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Research Paper

The Advent of Augmented Reality

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Abstract: *Technology was meant to ease our lives. But instead, it has disrupted our lives like never before. With the advent of the Internet of Things (IoT), most of our everyday devices have become 'smart'. Even management of waste, water usage, and energy usage has become 'smart' because of virtual IOT devices. Virtual IOT devices copy the behavior of actual physical IOT devices. It's software that develops and simulates thousands of virtual connected devices without actually owning or managing a single physical device. This article delves into the fundamentals of Augmented Reality. AR and VR are two upcoming immersive technologies that have taken the world by storm. Augmented Reality (AR) adds or 'augments' to the real-world environment. Whereas, Virtual Reality (VR) designs an artificial or virtual world for its users. Augmented Reality is applied in popular public devices like Google glasses and car IRV (Internal Rear View) mirrors. Augmented Reality uses smartphones, tablets, smart glasses, and head-up displays to digitally enhance our physical environment. This article, states the definition of Augmented Reality and delves into its history. Also, the different types of Augmented Reality systems are discussed. Which is Marker-based, Markerless, and Projection-based. The two main types of marker less AR are projection-based and location-based. And, finally, at the end of this article, the applications of Augmented Reality in various industries are discussed in detail. Earlier, Augmented Reality was mainly applied in streaming videos and games. Nowadays, it's very popularly applied in various industries like the Retail sector, Tourism sector, Construction industry, Medical Education and Training, Design, Branding and Modelling, Athletics, Education sector etc. AR has led to the creation of smart environments, which aid us in carrying out our daily tasks. So, thanks to this hugely popular immersive technology AR, today, we have Smart cities, Smart homes, and Smart manufacturing.*

Keywords: *Augmented reality, Virtual reality, Immersive technologies, Marker-based, Marker less, Projection-based, Goggle glasses, Car IRV mirrors*

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I. Introduction to Augmented Reality:

The IOT market globally, is expanding rapidly. Fortune Business Insights has predicted that by 2030, the global IOT market is predicted to reach $3,352.97 billion. Technology advancements continue to amaze people and devices have become more and more flawless and efficient in their functioning. This is because of software applications. Today, Software apps are developed so well and tested, that they copy the functioning of physical IOT devices. They are termed Virtual IOT devices. Technology has caused many disruptions. People from various walks of life in this present Industrial era 4.0 are now applying technology (Asmiatun et al., 2020). But with the advent of the Internet of Things (IoT), the focus is now on making devices more intelligent and self-learning today. Most of the devices we use today are 'smart'. Today, we have smartphones, smart televisions, smart monitors, smart tablets, etc. A smart washing machine can update its software by connecting to a network. Likewise, smart refrigerators can suggest recipes depending on the type of groceries stored within them.

Users can create and stimulate hundreds of virtual IOT devices, without actually owning or managing a single physical IOT device! We have Smart Waste management, Water usage management, Monitoring of energy usage, and simulation of connected cars driving in real conditions, etc.

Augmented Reality and Virtual Reality are two upcoming immersive technologies that have captivated people. These technologies have greatly changed how we perceive and interact with the physical and digital world. Virtual reality is all about designing a virtual world. VR immerses users in an alternative reality. Augmented reality is all about virtually overlapping the real world. In 1998, this technology was first commercially applied in a football match. It represented the 'physical kick of the ball' and the path the ball takes to reach the goalpost. AR technically puts on computer-generated information which is in the form of text,

images, 3D models, music, video, etc. Which is applied to the real world after stimulation. AR applies Multimedia, 3D modeling, Real-time Tracking and Registration, Intelligent Interaction, sensing, etc. to enhance our real-world environment. AR acts as the bridge between the digital world and the real world and helps people experience things around them in a new unique way. The most ideal way to sense an environment and a person's activities from a wearable sensor is through First-Person Vision which is leveraged by a mobile video camera as pointed out by Kanade and Hebert (2012). Popular examples that show public utilization of AR are Google Glass and Car IRV Mirror. AR blends digital aspects into our physical environment with the help of devices like smartphones, tablets, smart glasses, and head-up displays. So, AR applications present a mixed reality as we go about our everyday tasks, of working, studying, training, relaxing, or traveling.

For a long, AR has been blending digital elements into our real world via streaming videos and games that are user-friendly (Sutopo, 2022). Augmented Reality (AR) augments with the help of computer-generated 3D virtual objects. This allows users to interact with them via their mobile device screens (Lee et al., 2017). AR enables views either in person or through a device like a camera (Zailani, 2022). According to Ismayani (2020), AR combines 2D or 3D computer-generated objects to interact with the real world as well as the virtual world. At present, Augmented reality is being widely applied in many fields such as education, medical training, and retail sector, the construction industry, repair and maintenance, gaming and entertainment, design, branding, and modeling etc. (Adami & Budihartanti, 2016). AR software integrates animation, 3D images, and a camera to enhance the real world. AR is more effective as a learning media, as it enables visualization of abstract concepts (Mustaqim, 2016). AR devices have come a long way from cathode-ray tube (CRT) displays, liquid crystal displays (LCDs), light-emitting-diode (OLED) displays to the latest micro light-emitting-diode (LED) displays to the development of flat panel displays. Where the focus is mainly on high resolution, high dynamic range (HDR), glowing colors, wide viewing angles, motion picture response time, thin, lightweight, lower power consumption, and low cost.

AR is cost-effective and requires compatibility with any smart device to enjoy the experience. According to Milgram and Krishino (1994), AR technology has gained more popularity as cameras and smartphones are getting equipped with advanced digital features. Our real-world environment gets enhanced with such digital media products. Hence, AR is found in many applications like Google Glasses, Snapchat lenses, shopping apps, and parking lot navigation apps. Many products can be viewed in the comfort of our homes with the help of AR-enabled apps. One can get a 3D view of new furniture in our living room before purchasing it or one can view a pair of glasses on our face before purchase. Thanks to AR. shopping has become an enjoyable and interactive experience! And the best part is, this technology is cheaper as compared to Virtual Reality.

