**Chapter 10**

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CriticalAnalysis on Augmented reality in Cyber-Physical System: Challenges and Concerns

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**Abstract:** Augmented reality (AR) is rising as the central motivation of the computing economy. By certain evaluations, the all-out estimation of the AR showcase is relied upon to reach $100 billion shortly. The reason behind this is, AR applications, headsets, and smart glasses hold the guarantee to increase the value for all intents and purposes in each industry - from retail to modern assembling. From working MRI gear to performing complex medical procedures, AR tech holds the possibility to help the profundity and viability of clinical preparation in numerous territories. In the present physical retail condition, customers are utilizing their cell phones like never before to think about costs or look into extra data on items they're browsing. One of the greatest modern use instances of AR is for fix and support of complex gear. AR presents an assortment of chances to expand proficiency and cost reserve funds across numerous regions of business coordination. While innovation like tablets has gotten far-reaching in numerous schools and study halls. In the entertainment field, it's everything about structure a solid relationship with your marked characters and the crowd. Diversion brands are currently considering AR to be an incredible promoting chance to assemble further bonds between their characters and crowd. This chapter gives an overview of what in particular Augmented Reality is and the inspirations for building up this innovation. It also talks about Augmented Reality Technologies and frameworks and sums up the various application areas such as Education, Healthcare, Entertainment, Business, Maintenance, etc. of Augmented Reality. In the last section the chapter also covers how Augmented reality can be integrated with Cyber-Physical system.

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# Keywords: Augmented Reality (AR), Virtual Reality(VR), Cyber-Physical System (CPS), Head Mounted Display (HMD)

1. **INTRODUCTION**

Augmented Reality (AR) is characterized as an innovation that permitsthe overlapping of real-world objects and environments associating 3D virtual objects employing an AR gadget, and to authorize the virtual to communicate with the real-world objects to create pondered translations.Contrasting VR that attempts to recover and outplacethe whole real-life environment with a virtual one, AR is about augmenting a picture of the real world with images produced by computer and digital data. It endeavors to change the point of view by including pictures, video, data illustrations, sound, and different subtleties. Although virtual reality (VR) spots a client inside a virtualsurrounding, augmented reality (AR) means to introduce data that is straightforwardly enrolled in the physical condition[1]. AR surpassesmobile computing that overcomes any barrier implicating the virtual world and the real-world, both dimensionally and intellectually. With AR, the computerized data appears to turn out to be important for this present reality, in any event in the client's recognition.

Virtual 3D pictures are superimposed on real-world items dependent on their mathematical relationship within a gadget. The gadget must have the option to ascertain the position and direction of items concerning others. The consolidated picture is extended on mobile screens, AR glasses, etc.Rather, users wear some gadgets to permit a review of AR content. AR glasses do not submerge the user into a simulated environment unlike virtual reality headsets do. The functioning of these glasses is to superimposea virtual article onto this present reality object.Utilizing these glasses, a user can see the real-world item or condition in his/her surroundings [2].Besides, the main utilization of AR include defense and TV since the begetting of the term in 1990, AR is currently applied in the domain of gaming, instruction & preparing, and many more. Currently, it is improved with mobile phone innovation, for example, 3G, 4G,GPS, and remote sensing.

### Types of AR

There exist four kinds of augmented reality (See **Fig. 1):** Marker-less, Marker-based, Projection-based, and Superimposition-based AR.

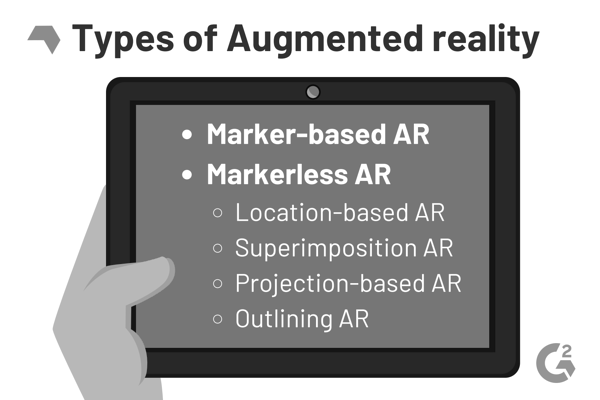


Fig. 1: Types of AR

#### 1.1.1 Marker-based AR

Marker-based AR utilizes markers to trigger an augmented experience. The markers regularly made with particular patterns like QR codes. To startthe 3D digital animations a marker and a camera is used. A marker is a unique visual item like an extraordinary sign.The system will compute the direction and position of the marker to situate the substance adequately. As it demands an uncommon visual object and a camera to scan that object therefore it also refers to image acknowledgment.At the point when a marker in the actual world is perceived by an AR application, the digital content is put on top of it.

Marker-based AR is ordinarily utilized for showcasing and retail purposes. Think business cards that talk and handouts that move.  It might be a printed QR code or any extraordinary symbols. Additionally, the AR device figures the direction as well as the position of a marker to locate the substance, at times. Subsequently, a marker starts advanced movements for clients to view, thus photographs mayconvert into 3D models.

#### 1.1.2 Marker-less AR

Marker-less AR is more adaptable than marker-based AR as it permits the client to choose where to put the virtual item. You can attempt various styles and areas digitally, without moving anything in your environmental factors. Marker lessAR depends on the gadget's equipment, including the camera, GPS, advanced compass, and accelerometer, to accumulate the data important for the AR programming to manage its responsibility.

Its application sectorinvolves various business, and navigation apps, for example, the innovation utilizes area-based data to figure out what content the client attains in a specific region.The accompanying sorts of AR fall under the umbrella of marker less AR in that they needn't bother with an actual marker to trigger the advanced substance.

**Location-Based:**Location-based AR is one of thewidely executed applications of AR. The motivationbehind this is the effortless accessibility of mobile phones and the provided key points as far as area recognition. This type of AR is generally employed to assist explorers in their excursions.

The area-based or position-based AR gives information related to the client’s location using a Global positioning system, a compass, a whirligig, and an accelerometer. At this instant, this information figures out the AR componentthat you explore or obtain in a specific territory. Besides the accessibility of smartphones,such kind of AR commonly creates directions as well as maps, close by the organization's information [3].

In this method, the information obtained from GPS or any other devices is used to recognize the location and direction of the user. The prediction was made about the location of the user, besides; related information regarding the articles can be viewed on the screen through the camera.

**Superimposition-based AR:**Superimposition AR perceives an article in the actual world and improves it somehow or another to give a substitute view. This can incorporate reproducing a segment of the item or the entire thing completely. Substitutes the actual glimpse with an augmented view, completely or incompletely. Object recognition undertakes a vital part, excluding it; the entire idea is just unimaginable.

