Augmented Reality

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Abstract: In this paper we will learn about Augmented Reality (AR), its history, development, current technologies and how it's changing the future. With the increase in computing power, internet access, high level of sensors, remote computation in cloud, devices are becoming more powerful than ever. This paper gives details about different AR technologies that are used how progress is made in AR today. It elaborates about the field of applications that are developed using AR from the beginning till today and what is to be seen in the future. We will also see about some limitations. The major source of this survey paper is from the scientific research papers published. The intended audience of this survey paper are students, teachers and academic researchers in augmented /mixed reality.

Keywords: Augmented Reality, ubiquitous computing, immersive computing, image registration, HMD's, AR display, calibration, human computer interaction, Mobile AR, AR applications, HoloLens

1. Introduction

The technology is changing every day in the way we interact with our computers and other hand-held devices like phones, tablets etc. It would not be a surprise if there will be no monitors, screens or mobile devices in next 7 years. In the late 80's the main form of interaction of human to the computer was through mouse, keyboard and monitors but today we have moved to touch screens, cameras and constantly improving with voice, eyes and gesture controls. The future of technology is where a person is interacting in the air where in all the computing power would be installed in the walls as envisioned by M. Weiser [1]. With the advancement in technology with the wearable devices, sensors and positioning devices things are changing fast. For example, the computer can assist an architect to visualize the building that he is going to build in a graphical view on the land. This technology is AR. AR adds virtual objects or information into real view of human. The term augmented not only refers to the visual and audio representation but also refers to other senses of human like touch, feel and smell. In future computer would be able to smell, touch [2] and taste [3] like human does.

Today Graphical User Interface is moving from the screen to different elements, like in our bodies (wearable computers) and into the physical devices near us [4]. Today we are not only integrating the display but also other factors that affects human perception of seeing things like our surroundings. AR has moved into commercial application. Microsoft, Google, HP, Apple, Oculus and many other companies are introducing wearable products in the field of AR. Immersive computing, ubiquitous computing, mobile AR, Mixed Reality and head mounted display's (HMD) are talk of the day. Rest of paper is divided into 7 sections. Section 2 and 3 describes about the history and definition of AR. Section 4, 5 and 6 will describe about the working, devices in AR and types of AR. Section 7 and 8 will give the application of AR and its limitations.

2. History

The birth of AR was back in the 1960's when Ivan Sutherland who is also known as father of graphics have envisioned AR. In 1965 in his book "The Ultimate Display" [5] he clearly mentions of his imagination that depicts the reality we are going through in the field of AR today. In 1968 Ivan created first HMD which was also named as "Sword of Damocles" [6] which showed augmented graphical cube pointing on the real wall through HMD. The HMD used at that time was so heavy that it was attached to the ceiling of the building for easy movement. The same is depicted in a video in YouTube [7].

(a) (b)

Fig. 1 (a) Picture depicting "The Sword of Damocles" world's first head-mounted display, built in 1968. Courtesy-Ivan Sutherland. Figure taken from [8] (b) Boeing developed the first wire bundling mechanism using AR Figure taken from [9].

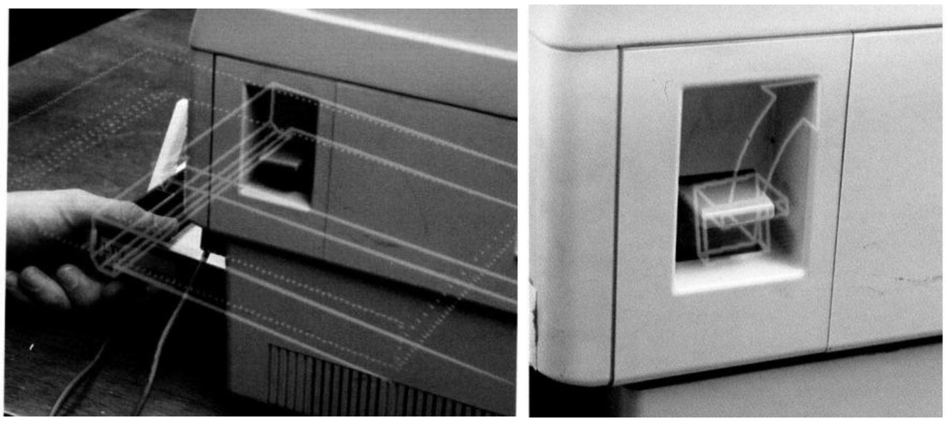
In 1974 Myron Krueger created artificial reality lab. The lab was called videoplace which had combination of cameras, projectors which created an interactive environment. Users could interact and play with the graphics during that time. In the late 1980's and 90's AR came out as an independent area for research. In the year 1992 Boeing developed a wire bundling mechanism using AR which helps the user to bundle up the wire on the board as shown in Fig. 1 (b). Boeing was the first to use the term "Augmented Reality". Before 1992 it was termed as computer mediated reality.

In 1993 UC Santa Barbara developed GPS based navigation system to help visually impaired by providing audio overlays spatially. In the same year S. Feiner, B. Macintyre and D. Seligman created KARMA [10], knowledge-based AR for maintenance assistance in the manufacturing industries. This system showed appropriate graphical instructions for repair and maintenance as shown in the Fig. 2. In 1997 S. Feiner, B. Maclntyre, T. Hollerer and A. Webster [11] created an application that gave tour guide to the campus visitor. The application showed information of the building structure when the camera was pointed towards it by understanding the building structure.

In 2000 Hirokazu Kato created open source toolkit that is widely used today called ARToolkit. This library uses video tracking to overlay graphics on top of the video. Later in 2009 ARToolkit introduced AR to web browsers. Today many JavaScript frameworks like Argon.js, awe.js, AR.js etc. exists that support AR on web.