Definition and History of AR:

Definition:

The Oxford English Dictionary defines Augmented Reality as "A technology that superimposes a computer-generated image on a user's view of the world, thus providing a composite view". Head-Up Display (HUD) is a technology that came before AR. HUD was first applied by BMW. It was just a display projected as a hologram on their car's front windshields. In comparison, AR involves sensing, computing, and information. The two technologies AR and VR have changed the way how we interact with screens. Providing us with new and exciting interactive experiences. These two exciting technologies have potential applications in marketing, gaming, brand development, medicine, entertainment, etc. Recent developments in digital processing, data transmission, optics, and display technologies have further revolutionized AR/VR applications. Increasingly, AR/VR display systems today have high image fidelity, compact form factor, and high optical efficiency.

The history of AR traced from the '60s to the 2000s

In the 60s:

Since 1868, Augmented reality has been around. When Charles Wheatstone used images of eyes to create 3D images with his stereoscope. Then, Ivan Sutherland invented AR in 1968 with his head-mounted display. This project was called 'The Sword of Damocles'. It was a head-mounted display (HMD), wherein computer-generated graphics aided humans in experiencing a mixed reality. In simple words, it was just a pair of glasses to view images in 3D. Ivan Sutherland invented this at the University of Salt Lake City in the United States. The stratagem was heavy and had to be suspended from the ceiling. It wasn't very comfortable, as users had to be strapped to the device for it to work properly. Since the installation was huge and used to hover over the heads of users, its name was derived from Greek Mythology as the 'Sword of Damocles'. For a revolutionary invention, the name seemed quite gloomy.

In 1974, a computer researcher and artist Myron Kruger, constructed a laboratory at the University of Connecticut. This lab was meant for artificial reality and was named 'Videoplace'. Inside the lab, onscreen silhouettes were produced which used to surround users providing an interactive experience. These onscreen projections were formed with the help of projection and camera technology.

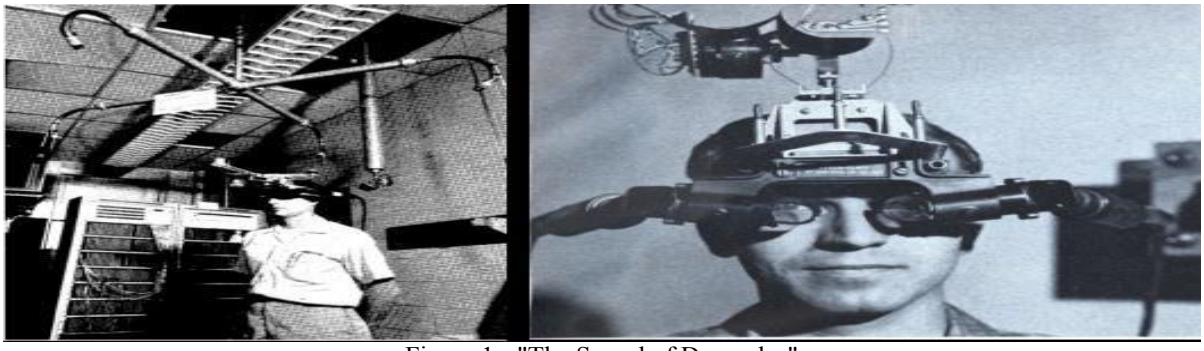


Figure 1 - "The Sword of Damocles"

In the 90s:

Thereafter, a researcher Mr. Thomas Caudell in the year 1990, introduced Augmented Reality. The word Augmented Reality was first coined by Tom Caudell and David Mizell, who were Boeing's computer service researchers. They were asked to replace Boeing's outdated large plywood board of instructions for the building of aircraft. For aircraft construction, the two researchers came up with a head-mounted display. This display overlaid the position of cables through the eyewear and projected them onto the boards. This technology was mainly used for aerospace engineering and military training. The aim was to help engineers efficiently locate and fix the problems in the machines. By projecting the holographic objects to the machines.

In 1992, a fully immersive AR Training system was first introduced by Lois Rosenburg. He created the virtual flying AR tool for the training of Air Force pilots called the 'Virtual Fixtures' at the US Air Force Research Laboratory. This virtual AR tool helped the military individuals to virtually guide and control machinery, to train Air Force pilots in safe flying practices. This was the first time that physical and digital objects had interacted with each other and today it is termed as 'mixed reality'.

In 1994, AR arrived in theatre and entertainment. Julie Martin, writer and producer was the first to introduce AR into theatre production. The show was named 'Dancing in Cyberspace' and it included acrobats dancing alongside virtual objects that were projected onto the stage.

In 1998, AR was first introduced in sports during a live NFL game. A virtual 1st and ten graphic systems were broadcasted during the game for the first time. It was also known as the yellow yard marker system which marked the actions on the field. This AR discovery clearly showed a yellow line overlaid on the field. So, everyone could quickly see when the team got a first down. This system is still in use today but it's in a more advanced version. This system was enhanced with a feature in 2003, wherein it provided aerial views overlaid with virtual objects

In 1999, AR was introduced into navigation. NASA's X-38 spacecraft was equipped with an AR system that would help in better navigation during test flights. It displayed map data right onto the pilot's screen.

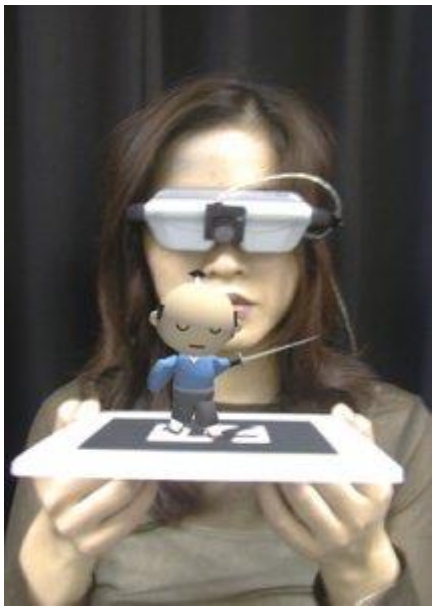
AR in the new century: In 2000, AR was first introduced into an online game. 'AR quake' was the name of the game launched. During the game, players wore a head-mounted display and carried a backpack that contained a computer and a gyroscope.