This category of AR provides a 'substitute' viewpoint on the article in concern, eitherby displacing the complete view with an augmented view on the item or by replacing a part of the item sees with an augmented view. For such a scenario, object acknowledgment assumes a fundamental role - legitimately, if the application doesn't have an idea of what it is looking at, it definitely can't superimposethe first view with an augmentedview.

This innovation can be used by health experts to inspect the patient from various points progressively. In an X-Ray machine,the live feed can be used to superimpose the X-Ray outlook on the organ of the patient on the genuine picture to showa better understanding of the injuries to bones. A head-mounted showcase or special goggles can be used in such an application.

In Defense applications, this type of AR can give a different viewpoint on an item without specifying additionalfacts in the content and obstructing the vision of the trooper from other significant articles around. Superimposition of infrared view or radioactive outlook on an article or a territory can help in saving lives.

**Project-based AR:**In Projection-based AR, synthetic light is being projected on the physical surfaces to recognize the communication of the client with the surfaces. It can be utilized on holograms as in Star Wars and other sci-fi films. It recognizes client association with a projection through its transformations. Projection-based AR is somewhat not quite the same as different kinds of markerless AR. Projection-based AR feels more attractive compared to an AR app that can be installed on mobile phones.

One of the far-reaching employments of projection-based AR methods is non-interactive. Projection on items can be used to make misdirection regardingthe position, direction, and depth of an item. If an item is mulled over and its structure is concentrated top to bottom, the dis-association of time from the projection is discovered. Then the projection light succession is planned cautiously to hoodwink the viewer’s mind.

**Outlining AR:** Outlining AR perceives limits and lines to help in circumstances when the natural eye can't. Object recognition is used in outlining AR to understand a client's immediate contextual elements. Think about operating a vehicle in poor light or viewing a building's construction from the outside. The driver can avoid danger by knowing exactly where the path's center is thanks to this depiction. Comparative applications include stepping away from your car and viewing the limit layout to determine exactly where the parking space is.

Although the human eye is considered the best camera on earth, still restrictions are there. We cannot glance at things for such a long duration. We are also not able to see accurately in low light and also human eye cannot find it in infrared. For these situations, unique cameras were constructed. These cameras are used by AR applications that perform sketching out.

Consider a case of driving a vehicle on a road in fog; the human eye may not entirely notice the limits of the road. So, advancedcameras that can see the environmental factors in such climatic conditions can be employed to plot the road limits within which the vehicle should remain. These systems would be proven highly important in dodging accidents. Also, there areextra sensors installedto identify the things around so that there are fewer chances of hitting any object.

Engineers and Architects use this category of AR to study the area of pillars and metal bars. This type of application could bring the structure's development information from an information base and give a cross-section/system perspective on a structure and can end up being a guide in fixing a structure or be utilized for instructive purposes.

### History of AR

**AR in the 1960s:** The very first head-mounted display was developed by Ivan Sutherland and Bob Sproullin 1960. This devicewas named[The Sword of Damocles](https://www.youtube.com/watch?v=NtwZXGprxag). Thiswas a rough device that showed primitive computerized illustrations.

**AR in the 1970s:** During the year 1975, an artificial reality laboratorywas designed by Myron Krueger which was named [Video place](https://www.youtube.com/watch?v=dmmxVA5xhuo).The aim was to madehuman movement communicationsusing digital stuff.Later on, the technique was employed on projectors, cameras, and on-screen outlines.

AR in the 1980s:  The first portable computer called [EyeTap](https://www.youtube.com/watch?v=jSAGHqcVupE)was madein 1980 by Steve Mann. It intended to be worn before the eye. This computer captured the scene and later, superimposed effects on it, and exhibits everything to a client who could as well play with it employing head movements. The heads-up display (HUD) was originated in 1987 by Douglas George and Robert Morris. The gadget is designed to showthe planetary information above the sky.

**AR in the 1990s:** The word augmented realityis believed to be born in the year 1990. The term initially came into view in the study oftwo researchers, Thomas Caudell and David Mizell. Later, in 1992 an augmented reality framework named “Virtual Fixtures” was fabricated by Louis Rosenberg. During1999, a circle of scientists guided by Frank Delgado and Mike Abernathy investigatedthe latest navigation software, which produced runways and street data from a helicopter video.

**AR in the 2000s:** Hirokazu Kato, a Japanese scientist, designed and presented [ARToolKit](https://artoolkit.org/) in the year 2000. Afterward, it was redesigned to work with Adobe. Eventually, in the year 2004,an outdoor helmet-mounted augmented reality framework was published by Trimble Navigation. In 2008 the [augmented reality Travel Guide](https://www.youtube.com/watch?v=8EA8xlicmT8) compatible with Android mobile gadgets was produced by Wikitude.

**AR 2013 to date:**During the year 2013, Google beta-tested Google Glass using an internet connection through Bluetooth. Later on, Microsoft published two innovations: Windows Holographic and HoloLensin the year 2015. In the very next year,the [Pokemon Go](http://www.pokemongo.com/) game was launched by Niantic. This game was meant for mobile devices and also inflates the gaming business and made $2 million in the first week.

## Technology behind AR

AR innovation permits real-time augmentation that happens inside the context of the environment. Animations, pictures, videos, and 3D structures might be utilized and the client can view things in natural and synthetic light.The technology behind the working of AR is explored beneath.

* **Simultaneous Localization and Mapping (SLAM) technology**): This technology is a group of algorithms that can figure outissues like simultaneous localization and mapping. The innovation makes use of highlight focuses to assist clients with understanding the physical world. The innovation permits applications to acknowledge 3D items and views. It permitschasing the physical world and the superimposition of digital simulations.

SLAM makes use of a mobile robot to recognize the general condition at that point make a virtual guide; and follow its position, direction, and way on the map. Besides AR, it can also be used on drones, un-manned automobiles, and robot cleaners. To understand locations it employsAI and machine learning.Sensors and camerasgather feature points from differentperspectives for Feature detection and matching.Then, the triangulation procedure infers the 3D location of the object.

* **Recognition-based AR:**It is a camera used to identify markers with the goal that asuperimposeis conceivable if there is a marker identified. The gadget recognizes and ascertains the position and direction of the marker and displacesthe real world marker with a 3D variant. At that point, it ascertains the position and orientation of others. Turning the marker pivots the whole item.
* **Location-based Approach: In this approach,**the simulations are created from the information gathered by GPS, digital compasses, accelerometers, and velocity meters.
* **Depth tracking technology: In this innovation,**depth map tracking cameras produce a real-time depth map by utilizing various advances to compute the real-time distance of objects in the tracking area from the camera. The innovation is used to separate an object from the general depth map and analyze it.
* **Natural feature tracking technology:**This technology helps in trackingrigid entities. A multistage tracking algorithm is utilized to assess the movement of an object more precisely.

