progresses. The surgical team's performance will improve if they can correctly register the pictures at this point.

Ultrasound imaging is another use for augmented reality in the medical field. The ultrasound technician may see a volumetric generated picture of the foetus layered on the pregnant woman's belly using an optical see-through display. The picture seems to be inside the abdomen and is displayed appropriately when the user moves.

G. Entertainment

For a long time, a rudimentary version of augmented reality has been used in the entertainment and journalism industries. When you watch the evening weather report, you'll notice that the speaker is always standing in front of shifting weather maps. The reporter is really standing in front of a blue screen in the studio. Using a process known as chroma-keying, this actual image is enhanced with computer-generated maps.

H. Robotics and Telerobotics

In the field of robotics and telerobotics, an augmented display can assist the system's user.

To direct the robot, a telerobotic operator utilizes a visual representation of the distant workspace. When the scene is in front of the operator, annotating the view would be beneficial.

Furthermore, augmenting the view with wireframe drawings of structures can aid visualization of the remote 3D geometry.

XII. LIMITATIONS

AR, like any other technology, has significant limits. Even though mobile devices have a wide range of applications in their current state, there are a number of challenges that need to be addressed before the technology is completely marketed and mainstreamed.

To begin, data should be presented over the wearer's whole field of view, not just a portion of it. The technology should also have a greater knowledge of natural body motions, allowing for smaller and lighter displays. Because there are so many locations where there is no access, internet connectivity is still a concern. Another significant restriction is the device's battery life, which should be increased to allow consumers to get the most out of the technology in everyday usage. Other hardware issues are also at play: mobile devices aren't strong enough to process large amounts of real-time data. For widespread use, the cost of such gadgets will need to be reduced. The problem of privacy is a major source of worry when it comes to technology. Users will be able to obtain information about strangers from their internet accounts using image recognition software and AR. Even if the majority of the information is provided voluntarily, having a stranger discover so much about you on the first meeting might be unsettling.

Finally, there's the information overload argument, which is frequently applied to technology in general. Many say that we live in a constantly connected world, and that having access to technology on demand 24 hours a day, 7 days a week would fundamentally alter how we see and think about reality. They frequently warn about the dangers of spending too much time in the virtual world and losing out on real-life events.

XIII. PAST, PRESENT AND FUTURE

Augmented reality has moved from the realm of science fiction to the realm of reality. Previously, the usage of augmented reality was limited due to the expensive cost of the technology. Researchers did not have many opportunities to explore with augmented reality. However, things have changed since then. Smartphones, PCs, and laptops have all been used to bring augmented reality into our daily lives. In the future, technology is likely to provide even more options. In the future, technology is likely to provide even more options. AR has proved to be a strong tool for business and the general public, from giving interactive weather forecasts to assisting fighter pilots in finding their targets at all hours of the day and night. Even in the software industry, this technology is expected to flourish by generating many more nesting projects and emerging into large-scale productions. Recent AR initiatives have shown the globe that the technology has a high economic value and the potential to outperform other AI technologies in the future. The AR market was valued at US$10.7 billion in 2019 and is expected to reach US$72.7 billion by 2024, representing a Compound Annual Growth Rate(CAGR) of 46.6 percent during the forecast period.

A. History

In a book authored by Frank L Baum in 1901, the notion of augmented reality was originally proposed. A 'character market,' as Baum described it, was a situation in which a set of electronic spectacles projected data onto individuals. AR was finally realized to some measure by a cinematographer named Morton Heilig in 1957, after a five-decade wait. Heilig created the non-computer controlled sensorama, which provided the spectator with noises, images, vibration, and scent. Ivan Sutherland, a Harvard professor and computer scientist, created the first head-mounted display device named "The Sword of Damocles" in 1968, which is when augmented reality was officially coined. Through a computer-generated visual sensory perception, the display system provided viewers with a real-world experience.