In 2005, AR was first introduced into phones in the form of apps. One of the first AR mobile apps for smartphones was AR Tennis. It was a two-player AR game developed for Nokia phones.

In 2008, it was AR's first debut in commercial print ads. The first automotive company to make use of AR technology in a magazine ad was BMW. It was an ad to promote the BMW's mini as a virtual 3D model. When the user held the print ad in front of the computer's camera, the BMW mini model appeared on the screen. The user could also achieve interaction in real-time, by moving the paper, he/she could move the virtual model on the screen. This was possible with the help of digital markers on the physical ad.

In 2009, Esquire magazine came out with its first AR-enabled magazine. By scanning the cover of the magazine, readers could make the actor Robert Downey Jr. come alive on the cover.

AR Toolkit, an open-source software library was founded in 2000. This library first brought AR to the browser in 2009. This paved the path for web AR. AR Toolkit creates AR applications. Wherein three-dimensional virtual images are overlaid on the real world. Through headset displays viewers could view these virtual images.



In 2013, AR came into the service support system. Volkswagen introduced the MARTA app which provides step-by-step repair instructions. This showed that AR can be applied to any type of industrial training.


2014, saw the release of Google Glass. This wearable AR technology-enabled access to many Google apps such as Google Maps, Gmail, etc.

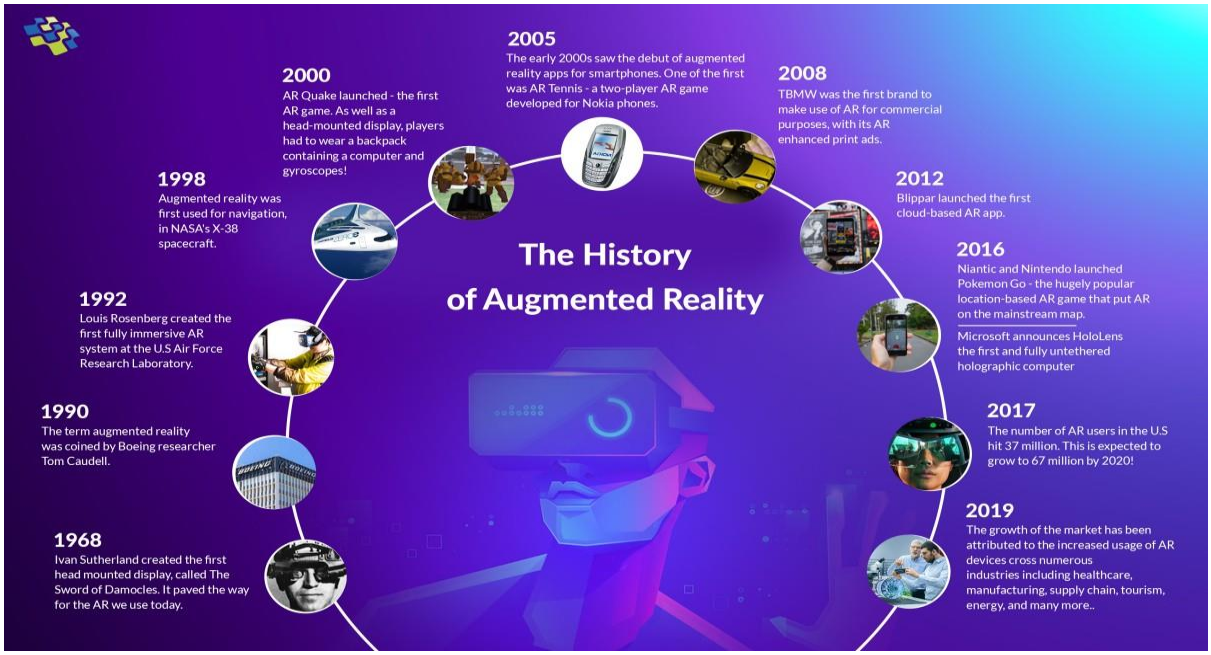
In 2014, the first AR game for Google Glass was developed by Blippar. This game was demonstrated at the Mobile World Congress.
2016, saw the release of the hugely popular location-based AR game 'Pokémon Go' developed by Nintendo and Niantic. This game put AR in the mainstream.

In 2016 also, Microsoft issued Microsoft HoloLens. This was Microsoft's version of wearable AR technology with more advanced features than Google Glass. Microsoft also came out with 'HoloLens 2'. Viewers could scan the environment and create their own AR experiences.

In 2017, AR brought about a revolution in the retail industry. Shoppers at IKEA could use their AR app to preview their furniture options before purchase. This was an encouragement to other industries to also do the same. Many e-commerce apps came out with AR-equipped features to lure online shoppers. The number of AR users rose to 37 million!

In 2017/2018, Google and Apple introduced their AR development kits. They released their AR kits on the platforms of IOS and Android. This development was the largest boost for AR in public awareness. Till today, ARKit and ARCore SDK are essential in the industry.
In 2021, a leading technology provider 'Svarmony' in Europe was founded in this year. Svarmony provides unique, boundless spatial experiences. They specialize in the development of AR-based navigation systems. Also, provide innovative XR solutions. Whereby, XR means extendable reality which is the combination of AR, VR, and MR (mixed reality).

As people become more and more dependent on their mobile devices, the adoption of augmented reality will be ever on the rise. Every day consumers are using AR technology, only that they are not aware of it. The majority of customers using smartphones are already using AR software advances. Above is one of the examples of Snapchat dog filters which is driven by AR. Wearable technology is slowly being accepted by the general public and so more and more people are becoming receptive to AR hardware. Modern AR technology has been customized for specific usage. Especially to daily users, wherein smart interactions have been applied to individual wearable glasses such as viewing the current time, weather, messages, etc.



Types of AR systems:

The types of AR systems are classified into two groups – Marker-based AR and Marker-less AR systems. Marker-based AR is also known as Triggered Augmented Reality as recognition-based AR or image recognition as it is user-defined images. Marker-based AR requires software which is in the form of an app. Users scan markers using their device's camera to trigger an augmentation. For example – Agency Mabu's Augmented Reality Christmas greeting card in 2018. Marker-based AR is a more primitive version of this technology. Marker-less AR is also known as View-based Augmented Reality. Which is a digital augmentation of a stored or static view.