For Augmented reality, a determined scope of information is perhapsused and individuals will view the outcome in natural as well as synthetic light. Additionally,clientsawakeof being in the real world which is promoted by computer vision, dissimilar to virtual reality.

Gadgets appropriate for AR described below:

* **Mobile devices**, accessible and highly compatiblewith AR mobile apps, includinggames and entertainment, business analytics, sports, and social websites.
* **Special AR devices**, developedbasically and exclusively for the AR experience. Such ashead-up displays (HUD, See Fig. 2). Data is sentto a transparent display directly into the interface seen by the user. Initially acquainted to train military fighters’ pilots, presently these gadgets are used in the aerospace sector, motorized industry, fabricating, sports, and so forth.



Fig. 2: Example of Head-up display

* **AR glasses,**Google Glasses, Laster See-Thru, Meta 2 Glasses, Laforge augmented reality eyewear and others. These articles are equipped for displaying alerts from your smartphone, helping the assembly line workers, access content hands-free, and many more (Fig. 3 depicts an example of AR Glasses).

  
Fig. 3: AR Glasses

* **AR contact lenses (See Fig. 4),** companiessuch as Samsung and Sony have released the establishment of AR lenses. Samsung is functioning on lenses as an extra appliance withsmartphones;on the other hand, Sony is fabricating lenses as uniqueAR gadgets.

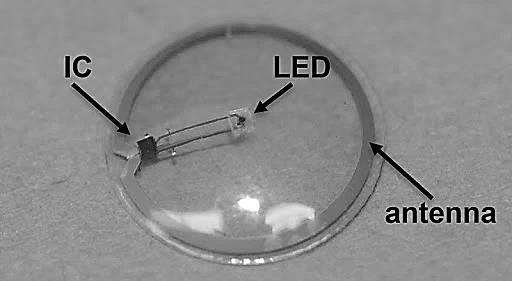


Fig. 4: AR Contact lenses

* **Virtual retinal displays** (As shown in Fig. 5), producing pictures by projecting laser light towards the human eye. Seeking flashy, sharp, and high-resolution pictures, these yet persist to be implemented for a practical purpose.

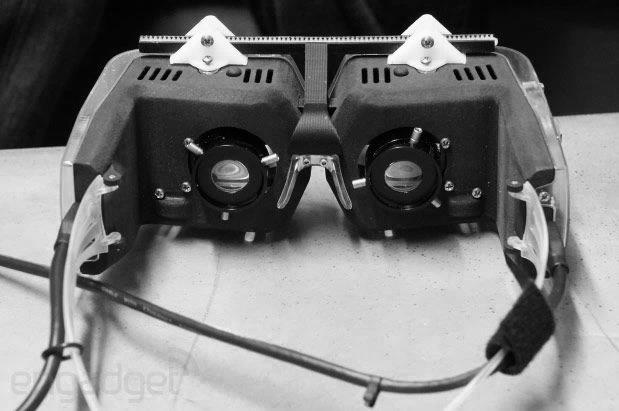


Fig. 5: Virtual Retinal Display

AR can be presented on monitors, glasses, cell phones, and HMDs.Moreover, there are mobile-based AR, head-mounted gear AR, smart glasses AR, and web-based AR. Smart glasses are wearable AR gadgets that give first-individual perspectives, while online doesn’t need downloading of any application.

### Devices and Components of AR

Numerous cutting edge gadgets until now uphold AR. Including smartphones and tablets to smart devices such as Google Glass or handheld gadgets, these innovations continuously growing. To handle AR gadgets and tools, primarily, have essentials, such as sensors, GPS, CPU, digital compass, cameras, accelerometer, Screen, etc.

**Cameras and sensors:**These are AR cameras or different cameras, and their task is to take 3D pictures of real-world items and convey them for further processing. The job of sensors is to gather information regardingthe client's association with the application and virtual articles and dispatch it for computing. The role of the Camera on the gadgets is to investigate the environmental factors, using these facts; a device discovers physical objects and produces 3D models.

**Processing devices: To process the 3D pictures and sensor signals,** AR gadgets use illustrations, GPUs, CPUs, GPS, flash memory, Wi-Fi, RAM, Bluetooth, etc.They may gauge speed, angle, direction, and so forth. However, AR gadgetsshould act like a small computer, something present-day smartphones by this time do.

**Projector: The** AR projection contains projecting produced simulations on AR headset lenses for viewing. This utilizes a small projector. This denotes a miniature projector on AR headsets thatgrasp datathrough sensors and displays digital content the usage of projections in AR has not been produced entirely at this point to use it in administrations**.**

**Reflectors: In spotting the virtual images through human eye,**reflectors (mirrors) are employed on AR gadgets.A matrix of small curved mirrors or double-sided mirrors is employedto throw back the light to the AR camera and the viewer’s eye with a motive to play out an accurate image alignment.

**Mobile devices:**Existing smartphones are entirely relevant for AR since they have incorporated GPS, sensors, cameras, gyroscopes, accelerometers, digital compasses, screens, and GPU/CPUs. Moreover, one can also install AR apps on smartphones for experiencing mobile AR.

**Head-Up Display or HUD: It is a**uniquegadget thatdisplays AR data to a transparent screen. Firstly it was utilized in the training of the military but now-a-day it can also utilize in aviation, automobile, manufacturing, sports, and so forth.

**AR glasses or smart glasses:**These glasses are used for showing notificationsfrom smartphones. Some of them are Google Glasses, Laforge AR eyewear, and Laster See-Thru, etc.

**AR contact lenses:** These lenses are worn to be in contact with the eye. Companies like Sony are focusing on lenses that have some highlights, for instance, the ability to take images or store data.