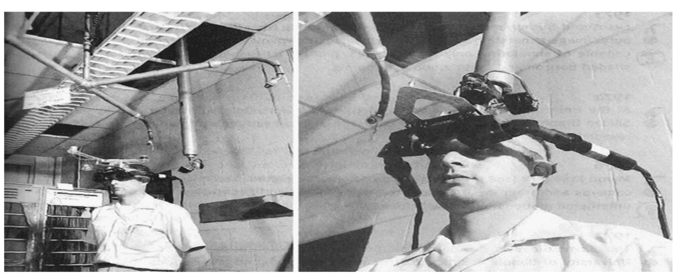

Fig. 4. The Sword of Damocles

In 1974, Myron Kruger, a computer researcher and artist, established a laboratory dedicated only to virtual reality. At the University of Connecticut, a lab known as "Videoplace" was in operation. Augmented reality emerged from the laboratory in the 1980s and 1990s and began to merge with real-world applications. Finally, in 1990, a Boeing researcher named Tom Caudell created the phrase "augmented reality." Louis Rosenberg created the first correctly indicated AR system at USAF Armstrong's Research Lab in 1992. The 'Virtual Fixtures' AR system was a highly sophisticated robotic system created to compensate for the lack of high-speed 3D graphics processing capacity.

Augmented reality reached the commercial sector soon after its introduction in the real-world mechanism. In 2013, Volkswagen introduced the MATRA (Mobile Augmented Reality Technical Assistance) app. Within its service handbook, it primarily provided technicians with step-by-step repair instructions. Google introduced its AI-powered Google Glass gadgets in 2014, which users could use to immerse themselves in an immersive experience. Microsoft has recently begun delivering HoloLens, their version of wearable AR technology. However, following the release of the Pokemon Go game in 2016, AR technology became well-known. Pokemon Go attracted a significant number of players, with 45 million users in the same year. Despite being dormant for a long time, AR has found its way into a variety of sectors.

B. Present

When augmented reality (AR) made its way into the business world and into numerous industries, its applications skyrocketed. AR is being used in a variety of industries, including gaming, healthcare, automotive, media, and education.

Medical students are being trained using augmented reality in the healthcare business. Its uses in healthcare span from MRI to doing extremely delicate surgery. AR also aids surgeons in the operating room by minimizing the necessity for intrusive cameras and probes. In the automobile industry, augmented reality is utilized to power cars and communicate with customers. Porsche's 'Tech Live Look' function allows the company's remote servicing engineers to connect with Porsche's Atlanta-based service headquarters and receive real-time help. Harley-Davidson has created an app that allows consumers to see and modify motorcycles in-store using their phones. Fortunately, AR ethics have not yet been called into question. However, things will change if consumers reach a point where the picture resolution and AR gadget are so powerful that they lose track of what they're doing.

C. Future

Augmented reality is being used in nearly every industry. Surprisingly, individuals who use AR technology are enthusiastic about its real-world applications. In terms of presenting meaningful material, they see AR as a good and transparent approach. AR-based software and apps are available from leading tech firms such as Google, Amazon, Microsoft, Facebook, and others. This will result in a significant rise in AR investment. AR-assisted training is anticipated to surpass $6 billion in revenue by 2022.

AR must become more than an afterthought on mobile devices before it can achieve its full potential. In a 2017 Time article, tech industry expert Tim Bajarin argues that “for AR to become genuinely useful, someone will have to create a platform for it that could house a range of apps and services.” “It's most probable that this platform will initially exist in smartphones, then expand to some sort of glasses or goggles, perhaps a more fully developed Google Glass, years later,” he adds.

The promise of AR will begin to be fully realized if it finds a compelling, full-featured platform and it becomes evident that a large number of customers are becoming AR adept. AR will help every industry, from architecture to education, sports, military training, and retail trade.

In its t-immersion.com blog article, "The Future Of Augmented Reality," Total Immersion lists the different industries that will witness greater AR activity in the near future. These industries are:

1) *E-Commerce:* Many companies will be integrating AR into their websites and mobile apps. In retail, this will result in applications that seamlessly “clothe” a user in sunglasses, jackets, footwear, and jewelry via the camera in the person’s smartphone.
2) *Digital Marketing:* AR technologies will continue to improve the way customers engage with brands. Marketing AR will likely be seen in packaging, on street signs, through gaming apps, and through interactions with other products.
3) *Geolocation:* The ability of mobile devices to inform us of our surroundings be greatly improved over time. AR could benefit everything from real-time travel advisories to restaurant suggestions.
4) *Educational Resources:* Researchers are already attempting to find new and beneficial ways to use AR in training situations. The military and healthcare industries, in particular, are developing powerful AR training simulations.