Marker-based AR or Triggered augmented reality technologies:

Triggered AR provides the 'triggers or characteristics that induce the augmentation. Triggered AR is also known as a Marker-based AR system as it requires a marker to initiate an augmentation. Triggers or markers can be either paper, object markers, GPS location, dynamic augmentation of objects, or Complex augmentation. The camera can also be a marker. By using markers, Marker-based AR triggers an improved experience for users. It starts by framing a well-known pattern, for example, a QR code or an AR Tag. This allows the tracker to define a World Coordinate System (WCS). According to the size of the marker, the tracker will be able to fix the camera position concerning the WCS. The real size of the framed objects needs to be known in advance to calculate the relative positions. An AR system is characterized by high-level blocks like the tracking system, an asset or scene generator, and a combiner. Most of the AR systems rely on an optical tracker such as a camera to frame the real environment and then the video stream is received by a head tracking module. This module computes the position and orientation of the head concerning the framed objects. Orientation and position need to be correctly calculated to align assets well. A reference frame has to be defined when absolute

values of the positions are required. Marker-based AR is extensively used in marketing and retail. In the form of talking visiting cards and moving brochures. In the comfort of your home, marker-based AR allows you to browse through a variety of alternative products to see and decide which one looks best in your home before going for the purchase. The major limitation of marker-based AR is that it can be used only with mobile devices like smartphones or tablets. Users need to download a dedicated app. Android users need to download AR from the Google Play Store. For Apple iPhone users with IOS 13 have to access built-in AR support. For example, the IKEA Place app uses a smartphone or tablet camera to scan the environment of the user. Then detects a flat surface like a floor or a table. The user selects a piece of furniture from IKEA's catalog. The app uses Marker-based AR to place the digital product on to the detected environment and adjusts the digital object's position and scale with the help of AR.

Marker-less AR as the name denotes, does not have any markers like QR codes or images. It uses sensors like GPS, or compass to determine a user's location and orientation. It places relevant digital information into the real world. So, a markerless AR system uses environment features to correctly calculate camera orientation and align all the other assets. This type of AR is mainly found in navigation apps, tourism guides, and location-specific information services. In Marker-less AR four types are there, namely location-based AR, projection-based AR, contour AR, and Overlay AR. For example, the GO game uses marker-less AR to place virtual characters in real-time locations for players to discover.

Location-based AR uses the device's GPS location and pairs dynamic location with points of interest to provide the user with relevant information. Pokémon GO is the best example of Marker-less AR. It is location-based AR which is a smartphone game. It uses AR to link a virtual image of Pokémon to a specific location after analyzing the user's data from the GPS, and the camera. For example – in Google Maps, GPS location is used to find out restaurants, etc.

Projection-based AR projects digital content onto physical surfaces or objects in the real world. Without using a headset or any other device, it creates an augmented experience for the user. Through projectors, it displays images, animations, prototypes, or any kind of information directly into a physical space. Projection-based AR creates interactive displays, virtual keyboards, or immersive gaming experiences. This type of AR is frequently applied in interactive marketing campaigns, museums, events, etc. With the help of sensors, users can also interact with the projections. For example – some entertainment areas use projection-based AR on their floors. Projectors are placed on the ceiling which casts visuals on the floor. When users step on them, their movements are tracked through sensors and the AR responds accordingly. Another famous example is Disney's "Enchanted Tales of Belle" which uses projection-based AR to bring the 'Belle character to life and create an interactive story-telling experience.

Contour-based AR detects and tracks the contours or outlines of real-world objects and overlays them with digital content. This type of AR uses a computer vision algorithm to recognize and analyze the physical boundaries of objects so that virtual content can be properly aligned. For example – Contour-based AR is applied to in-car navigation systems. Where, in low visibility areas, this type of AR can be applied to outline greenbelts or footpaths. So, as to enable safe driving.

Overlay AR is when virtual images are overlaid or replace physical objects in the real world. This type of AR is mainly used in medicine to place 3D images onto a patient's body. So that surgeons can get accurate guidance during surgery. Usually, surgeons overlay CT or MRI scans over a patient's body to achieve accuracy in surgery.

Applications of Augmented Reality:

AR has, in recent years grabbed the attention of everyone, right from businessmen to ordinary customers. AR applications have been one of the world's biggest breakthroughs and have been adopted in many fields. As this technology has the potential to blend the virtual world with the real world, it is being applied in many industries namely manufacturing, entertainment, education, sports, military, medicine, retail, real estate, advertising healthcare, and many more. Today, we find Augmented Reality (AR), Virtual Reality (VR), and Extended Reality (XR) have stretched from entertainment into many areas like education, manufacturing, and marketing. Day by day, the potential uses of AR are increasing. The current mobile devices have become ideal platforms for AR applications because of being equipped with sophisticated sensors, powerful processors, and increased storage capacities along with strong and persistent network connections. Most of these commercial applications are built on top of commercial-off-the-shelf (COTS) mobile platforms such as iPhone and Android. This immersive technology is also being applied in tourism, cultural heritage, and architecture. Highlighted below, are some of the sectors where this impressive technology is applied to.

Medical Education, Training, and Healthcare – in many aspects of medicine AR technology is being applied. In the hands of medical students, AR has become a critical learning tool. It is challenging to learn about our body's intricate nervous system and organs. With the help of AR, students can make 3D pictures of organs and view them in real time. Medical professionals can easily understand the complex procedures of the human body with the help of AR technology. Which would have taken them days to understand otherwise. Doctors can accurately locate the surgical site in the patient's body with the help of AR. Doctors can observe a fetus's growth in real-time and upon wearing the relevant AR equipment it can also remind the patients to take their medicine on time. AR also aids pharma companies greatly by providing them with critical drug information. Workers can create three-dimensional versions, to observe and understand how a drug works in the human body. Another area, where AR technology adds value is in the eyes. Which is one of the delicate parts of the human body. In ophthalmology, trainee doctors sharpen their surgical skills in doing eye operations by undergoing augmented reality-enabled training. Healthcare can be delivered accurately also with the help of AR as doctors can work hands-free, easily access training videos, and run quality assurance checklists. Healthcare professionals can connect with coworkers through live video streams, record, and share voice communications, and collaborate and troubleshoot issues in real-time. Many AR apps like smart glasses, MedicAR, and MEVIS surgery give valuable AR-supported healthcare-related content to their users.