**Virtual retinal displays:**These devices are used to generate photos by projecting laser lights into the human eye.

1. **Benefits of AR**

**Here we present a few benefits of AR:**

* Integration or appropriation relies upon your utilization and application. You might need to utilize it for checking support and production work, perform virtual walkthroughs of land property, and publicize items, and so on.
* Today, virtual fitting rooms can assist the decline of buying returns and upgradeshopping choices made by purchasers.
* Salespersons can deliver and distribute intriguing marked AR substance and supplement promotions in them so individuals can become more acquainted with their items when they view the product. AR enhancescommitment.
* In the field of manufacturing, AR markers on pictures of assembling gear help venture chiefs to monitor work distantly. It lessens the requirement to utilize computerized maps and plants. For example, a gadget can be pointed on the spot to decide whether it will fit in the position.
* Immersive real-life simulations are conveying instructive advantages to students. Simulations in game-based learning and training come in with mental advantages and increment compassion among students as appeared by specialists.
* Medical understudies can utilize AR and VR simulations to attempt first and however many medical procedures as could reasonably be expected without heavy spending plans or superfluous wounds to patients, all with submersion and close real experiences.
* AR empowers the virtual travel industry. AR applications, for example, can give directions to alluring destinations, render the marks in the town, and give data on touring. A genuine model is a GPS route application.
* AR is required to extend to $150 billion by 2020. It is extending more than VR with $120 billion contrasted with $30 billion. AR-empowered gadgets are relied upon to arrive at 2.5 billion by2023.
* Expandingtheir applications is a well-known way that organizations are utilizing to draw in with AR innovation. Organizations can in any case place promotions on third-party AR platforms, purchase licenses on created software, or lease spaces for their AR content and clients.
* Manufacturers can utilize AR advancement platforms, for example, ARKit and ARCore to create applications and incorporate AR into merchandise services.

## 5. Applications of AR

Augmented reality penetrates our day to day routine in different manners. The virtual objects show information that cannot discover directly by the viewers with their senses. The virtual objects disclose information that assists a user to execute real-world tasks. AR is a particular illustration of what Fred Brooks termed Intelligence Amplification (IA): utilizing the computer as equipment to make a task simple for an individual to execute. There are various classes of AR application domains; these classes incorporatefirmly acknowledged areassuch as medical, entertainment and games, military, education, manufacturing, and robotics. The underneath sub-sections describe various application fields [9].

**5.1. Healthcare**

Healthcare augmented reality attains its principalmotivational forcefrom the requirement of imagining clinical information and the patient surrounded bya similar space. This would demand real-time illusion of co-registered varied data, and was presumably the motiveof countlessmedical AR alternatives.In 1968, Sutherland introduced a followed head-mounted presentation as an innovative human-computer interface liberating perspective ward portrayal of virtual objects. Ultrasound is anotherapplication of augmented reality in the field of healthcare. The ultrasound expert can see a volumetric delivered photo of the hatchling overlaid on the midsection of the pregnant lady employing an optical transparent showcase.The photo looks like it was inside the midriff and is viably conveyed as the person moves. Recently a helpful careful framework was introduced, guided by hand motions, and upheld by an augmented reality-driven surgical field [13].

In medical services, industry experts foresee the worldwide AR market to develop at a sizable 23 percent compound yearly rate from 2017 to 2023[12]. As of now, AR is utilized in zones, for example, patient and specialist training, careful representation, and infection reproduction to upgrade understanding of medicines and results. For instance, one AR application maps the body of the sufferer, demonstrating the specific area of veins so the clinical staff can hit the imprint the first run through when drawing blood. One more AR application recreates tumors in 3D so specialists can see X-beams progressively without radiation presentation. One capacity develops 3D visuals of organs from various plots for more prominent exactness in the join.

AR innovation likewise helps increment learning maintenance and comprehension for specialists and patients by introducing complex thoughts in intuitive arrangements. For example, one worldwide drug organization utilizes a 3D heart displaying application to show the development of medication through the organ and its belongings as a major aspect of another treatment. Both HCPs and patients can all the more likely comprehend the science by perceiving how it functions in the body with AR. To make more prominent compassion and perception of a patient's malady, one application mimics the impacts of degenerative eye ailment.

Medical sector workers have hurried to comprehend the benefits of AR advancements. Training is an undeniable usage of augmented reality in the medical care field. Medical workers require to achieveexpertise with a colossal measure of data about living systems and how the body capacities. AR applications authorize students to visualize and cooperate with 3-Ddepictionsof bodies [10].

In any case, it's not just medical fieldpersonswho benefitfrom augmented reality. It's additionally confirming massively important as an apparatus for educating the patient, permitting clinical professionals to help patients with comprehending surgeries and working on medications.

In the present time, experts usesome strategies to view the zone on which they have to work, yet an augmented reality, which can extend 3-D depiction of the life system of the sufferer into the expert’s field of view, is likely to enhance exactness and consequences for the patients. The functional use of AR which is being used presently is vein perception. Several patients are not comfortable with being infused or having blood taken, the situation is more dreadful when it's tough to find out a vein and the patient must be "trapped" a few times.

AccuVein for instance, which is being used in clinics currently, can extend a guide of a patient's veins onto their skin, making it simpler for medical professionals to discover the vein in the first attempt.

Though augmented reality is utilized each day by medical sector workers all over the US, there is the best approach before the vision that is introduced by CableLabs for instance turns into a reality. That implies there is a huge scope for organizations that comprehend augmented reality and have the vision to make creative new AR items and applications.

**5.2. Military**

AR can be utilized to show the genuine cutting edge scene and increase it with clarification facts. Some HMD's were investigated and worked by the organization Liteye for military utilization. In hybrid optical and inertial tracker that pre-owned scaled-down MEMS (miniature electro-mechanical system) sensors were produced for cockpit helmet tracking. It was depicted how to utilize the AR strategy for the arranging of military preparation in the metropolitan landscape. Utilizing AR strategy to show an animated landscape, which could be utilized for military intercession planning, was created by the organization Arcane. The helicopter night vision framework was created by Canada's Institute for Aerospace Research (NRC-IAR) utilizing AR to grow the operational envelope of rotorcraft and improve pilots' capacity to explore in corrupted visual conditions. HMD was made to a showcase that can be joined with a compact data framework in the military. Extra focal points unequivocal for military customers may be preparing in huge scope battle situations and mimicking constant foe activity, as in the Battlefield Augmented Reality System [14].

AR is frequently used to comprehend difficulties, for example, the lack of data and assets, and traded off viability and security because of unreasonable or high-risk training circumstances. Regularly utilized for preparing purposes, AR is viable for fighting simulations, military sand tables, combat zone perceptions, and different applications that place a high premium on the sensitive portrayal of defense exercises. The utilization of AR in defense can likewise appear as smart glasses and shows that current data concerns spatial direction, situational mindfulness, weapons focusing on, computerized territory, and other basic information, to relieve slips in wellbeing, speed, and coordination. Gadgets can likewise permit soldiers to acquaint themselves with highlights, for example, night vision, warm detecting, and applications that measure essential signs during training.