Artificial intelligence and virtual reality will be intertwined in the future of augmented reality. Social media sites such as Instagram and Snapc hat already employ a combination of AI and AR to create entertaining effects. We will see a lot more visual improvements like this in the future. In the industrial sector, augmented reality will provide a new level of complexity. After 2021, we will witness a rapid increase in the number of industries that utilize augmented reality to train their personnel and implement it in their daily job. In addition, apps are being developed to make augmented reality more efficient in the near future.

XIV.FUTURE WORK

Despite recent improvements in AR, there is still more to be done. Here are nine areas where further study is needed if augmented reality is to become widely used.

1) *Ubiquitous tracking and system portability:* Several excellent augmented reality demos have created engaging worlds with virtually pixel-perfect registration. Such demonstrations, on the other hand, only operate in controlled, well-prepared situations. The ultimate objective is to create a tracking system that allows for reliable registration in any given setting, whether indoors or out. Allowing AR systems to move wherever they are needed also necessitates portable and wearable systems that are both comfortable and inconspicuous.
2) *Ease of setup and use:* Most existing AR systems require experienced users to calibrate and operate them (usually the system creators). If augmented reality applications are to become mainstream, non-expert users must be able to deploy and operate the systems. This necessitates more resilient solutions that eliminate or reduce the need for calibration and setup. Calibration-free and autocalibration algorithms for both sensor processing and registration are two research directions that support this need.
3) *Broader sensing capabilities:* Because an AR system alters the user's view of the actual world, the system should ideally be aware of the condition of everything in the environment at all times. An AR system should track everything, not only the user's head and hands. This includes all other body parts, as well as all objects and people in the surroundings. Systems that use vision-based and scanning light methods to get real-time depth information of the surrounding environment reflect development in this direction.
4) *Interface and Visualization paradigms:* To replace the WIMP(Weakly Interacting Massive Particle) standard, which is unsuitable for wearable AR systems, researchers must continue to create alternative interface approaches. To deal with density, occlusion, and general situational awareness difficulties, new visualisation techniques are required. More realistic and deeper AR experiences may result from the design and presentation of narrative performances and frameworks.
5) *Proven Applications:* Many AR application concepts and prototypes have been created, but experimental validation and demonstration of quantifiable performance gains in an AR application are still absent. Such proof is necessary to justify the cost and effort involved in implementing this new technology.
6) *User studies and perception issues:* Few user studies have been conducted with AR systems, possibly due to the limited number of experimenters who have access to such devices. More research is needed on basic visual conflicts and optical illusions created by mixing real and virtual worlds. The interfaces and visualisation techniques created for AR systems must be guided and validated by the experimental findings.
7) *Photorealistic and Advanced rendering:* Although many AR applications just require basic visuals such as wireframe outlines and text labels, the ultimate objective is to make virtual things indistinguishable from real-world items. This must be done in real time, without the need for artists or programmers to intervene manually. Some progress has been made in this direction, but not always in real time. Because the ability to remove actual items from the environment is so important, new Mediated Reality methods are needed.
8) *AR in all senses:* The primary focus of research has been on improving visual perception. In the end, captivating AR settings may necessitate the use of other senses as well (touch, hearing, etc.) Recent systems, for example, have shown audio and haptic AR environments.
9) *Social acceptance:* The adoption of AR apps is not hampered solely by technical difficulties. The technology must be socially acceptable to the users as well. The information-display tracking can also be utilised for monitoring and recording. What kind of interactions will non-augmented users have with AR users? Even fashion is a consideration: would individuals be willing to use the equipment if it detracts from their appearance?

XV. CONCLUSION

Researchers have been paying close attention to augmented reality technologies in recent years. Augmented reality technology has demonstrated a tremendous momentum of development, driven by computer vision and artificial intelligence technologies. The precision of tracking registration, the performance of display equipment, and the nature of human-computer interaction have all been substantially enhanced. However, it is clear that augmented reality technology still has a lot of issues to work out. In terms of tracking registration technology, the present technique can only employ a small amount of information in the scene, such as feature point information, resulting in an inadequate knowledge of the system's relationship to the environment. In terms of display technology, the size and cost of augmented reality glasses that give users with a strong feeling of immersion are insufficient to fulfill consumer demand. The more natural and multi-user augmented reality interface technology is still being researched in terms of interaction mode.

In the coming years, augmented reality technology will be used in a variety of ways, particularly in the context of mobile intelligent terminals. Mobile devices are more common than helmet-mounted displays, despite the fact that they are less submersible. Simultaneously, the introduction of the ARKit and ARCore development platforms enables the technological integration of augmented reality and smart mobile devices. Smart wearable gadgets that can fully exploit the benefits of augmented reality technology will help humans integrate into a more realistic environment in the future. People can engage in more natural human-computer interaction with the system.