Gaming and Entertainment Sector – AR technology has become very popular in the gaming and entertainment sector. What with the Pokémon Go game becoming a smash hit a few years back? From this video game series, around 250 million players a month used to get transported to real-world locations. This game pointed out the potential of AR technology in the gaming sector. Many mobile games have become super successes thanks to AR technology. Games like Ingress and Jurassic World Alive have become super hits because of the AR technology. These games use GPS and cameras to create augmented reality. So, AR has found a natural home in the gaming sector.

Central Park, NY overrun with people playing the Pokémon Go game.

Retail Sector – In the retail sector, one can see the most innovative and captivating applications of AR. Customer engagement has reached another level. What with both offline and online retailers making full use of augmented technology in their apps? This technology is widely applied by almost everybody today because of its ready availability and reasonable price. Shoppers can do amazing things with AR like imagining products in their home before purchase or measuring objects by using their smartphone's cameras. This encourages more purchases among customers as they can try out products before purchase. Because of augmented reality, many try-ons have become popular like eyewear try-ons, make-up try-ons, car accessories try-ons, jewelry try-ons, electrical appliances try-ons, furniture try-ons, and many more. According to Deloitte, 71% of AR users said that they would shop with AR apps more often. So, AR technology is enabling so much purchasing power as the technology pervades our daily lives. Leading retail brands like IKEA, and Amazon provide AR-enabled e-commerce shopping experiences over augmented reality mobile or wearable glasses interface. Like for example – the IKEA AR mobile app takes pictures of the shopper's living room. Measures it and recommends furniture to fit into that space. Many brands like Lakme, Maybelline, L'Oreal, etc. provide virtual makeup try-on options. Virtual makeup try-on apps allow users to try out a variety of makeup products and shades from different brands. Users can experiment with different styles before deciding on their purchase decision. Users can use a live camera or upload a selfie to try out different categories of products as in the case of Lakme, Maybelline, or L'Oreal. Lakme allows users to try out various eye, lip, or face makeup products, whereas L'Oreal allows users to just tap and try on hundreds of shades to see their look live. Such virtual makeup apps enable brands to avoid in-store rush during peak shopping hours. Not only e-commerce, augmented reality has found a place in physical store locations too. For example, footwear company Converse is using augmented reality to virtually try out their shoes. AR helps these customers to virtually view the shoes on their feet before going for purchase. So, AR greatly aids Converse customers to have an interactive and convenient shopping experience and also reduces returns due to incorrect sizing. Another example that strengthens the usage of AR is the world-famous motorcycle brand. Harley Davidson has built their brand by developing an AR app to be used by shoppers in their stores. Shoppers can view the bike which they wish to buy. Through the app itself, they can customize the colours and features of the motorcycle.

These smart glasses are self-contained and use see-through waveguide optics to merge digital instructions with real-world tasks. These smart glasses allow users to see product information once they step into the store just by looking at the products. buyers can read the product description, and reviews and filter products according to their preference. Through shopping apps, buyers can carry out shopping-related tasks by applying voice control capabilities. Suppose, a buyer voices a product price, the smart AR glasses will show products within that price range in his visual field.

Logistics – AR technology has radically transformed logistics companies. AR has made logistics a sustainable business by providing timely and efficient delivery. Workers at the logistics warehouses use AR glasses to access a digital packing list in their operations. The glasses show the workers the best route to reduce travel time. AR-enabled devices also detect damages in products, pack cargo in perfect sizes, and make maximum use of freight loading spaces. This makes warehouse management more cost-effective and efficient. In logistics and warehousing, AR streamlines the picking process and helps workers to locate items quickly. Thereby, reducing the errors and time wastage in manual searches.

Design, Branding, and Modelling – the first step in designing is visualization. Nowadays, AR technology is being applied more in design, branding, and modelling. Product concepts and user experiences can be visualized and developed through drawing and CAD modelling. These tools help designers to develop 3D models and digital content effortlessly. AR design helps to transfer concepts from the screen to the physical environment in proper scale and alignment. Compared to other ways of prototyping, the usage of AR technology helps to design with greater reliability at lesser costs. In the automobile industry, for example, car designers can improve greatly on the structure of the cars they design. This technology enables them to make visual comparisons too. AR

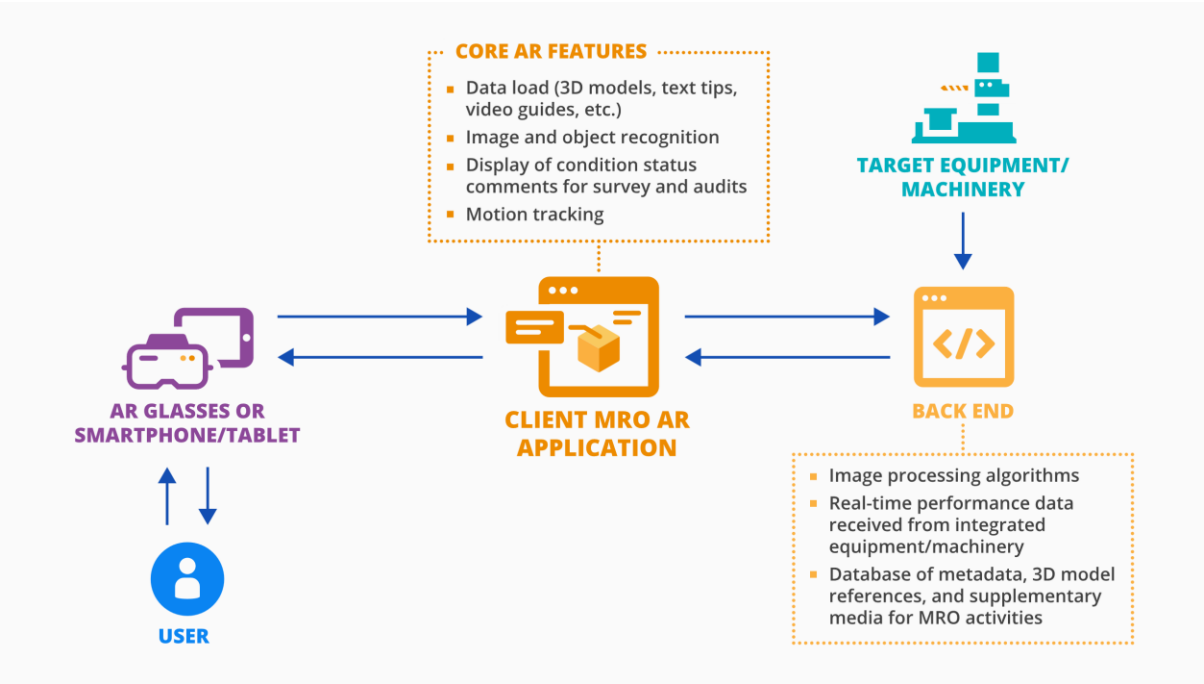
technology can guide workers to design more efficient products in 3D. AR technology also helps consumers to collect all pictorial information about a product. Without opening the product package only, they can just scan a picture of the product to collect all relevant information about the product. Even, in the field of art, AR technology is applied. It enables viewers to view the art from various angles and interpret it.