Since military and fighting are continually developing with new advancements that help most current advances like VR and AR to bestowtheir part in the military. Different ways to military growth reality are[17] :

* Tactical Augmented Reality: TAR additionally encourages officers to give their accurate location and give places of the adversary forces. TAR resembles the night-vision goggles (NVG), however, it provides substantially more prospects. The framework is mounted to the helmet a similar way the goggles are and can work throughoutthe day as well as night. In this way, TAR essentially surpasses the ordinary handheld GPS gadget and goggles. Subsequently, a warrior would not need to peer down at whatever point they need to inspect their GPS area.Also, there is a warm site on the armament that is associated wirelessly with the tactical augmented reality eyepiece and a tablet on the officer's abdomen. This type of framework permits officers to view the target they are focusing on and the separation to it. Likewise, the display can be part of two with the goal that you can view simultaneously the position of your weapon and the view from your frontal camera affixed on the helmet. For example, an officer can view around a corner or above the divider without any threat of having a headshot.
* Helmet Mounted AR Display( Shown in Fig. 6): Besides the assistance of mounted displays, the warriors can battle with one another however in a reasonable manner. It gives overlays that contain distinctive data of the united armed forces. HUD 3.0 will have the option to do everything the 1.0 can additionally covering computerized landscape, impediments, and virtual enemies. This element of augmented reality will authorize convoluted preparing circumstances to be run at a less cost.



Fig. 6: Helmet Mounted Display

* Synthetic Training Environment (STE): Training is not anything co-related with the real-timebattle. At the point when you are in the core of a hot zone where gunfire is surrounding you, it is impossible to remain quiet and settle on the right decisions. Investing energy in sleeping quarters and taking shots at 2D cardboard models won't set you up for the real-time activities to the full degree. Nonetheless, there may be an approaching arrangement gave by augmented reality. STE, an AR framework that should assist train warriors more vividly, placing them into all the more truly and intellectually pushing operational conditions. One of the key goals sought after by the STE designers is to make such a preparation choice that would permit officers to build up versatile units with a higher availability level. Even though there are no models yet, the Army delegates have big expectations that it will be conceivable to utilize STE preparing for battle groups (infantry, aeronautics, Stryker, and so forth.). Fig. 7 depicts the STE.



Fig. 7: Synthetic Training Environment

**5.3. Entertainment and Games**

To produce games augmented reality has been applied in entertainment. Additionally,it will increase the visibility of significant game aspects in life sports broadcasting. In situations where a massive population is achieved, AR can likely help advertisers to display virtual advertisement.

At the point when we discuss the part of AR in gaming as well as animation, how might we overlook the famous game "Pokémon Go". It's simply due to this celebrated game, AR returns to the center of attention of individuals. In the gaming business, AR turned into the main sprinters as it encourages the gamers to be in a conjured up universe like battling with zombies, aliens, or catch anecdotal makers. Another acclaimed game dependent on enlarged the truth is "Ingress" created by Niantic studio which likewise turns into a monstrous hit. With the use of AR in the gaming and media outlet, gamers need to be an aspect of the game and with this longing to be remembered for the game, the game experience gets improved [17].

It is assessed thataugmented reality will be reached $80-162 billion in markets by 2026. With such a huge potential, there will countless organizations hoping to obtain a bit of it, such an extensive amount that we experience in the present time for diversion will probably observe an augmented reality update in the following decade.The absolute greatest names in augmented reality equipment presently are Microsoft, with their generous interest in their Hololens headset, and Magic Leap, who burst onto the scene with probably the most emotional exhibits of the opportunities for increased reality innovation quite a long while back.

There will be numerous fresher names to spring up as the months and years pass by and the innovation turns out to be more modern, yet probably the greatest progress in augmented reality won't need any more complex equipment than your cell phone. Some applications let you move your cell phone toward a planetarium while gazing toward the night sky just as games like Pokemon Go and many more.Foreign movies and TV shows could likewise be given captions continuously without expecting to discover uncommonly captioned adaptations, giving foreign movies and TV shows more extensive arrive at then they may have something else. Physical games can include whole layers of unpredictability, from the more seasoned card and table games to work area pretending games like Dungeons and Dragons and Warhammer.

Organizations can make money from VR games by offering them for sale or by demanding money from brands for advertising. VR games enable a player to make use of their full-body which can help players to stay in shape or even shed pounds. Using AR, sports lovers can attain significant information, such as the speed and direction of the ball, right at the sports ground in real-time.

Also, VR started walking into specific sections of sports. VR explorers accept that it should turn into a prevailing part of the computerized insight of significant sports events. Video approach around 360-degree and VR makes it possible to take live communicating of games, and different shows higher than ever, giving energizing vivid encounters to enthusiasts worldwide.

**5.4. Education**

Additional opportunities for teaching and learning delivered by AR have been progressively perceived by educational researchers. These educational advantages have made AR the most emerging technology for education in the upcoming years[8].

**Interactive education**: Almost absolutely AR can make educational surroundings more profitable, pleasurable, and intuitive than some other time AR not exclusively can draw in a student in a variety of intuitive manners that have never been conceivable yet moreover can furnish every person with one's interesting revelation way with rich content from computer created 3-D situations and models.

**Simplicity:** As showed up in a lot of past investigations and expert’s opinions, AR could almost certainly be revolved around straightforwardness and simplicity of giving instruction and preparing encounters, so students can acknowledge information and abilities with 3D simulations produced by PCs and other electronic devices. Additionally, related businesses and progressions, for example, PC and mobile enterprises, data and correspondence advances, and Internet network frameworks, including both wired and wireless services, potentially empower AR in education and training considerably more clear and compact to approach and use than any time in late memory.

**Contextual information:**From the viewpoint of specialists and pros in the field of educational AR, it is possible that training and education focused augmented reality must uplift the degree and nature of data in both school and business settings by making education and training conditions more instructive, profitable, and logical. In this perspective, there seem to be various important segments conceivably implanted in educational AR applications to improve the idea of the nature of quality of education and training by making and passing on rich, supportive, and productive content. For instance, Geotag data for chronicled and social legacies could be associated just as a comment concerning complex physical articles and antiques could promptly be added to AR instruments in both business and school settings.

**Efficiency and effectiveness:**There is the potential that AR can advance the effectiveness of education and training in scholarly and corporate environmental factors by giving data at the perfect time and correct spot and offering rich content with PC created 3D imagery. AR may participate in constructivist musings of education where understudies assume responsibility for their learning and could give chances for more real education and training styles. Besides, there are no real outcomes if blunders are made during skill training as far as perilous and dangerous workplaces. As the eventual outcomes of a few examinations have appeared, AR frameworks can give spurring, engaging, and connecting with conditions helpful for learning. Additionally, AR applications in instructive settings are alluring, invigorating, and energizing for understudies and give viable and productive backings to the clients.