In the future, augmented reality technology will have a significant impact on human existence, since it is an unavoidable trend in scientific and technical progress.

XVI. ACKNOWLEDGMENT

We would like to thank Inderprastha Engineering College, Sahibabad and their faculty for providing us the opportunity and the guidance needed to complete this paper.

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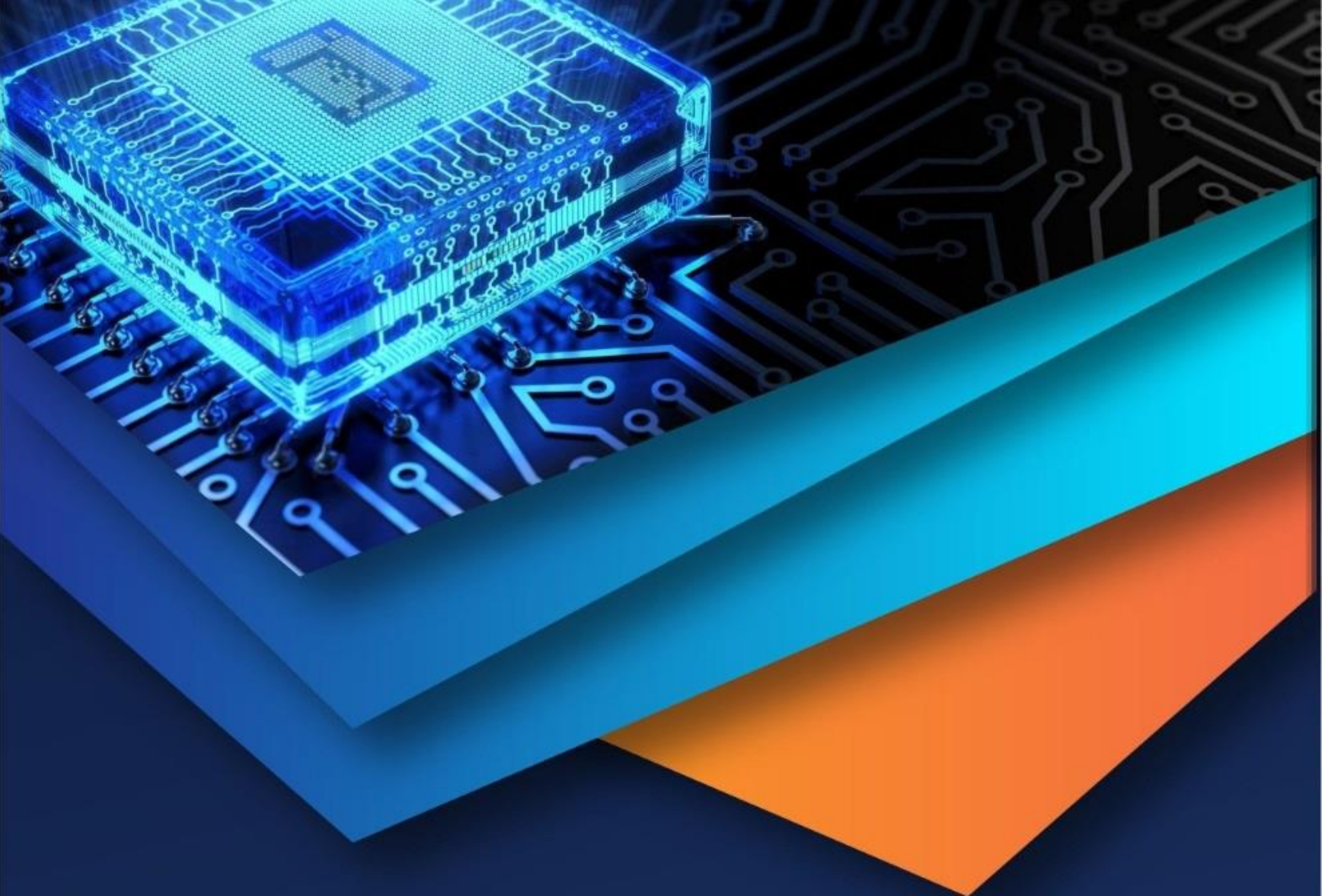

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