Tourism Business – augmented reality technology is applied in the tourism business to restore historical sites by using mobile phone cameras, screen software, etc. to fit in the real scenes. In archaeological studies, AR technology is used to zoom in on relics in real so that archaeologists can accurately identify their location.

A few years back, a British resort implemented AR in its operations. They made it compatible with the wall maps placed in the hotel. Guests with the help of their smartphones or tablets could scan these maps to get relevant information about local tourist spots. Thus, the hotel's guests could enjoy more their travels thanks to AR technology. Location-based features provided a better experience that was customized to individual customer's interests and demands. In 2018 itself, individual locations like Gatwick airport had experimented with augmented reality. They installed navigational beacons to guide passengers via their smartphones.

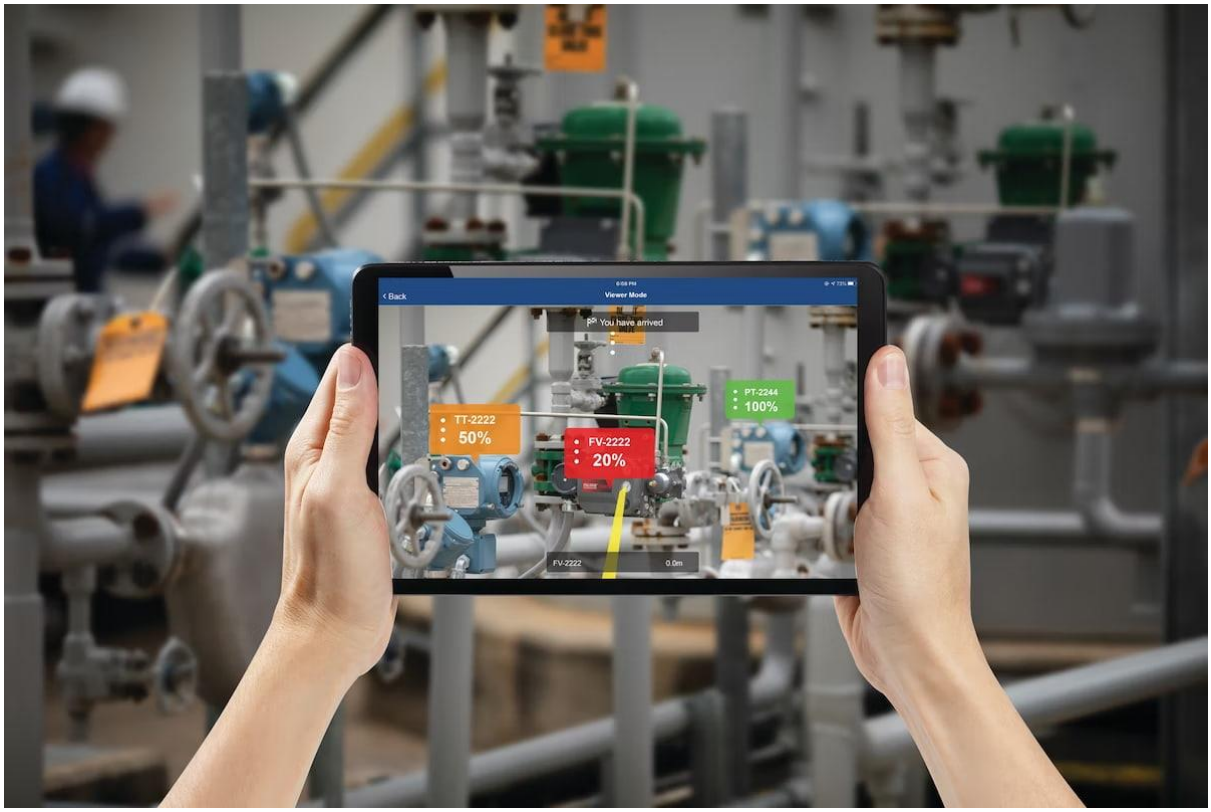
Education Sector – According to Supriyadi et al.,2022, the application of Augmented Reality (AR) and Virtual Reality (VR) has been one of the world's innovations that has been adapted to many fields including Education. It has enabled learners to learn effectively either in a classroom setting or in an on-the-job setting environment. It also aids educators in creating interactive, engaging content. Which would keep their students engaged and encourage deeper learning. Today, AR and VR are commonly applied to the teaching and learning process. Students can access vast amounts of data and learning materials. Teachers have become facilitators and prepare online lessons customized to student needs. Learning outcomes have been greatly enhanced because of stimulations, 3D models, and advanced audiovisual effects. Many subjects are applying AR technology such as Anatomy of Living Things in Biology. Teachers and students can understand the anatomy of living things by 3D visualization of cells from various angles. Studying Atoms in Chemistry becomes more interesting with AR media. Students can enjoy the process of how atoms are formed and how they merge with other atoms. AR also makes studying Earth and Space in Geography more interesting. Teachers are motivated to join up with students to explore various facets of the Earth and Space. Atlases and maps have become rigid and boring. Movie screening in Education using AR has made videos more realistic and appealing. The image quality and environment built into these videos make it a memorable learning experience for students. Thanks to AR-based technology, solving geometry problems has become very easy. Students afraid of maths would also be willing to learn it. History also has become attractive to students via 3D stories because of this innovative technology. So, the influence of Augmented Reality has been tremendous on education. It has spurred the motivation and willingness of students to learn. ThirdEyeX2 smart glasses are AR tools that help instructors supplement traditional learning content with immersive AR experiences. This enables students to solve complex problems, receive live mentoring, and do remote learning seamlessly.