**AR keywords in the future:** There are numerous keywords about AR in the future alluded to by a huge number of specialists and investigators in the field of AR in training and considered as the eventual outcomes of the enhancements of AR in the coming years. These incorporate AR sensor and programming advancement for the normalization of existing mobile gadgets, creating an intensity of versatile innovation and gadgets, and the improvement of head-mounted presentations and other AR equipment.

**5.5. Industrial Maintenance**

In the domain of mechanical support, AR is realistic assistance for staff in their particularly mentioning specific work. Corporate segments, for example, military, manufacturing,and various enterprises are the applied fields where AR seriously raise the range of the development itself. Particularly, according to their assessments that concern the military area, with the assistance of AR advancement, military mechanical staff can lead their ordinary upkeep tasks in an invulnerable vehicle even more safely and beneficially. For doing this, there are a couple of needed devices and instruments, for instance, a followed head-worn display to expand a technician's regular view with text, marks, bolts, and vivified groupings planned to inspire task cognizance, area, and execution. A comparative thought of the AR development as the military help works can be applied to amassing ventures. A huge assessment in the AR domain has been getting ready for associations to use AR development in their parts. For instance, BMW, one of the eminent German motor vehicle associations, has been enthusiastic about utilizing AR techniques in their vehicle backing and fix divisions and developed AR upkeep and fix system and information glasses.The professionals wearing uncommon information goggles and interacting with their workers have the complete information available to them, correctly where they demand it.With the usage of AR glasses,mechanics get an additional3-D view of the component they are repairingwhichassists them in investigating and explaining the deficit. Besides the real environment, they viewanimated segments about the part that necessities displacing and the devices to be used, on the other side sound guidance communicates with mechanics about every one of the functioning strides using earphones coordinated within the goggles.

**5.6. E-commerce and Retail**

AR application improvement is going to rebuild online and offline shopping. Using AR applications customers can connect with items and it will also make it possible to have customized shopping experiences. Imagine yourself strolling in a store with a cell phone. You will see information such as costs, uncommon offers, or limits on your phone’s screen.

Lesser number of offline buys isencouraging retailers to have a glance at the virtual world. Besides, it is a possibility for online retailers, where a buyer can go through a virtual store and have a look at the products as they would, in reality. Companies can run stores and deliver products to the users without having any physical space.

**5.7. Interior Design, Landscaping & Urban Planning**

Given the abilities of this innovation, it is just common that it has discovered applications in engineering plans and development. AR can assist experts with envisioning their last plans effortlessly during the planning phase. They can even take virtual visits inside their designs utilizing headsets, and tinker with the plan in a completely vivid climate. This can even be extended to city organizers who can display whole city formats and go for a visit.

AR is ideal for any action that has some component of the spatial plan. Applications like IKEA not just assistance to gauge items and walls. Originators and proprietors can test a color scheme and different thoughts and compute the vital materials and work costs. Laborers can rejuvenate diagrams and pictures for customers to perceive how their planned homes may look.Additionally, an AR application can assist with landscaping. VR offers some assistance in making plans for any development. It likewise helps in introducing a design idea in a great light and imagining the applicable information.

**5.8. Real Estate and Architecture**

The Internet is the primary spot where purchasers and tenants search for properties. AR can help clients experience homes diversely and save time. For planned speculators, AR lets feature properties before they have been constructed or transform 2D outlines into intelligent 3D representations.

VR glasses and 3D shots of properties likewise make a decent effect. Land dealings can be debilitating both for real estate agents and customers. VR can limit the driving and strolling to see various properties, the need to recall various insights regarding every one, the pressure of decision, and different disappointments. VR features of properties guarantee great presentation, can assemble a large number of perspectives, draw in worldwide purchasers, and drastically diminish an opportunity to bring a deal to a close. A real estate professional can lead a visit through a property distantly and even observe where the customer is looking, tending to issues progressively. Investigating 3D plans through VR additionally overcomes any issues between an architect’s creative mind and this present reality.

AR can help visualize structures before they are assembled and recreate their conduct under different climate conditions. Not just this, it can likewise help convert 2D prints into 3D perceptions and undertaking time in space before you, accordingly giving a greatly improved comprehension of the structure than what a typical print can pass on.

One more method of utilizing AR in engineering is to use superimposition strategies to imagine how a structural change would glance as a general rule. Using AR in an engineer's workspace can assist the draftsman with imagining his plan as though it were life. Unique goggles with little assistance from 3D preparing units can change over the workspace into a super-progressed field of creative mind where 3D drawings made in CAD programming on PCs wake up similarly as Ironman plans his toys.

**5.9. Tourism and Travel**

The travel industry includes different transportation modes, lodging appointments, friendliness, visits, and tours, nearby encounters like cooking or celebrations, gifts, and so forth Hence, the business teems with AR business openings.

Navigation is an undeniable example. Google Maps has an AR overhaul as of late. Users can see the roads through their cell phone's camera, and the bearings show up on their screen. GPS applications fueled by AR may show traveler routes, interpret the signs in the city, and give touring tips. AR joined with Wi-Fi, reference points or super wideband will encourage indoor routes. Air terminals, train stations, career expos, shopping centers, and workplaces will become more user-friendly.

AR-improved special materials and VR encounters including 3D recordings of areas can engage travel organizations to lure customers to purchase trips. Urban areas and individual business visionaries ought to likewise utilize AR in encouraging route and making shows that draw vacationers.

In any case, these advances require a few enhancements in precision and convenience. Since the application doesn't comprehend what you are watching and relies upon GPS, gyro sensor, and compass information, the inaccessibility of any of these administrations will corrupt the experience of the application to a huge degree. For instance, if the compass of your phone is precisely adjusted by 90 degrees, at that point contingent upon AR application would expect you to hold the telephone before you and stroll to one side! If the gyro-sensor fizzles, at that point the application may very well advise you to burrow the ground to arrive at your objective. Be that as it may, such a case would be uncommon. What is more normal is losing the GPS signal which would make the AR program pointless.

Another significant utilization of AR for authentic spots can be in the type of chronicled picture superimposition. For instance, you visit New York and guide your camera toward the Statue of Liberty; an AR application at that point allows you to pick pictures of the Statue and its environmental factors at various focuses as expected, and afterward superimposes them on the live picture.

At historical centers and galleries, adding more inside and out data about shows or rejuvenating them on a portable screen guarantees a fuller and more brilliant experience. VR can give guests shockingly better instructive and social encounters. That was about how AR can be executed in the travel industry

**5.10. Communication and Collaboration**

Representation is fundamental for ventures in any industry. Without tables, graphs, infographics, and different methods for perception, information, insights, and examination are difficult to see, significantly less to impart to individuals. AR gives a fantastic instrument for displaying information by setting it in a visual setting and rejuvenating it. Ultimately, VR will make perception a stride higher, giving vivid encounters to individuals contemplating and talking about information and models.

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With regards to global organizations, AR and VR additionally help to eliminate the obstructions. The innovations can help with interpretations or making a typical space. VR empowers individuals to attend meetings or shows virtually and carries live occasions to the individuals who couldn't partake in something else. Members situated far and wide offer a VR experience simultaneously, which again guarantees all the more clear and gainful participation.

**5.11. Manufacturing and Occupational Safety**

AR innovation can encourage and quicken measures at manufacturing plants. AR empowers architects to show models, building destinations, and so forth, and offer their vision. AR markers on gear help to screen the work in advancement. Advanced guides and plans save time and advance agreement. AR glasses can give assembling and field laborers constant information that assists with diminishing blunders and improve exactness, security, and quality.

Augmented reality impersonates real-time situations short the danger. Thusly, it is turning into a standard preparing device for representatives who need to manage actual peril. Mining organizations can utilize VR to prepare representatives without sending them underground.

Utilizing VR for representation or demonstrating limits the requirement for 3D printer displaying and further encourages the work. Companies are consolidating AR, VR, and live IoT tangible information to make an advanced imitation of an actual resource. Such 'advanced twins' will change the best approach to do numerous positions and manage numerous issues. They'll permit reviewing the articles in VR without visiting distant or perilous locales. For instance, a specialist found aground can utilize an advanced twin of breaking down wind turbine to recognize and fix the issue continuously.

**5.12. Advertising & Marketing**

Imaginative uses of AR can fortifyuser connections while expanding the inclination to purchase. Awesome productsstimulate buyers to consistently use a brand's portable app. Exceptional and new AR experiences offer an opportunity to shock users and contenders that do not do anything like that before.

An AR application transforms a shopping center into an entertainment mecca. Children and grown-ups connect with virtual characters, mess around and win prizes, and will return for additional. A virtual experience catches 100% of the client's eye, which implies promoters can pitch their message. Much the same as PCs and afterward cell phones, VR will turn into the following critical figuring stage and a front line for advertisers and brands. Why not snatch an extraordinary business opportunity almost immediately? On the off chance that you own a persuasive blog, site, YouTube channel, or informal organization, you can begin with charging for audits and promotions of VR items or accepting commissions on any items sold through the advertisements on your foundation.

**5.13. Sports and Entertainment**

You have just observed AR at work at a few ongoing games; however, this probably won't be evident from the outset. A great representation is showing the score and names of players straightforwardly on the field of play. AR additionally gives significant assistance in investigating vital occasions continuously, which in certain games can thoroughly change the result of the game.

For instance, in a Cricket game, the LBW (Leg Before Wicket) is a notable technique for excusing a batsman, contingent upon (I) the direction of the ball and (ii) the item that the ball contacts first in quite a while direction. Moment activity replays joining the AR innovation called "Hawkeye" plot the direction of the ball and foresees whether the ball would have hit the stumps on the off chance that it followed on its way without deviation. Another AR framework is known as "Hotspot" utilizes infrared cameras to feature the purpose of contact between the ball and different surfaces dependent on showing little deviations in temperature due to friction.

Other than cricket, AR is likewise utilized in different games, for example, in swimming to think about the current situation of the lead swimmer with those simply behind him or with a projection of where the world holder would be if he were in a similar race. The game of tennis has adjusted AR advances splendidly to help umpires and watchers inline calls, and football is by all accounts following intimately with recommendations by FIFA to present objective line advances.

**5.14. Arts**

There is no better word to epitomize the employments of AR advances in the field of art, than "Photoshop". Adobe Photoshop, with plenty of choices and impacts, is that extraordinary programming that merits acknowledgment in IT paradise for transforming numerous geeks into skilled specialists. By superimposing pictures on top of one another, Photoshop permits new pictures and impacts to be made. Distinguishing designs and anticipating their congruity in a scene can help transform drilling things aroundus into bits of workmanship. Joined with devoted and amazing equipment, AR could change the nightfall from your gallery into the loveliest dusk on seashore! Portable applications presently let us "clean up" photographs soon as we click them. The famous 'negative' and 'sepia' impact additionally qualifies as a means by which we have increased our real factors and created bits of workmanship.

## 5.15. Used at Gatwick Airport

AR is being utilized by Gatwick Airport's application to assist travelers with getting their plane. Their application has been effective to such an extent that it has won honors. The application won the Mobile Innovation of the Year Award at the National Technology grants in 2017. It furnishes travelers with customized wayfinding around the air terminal and is intending to incorporate smart chatbots to improve the administration significantly more.

Their application uses more than 2,000 signals to show manage travelers through AR-augmented phone maps through their two occupied terminals. It is trusted that as the application develops it will make tremendous upgrades to general traffic move through the air terminal.

1. **Integration of CSP and AR**

The term "cyber-physical system" (CPS) refers to a wide variety of advanced, multi-disciplinary, succeeding designed systems that integrate embedded computing innovations into the real environment. Since CPS is a fairly broad field of study, it has a variety of applications that span various sectors. Furthermore, it is anticipated that the development of new technologies would have a significant impact on CPS research. Every CPS application must be created with the most recent technology, required system-level specifications, and overall influence on the actual world in mind.CPS is an academic exercise that promotes the confluence of the physical and the virtual, not their unification. It amalgamate computer science models and procedures with engineering models and methods from various domains such as aeronautical, mechanical, civil, electrical, and industrial engineering etc.

The term “cyber-physical systems” was coined in 2006 by Helen Gill of the National Science Foundation in the USA. The phrase "CPS" is occasionally mistaken for "cyber security," which refers to the privacy, accuracy, and accessibility of data but has nothing to do with actual physical processes. Therefore, the term "cyber security" refers to the safety of cyberspace and is only tangentially connected to cybernetics. Although CPS presents a number of difficult security and privacy issues, these are not the only ones.The names Internet of Things (IoT), Industrial Internet, Industry 4.0, Machine-to-Machine (M2M), TSensors (trillion sensors) etc. are all closely related to CPS. All of them illustrate a technology that profoundly connects our physical and digital domain.