Repair and Maintenance – nowadays, many industries are applying AR for equipment maintenance, repair, and overhaul activities(MRO). A technician just points the camera at the machine, electrical wiring, or plumbing and the system just displays the relevant information on the screen. This improves the quality of work by 90%, speeds up MRO activities by 30%, and also makes MRO work cost-effective. The main factors that have made AR software popular for MRO activities are that it improves a technician's productivity, makes MRO operations more accurate and safer, and also ensures MRO is compliant with industry standards.



Training – imagine a training program where you can learn new skills without making a single mistake in the real world. Where you can get an immersive experience by interacting with virtual objects and scenarios and where you can learn at your own pace too. This is where AR-enabled training has come into play. AR is a great help in the training industry. AR technology helps to train spatial and psychomotor skills. For example, AR technology provides real-time feedback for hand hygiene training. AR technology helps to make training and development a more interactive and immersive experience for learners. Rather than just theory, learners can focus more on practical aspects of training thanks to AR technology. AR-enabled training helps to improve user engagement, delivers unforgettable experiences, and helps trainers stand out from their competitors. AR-enabled content helps learners practice with headsets and goggles. AR helps to stimulate a real-world environment. For example – budding doctors use AR or VR tools to complete virtual surgeries which helps them to practice their surgical skills. AR tools can also help them to diagnose diseases. AR-enabled training content also encourages collaboration. As it can be easily shared amongst students, teachers, and other stakeholders. Corporate learning and development organizations use AR extensively. For example – Walmart and Chipotle companies provide employee training which includes multi-sensory experiences which results in more effective practical training. Trainees can observe and interact with their natural surroundings in new ways. Learners can explore and manipulate data in real space. By just moving their hand finger or body rather than using a computer interface. With virtual training, it reduces risk to products or equipment while training. AR enhances teaching and learning processes by enabling educators to provide personalized game-based learning that extends beyond the classroom. AR-enabled training can be applied in high-risk training situations wherein, new workers can practice in a safe and secure environment. Such kind of training is particularly applied in industries like manufacturing, aviation, telecom, and healthcare. According to a study, AR-enabled training reduces onboarding time by 40-60% and improves worker's productivity by 90%. Hence, augmented reality training provides benefits like being cost-effective, providing real-time guidance, and enabling remote collaboration. Not only medical students, and surgeons, but also firefighters, pilots, and chemists can be trained easily by simulating risky environments at lesser costs. They can be trained at very little risk and this type of training would be invaluable when they have to handle real-life situations.

Manufacturing – AR technology helps workers to use data in real-time by visualizing and using it. This enables the employees to make accurate, timely data-driven decisions. AR technology also promotes cross-team collaboration, and paperless work and simplifies the manufacturing workflow. AR technology also promotes safety in the manufacturing environment. By providing workers with real-time warnings and alerts about potential hazards. AR helps manufacturers to avoid costly mistakes by saving their time and money. It helps to identify, locate, and scan products in the warehouse.



It helps manufacturers identify issues, improve processes, and optimize maintenance. By applying AR technology in their factories manufacturers can make their factories more flexible, agile, and cost-effective. Imagine, as a factory owner, with the help of AR you can create a digital twin of your factory floor. Which will enable workers to manage predictive maintenance remotely and efficiently. They can optimize production lines. AR paired with IOT helps to create a digital clone of physical objects. They can also access automated and manual data at the same time. For example – augmented work instructions can track the actions that led to the defect, and can track step times and real-time operational metrics. AR can help to create prototypes effectively without waste of natural resources, time, and labor. Workers can also easily access inventory data while moving

around the warehouse. AR also aids warehouse operators to quickly access the production line data so that they can plan and schedule their operations. Manufacturers can move from reactive maintenance to predictive maintenance because of AR. With the help of AR, system engineers can project the right amount of information at the precise moment to workers directly onto the shop floor. AR can also be used for inventory management, prototype designing, plant layout planning, providing real-time employee instructions optimizing assembly line operations, and reducing the risk of accidents and disruptions which are among the many benefits offered.

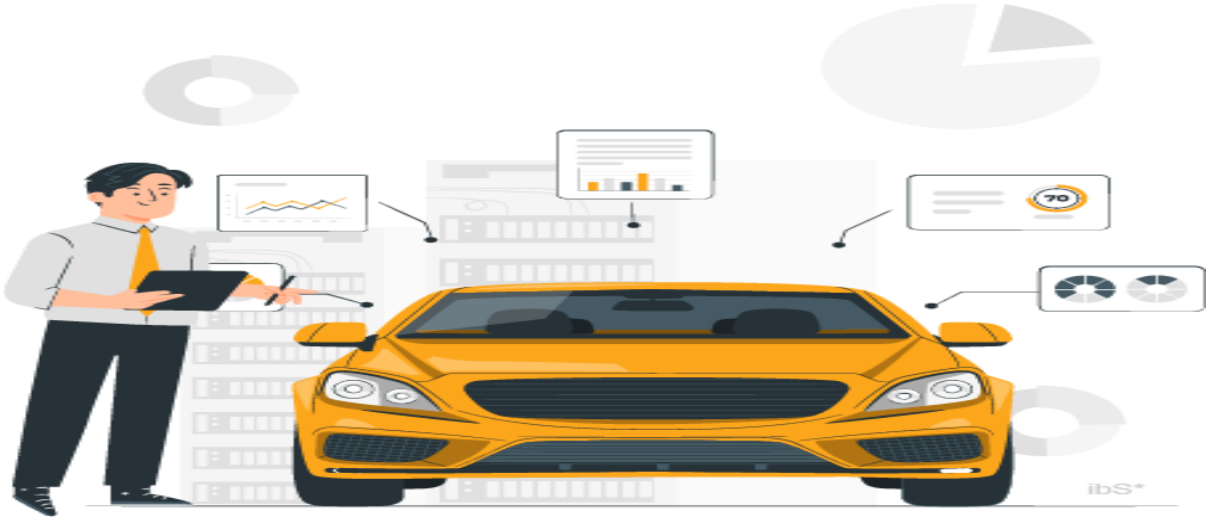
Search and rescue missions – AR plays a good role in search and rescue missions. The AR system meant for rescue is equipped with an aerial camera, which integrates the real scene with the forest road name and location as identified geographically. This greatly helps to rescue the person in a short time efficiently.