Since the term "CPS" does not specifically refer to either implementation strategies or specific applications, we believe it to be more enduring and foundational than all of the others. Instead, it concentrates on the central conceptual conundrum of integrating the engineering traditions of the cyber and the physical worlds.

The number of systems that connect digital (cyber) systems with the real environment has significantly increased as a result of advancements in digital electronics; these systems are now referred to as "cyber-physical systems" (CPS). As a result of special difficulties and intricate functional, reliability, and performance constraints, the design of CPS necessitates a large degree of reasoning.

The physical environment, interfaces, and cyber systems that make up CPS are well-known despite the fact that the concept is still relatively new. The physical world is used to describe the physical occurrences that need to be tracked or managed. The term "cyber systems" describes the communication and information capabilities of the newest generation of embedded devices. The communication network and other intermediary parts, such as connected sensors, actuators, analog-to-digital converters (ADC), and digital-to-analog converters (DAC), are referred to as interfaces and are in charge of connecting cyber systems with the real world. Other sources of energy are transformed into electricity (analogue signal) via sensors, and vice versa, by actuators.

Cyber-Physical Systems (CPSs) combine the characteristics of physical phenomena to those of software and communications, offering abstractions and modeling, design, and analysis methods for the combined entity. Physical systems, networking, and computer dynamics interact in ways that necessitate whole new design technologies. Software is ingrained in devices whose main function is not computing alone, such as vehicles, healthcare equipment, scientific equipment’s. The innovation depends on a variety of disciplines, including embedded frameworks, computers, communications, etc. [21].

When it comes to design, CPSs present a number of difficulties:

* Proposed designs are examined and optimized using modeling approaches before prototypes are created. This might help to guarantee high-quality and affordable designs. Future CPS will need to integrate hardware and software models more thoroughly, as well as models for other intricate components of the CPS environment, like human behavior.
* For many CPSs, there might only be limited knowledge available about some of the constituent systems; therefore, modeling techniques must be able to handle this while still providing enough information to let us rely on the behavior of the finished CPS.
* Designing cross-cutting behaviors like fault tolerance, security, or performance can be quite challenging.

AR technology is a framework that enhances reality by adding virtual objects or information that appears to exist alongside the real world. AR is similar to VR, which is a type of technology that helps us to understand the concept of CPS.

One way to improve bi-directional coordination between physical systems and cyber-physical systems is by using virtual prototyping. This involves creating digital models that allow us to test, evaluate and modify prototypes in virtual design environments. Virtual prototyping also allows us to explore the "what if" scenarios that can help us identify and correct any problems before construction. Wireless sensors use radiofrequency identification (RFID) technology to identify tags and readers. As compare to wired sensors, it provides high flexibility in terms of placement, lower installation and maintenance cost.

The four crucial elements of enabling technologies that improve bi-directional coordination in cyber-physical systems are underneath:

1) Virtual prototyping: In virtual design environments, prototypes are tested, assessed, and modified through the use of simulation techniques. In order to identify and fix any issues before construction, virtual prototyping entails constructing digital models in 3D, 4D, nD, and VR that offer expanded facilities for further exploration of features and behaviors.

2) Wireless Sensors: RFID technology, which is based on the identification of electromagnetic signals by tags and readers, is a wireless sensor technology. It provides greater placement flexibility and lower installation and maintenance costs when compared to wired sensors.

3) Mobile Devices: Today's workplace environments are populated with a wide variety of mobile devices, including smartphones and tablets. Information can be read and written on a display screen using a tiny computing device. For instance, tablet PCs can store a variety of information that can be utilized to quickly enter building data while navigating models. In addition, the majority of mobile devices offer external data-capture features like barcode scanners and RFID readers. The wireless connectivity of mobile devices is an additional key aspect. Wireless data transmission from a mobile device to a nearby or distant server is possible.

4) Communication Networks: One of the most crucial technologies for improving bi-directional communication in order to convey and exchange information between fixed and mobile devices is the communication network. The internet, wireless local area network, and the wireless personal area network (WPAN), which combines ultra wide band, Zigbee, and Bluetooth, are some examples of communication networks in use.

Chao Liu et. al. proposes a Cyber-Physical Machine Tool (CPMT), which combines networking and computing capabilities with physical machine tool and machining processes. Humans and CPMT are able to interact naturally and effectively thanks to augmented reality (AR). It is suggested to use an AR-assisted Intelligent Window for CPMT. The Intelligent Window, which offers users simple ways to interact with CPMT, is essentially a sophisticated Human-Machine Interface (HMI). Four key functional modules make up the proposed Intelligent Window: Real-time Control, AR-enabled Process Monitoring, AR-enabled Machining Simulation, and Process Optimization. Utilizing a touch-screen PC, an AR-assisted Intelligent Window for an EMCO Concept 105 milling machine is created. Based on the knowledge gathered from the tests, the benefits and potentials of CPS and AR in the manufacturing industry are examined [22].

ShayeganOmidshafieiet. al. proposes a design for CPS rapid prototyping. This system is known as MAR-CPS (Measurable Augmented Reality for Prototyping Cyber-Physical Systems), combines sensors and physical vehicles, a motion capture innovation, a projection framework, and a communication network. The projection system's function is to supplement an actual laboratory space with the perceptions of autonomous cars and a simulated mission environment, which will then be measured by actual sensors on the vehicles. This approach's primary goal is the quick design of planning, sensing, and learning algorithms for single-agent or multi-agent autonomous systems. Additionally, the suggested architecture enables researchers to display an identical replicated outside world in a controlled, indoor space, which can be crucial when testing in outdoor environments is disfavored because of safety, regulatory, or monetary concerns [22].

1. **Conclusion and Summary**

Augmented reality assures making quick, programmed, and actionable linksamong the physical world and electronic information. It provides a fundamental and prompt user interface to an electronically improved physical world. The monstrous ability of AR as an outlook changing user interface representation becomes evident when we audit the latest barely any achievements in human-computer cooperation: the upliftment of the World Wide Web, the social network, and the mobile device revolution. Augmented reality may cover computer-created data on perspectives on this present reality, enhancing an individual’s observation and perception in wonderful fresh manners.

In this chapter,we elaborate on augmented reality, its related technologies, and various applications.In Section 1 we mention the introduction, types, and historical background of augmented reality. Section 2 describes the technology behind augmented reality; it's working, and its benefits. The section there elaborated on the various application areas of augmented reality such as Healthcare, Military, Education, Entertainment and games, and Industrial maintenance. In last, the chapter covers the integration of CPS and AR.

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