Sports – AR technology greatly enhances sports training and fitness activities by providing virtual coaching. Provides immersive workout experiences and provides accurate performance analysis. For athletic training, AR technology is a great boon. Athletes use AR glasses to stay ahead of their game. The glasses provide them with an understanding of how to improve their performance in real-time. It provides them with on-the-spot solutions and is great for training, planning, and strategizing sports performances. The Vuzix Labs Smart Swim are swim glasses used by swimmers. These glasses provide swimmers with workout status and provide swim performance information. These glasses aid swimmers in reaching their optimum performance levels easily. This device also helps swimmers connect with their coach and makes their underwater experiences more enjoyable with their favorite TV shows and videos. For cyclists and runners, Raptor AR headsets and solos provide augmented reality experiences to them. Without removing their focus on the road, cyclists and runners can access data.

Advertising – in the advertising field also, AR technology greatly enhances product discovery experiences. AR technology provides immersive experiences that connect brands and customers emotionally. Augmented reality creates engaging ads, which allow consumers to interact with them in real time. People can interact with AR-enabled billboards promoting virtual goods in real time. Such ads will be more compelling and have a lasting effect. AR applications are found in the print media such as magazines and newspapers. Wherein readers, can scan print ads with AR-capable devices to access extra material like product information, videos, etc. In-store experiences are greatly enhanced for customers through AR. They can take a virtual tour of the store complete with product details and discounts through an AR application.

Construction – AR technology is a crucial tool in the construction industry wherein it's applied throughout the actual construction process. This technology helps to visualize space and enables designers to view objects in 3D models in augmented and virtual reality. AR also educates workers about safety measures to be followed during construction. Besides, it helps to capture and monitor the progress of construction. By enabling direct comparison of actual sites with 3D models to see if they are deviating from the original design. For example, Vuzix Blades are smart glasses available in India, which can be purchased online from Amazon or Ubuy. Vuzix blades are hands-free AR glasses that combine digital instructions with real-world tasks. Used mainly by industrial workers and businesses. Like engineers, architects, construction people, etc. They provide safety, reduce errors and distractions, and provide assisted reality.

Social media – AR in social media creates fascinating experiences for users. Users of social media can engage with products and services in creative ways. For example, Snapchat uses AR to allow users to add filters and other special effects to their images and videos. Brands create their own customized Snapchat filters to advertise their products. Popular AR applications that use IOS and Android apps allow users to add 3D objects to their photos and videos. Companies create custom experiences and allow users to visualize products before purchase. AR in social media creates thrilling, collaborative experiences that make the brand stronger, build up demand, and shorten the sales cycle. AR apps allow shoppers to research in multidimensional ways, making the shopping experience more enjoyable and engaging.



Automotive and transportation – AR facilitates industrial designers to experience a product's design and operation before completion. They can visualize the car's body structure and engine layout. Volkswagen has applied AR to compare differences between digital and physical crash test images. AR aids in analyzing, evaluating, and enhancing 3D models of designs and also helps to compare computer-aided design models (CAD) with physical prototypes.

Live Language Translation – The world has over 7000 spoken languages. It's not possible to learn all the languages. Translation is the next best option and that is where AR comes into play. AR translation applications like 'Google Translate's Word Lens offer many benefits like instant translation and can also overlay translated text over live videos.

II. Conclusion:

As Apple CEO Tim Cook famously stated in 2017 Augmented Reality is going to change the way we use technology forever. The market research done by Juniper Research further strengthens this statement by Tim Cook. According to Juniper Research, they predict that by 2024, the AR market will reach $43.8 billion and 10 billion installations. So, the bottom line is that AR is going to get more and more integrated into our everyday products and services. In the coming days, AR will become more accessible to the common people, as the developments in display technologies have led to cheaper AR devices and enhanced smartphone-based AR capabilities. Today, many people use Augmented reality without realizing it. The AR cloud will allow digital overlay on a massive scale by offering a cloud-based medium. The cloud will enable AR applications to run on higher computational power. A smartphone or head-mounted display will limit AR's processing power only to the device's Graphics processing unit (GPU) and Central processing unit (CPU). Whereas, AR apps in the cloud can power several GPUs and CPUs at the same time. This means one can do more with AR as the performance and quality of graphics will be greatly improved. Restaurants like MacDonald's, Pizza Hut, and Haldirams are applying this game-changing technology to create interactive menus. Customers seated at the tables, just point their smartphone cameras to the QR code at the table. Instantly, they get an informative menu with 3D models. Additional information can also be provided, such as the cooking process, etc. The impact of AR is significant and far-reaching. It has a significant impact on the economy by boosting productivity, workforce efficiency, safety, improves operational performance thereby making factories more cost-effective. The social impact of this technology in two ways. One way is it improves work collaboration, increases productivity, and provides more value to the economy. But the other way is that the rapid development of this technology and machine learning threatens to displace human labor. Augmented technology has a positive on the environment by enhancing the users' perceptions of the environment and making it visually appealing. Through digital overlays, AR can reduce pollution and promote sustainability. However, too much dependence on AR systems can make users miss important environmental cues leading to accidents, injuries, etc. Ethical considerations of AR are many. It may lead to a violation of privacy, which can lead to legal complications and exploitation of data and information. The challenges of cybersecurity in AR need to be tackled. The future of AR is bright and will become more and more an essential part of our daily lives. Providing users with more and more interactive and immersive experiences.

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