In 2014 many companies started working with AR in the commercial field like Google announced Google Glass, Magic leap announced 50-million-dollar investment in AR. Google glass had to shut down their production because of privacy issue. Many companies have banned use of Google glass because of privacy issue.

In 2016 Microsoft announces HoloLens and Meta 2 Developer kit. Microsoft is working with HoloLens in wide variety of area. Their product is still under research and development, but the developer version is out for testing and use.



(a) (b)

Fig. 2-Karma AR HMD- (a) intend to show the tray when it will be taken out. (b) AR is showing the lids lever to pull out for maintenance work. Figure taken from [10]

3. What is Augmented Reality?

Augmented Reality is the combination of information augmented with physical environment in real time. AR can be defined as combination of 3 things

- first real physical world,
- second virtual image that is to be augmented,
- and last the surroundings.

AR captures the view through cameras around the user, add new information to it and present it to the user. The augmentation can be a 3D object giving the user more advanced experience of the world. For any AR to be implemented the computer should be aware of the environment. There are other factors like the location, the distance of the object, height or we can say the 6 degrees of freedom of any object for any AR application to understand and provide an augmented view.

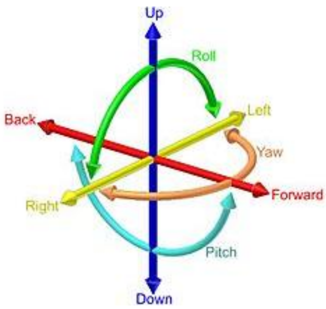


Fig. 3 Six degree of freedom (6DoF). Figure taken from [48]

AR is different from the Virtual Reality (VR) because in VR everything is converted into virtual world using graphics but in AR user can see the real world as well the virtual world which is augmented. There is another term called Mixed Reality which lies somewhere between AR and VR as shown in Fig. 5.

(a) (b) (c)

Fig. 4 The user is reading a book with 3 different methods (a) Reality (b) AR using HMD (c) VR using HMD. Figure taken from [12]

Fig. 5 Reality Virtually Continuum by P. Milgram and F. Kishino [44]

The digital information that is augmented can be graphics, text or any kind of information that we see on our monitor screens into your lenses. One such example is shown in the Fig. 6.

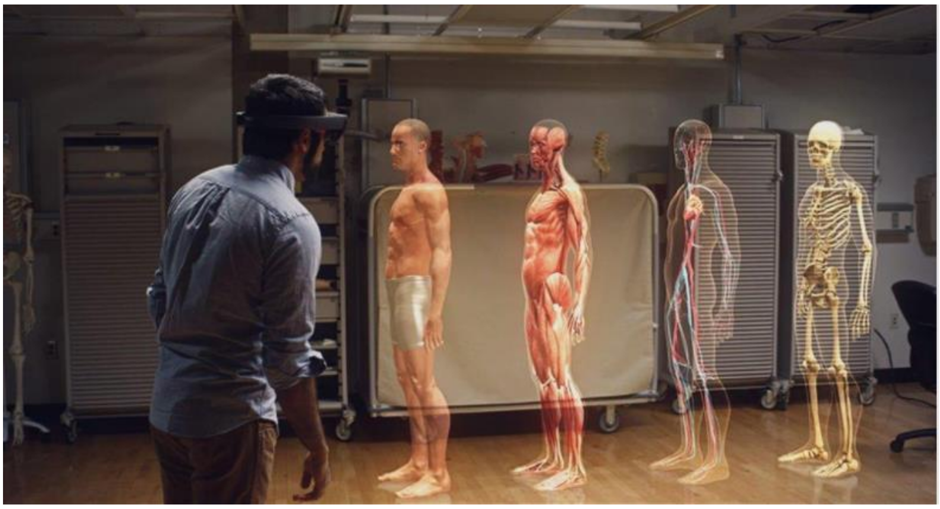


Fig. 6 User can see the human anatomy along with other physical objects in mixed reality with Microsoft HoloLens. Figure taken from [13]

4. Working of the AR

AR works on 4 main principle.

4.1 Register the physical view.
4.2 Process the image
4.3 Augment the digital information on top of the physical view and render the view to the display.
4.4 User interaction.

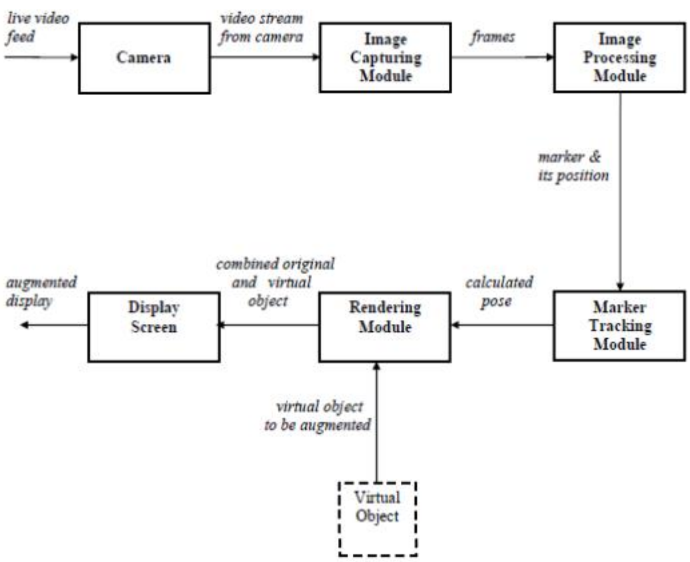


Fig. 7 Basic AR Architecture for marker based AR. Figure taken from [14]

4.1 Register the view

Live video is taken into AR device with a camera or group of cameras. Registering a view is the method to integrate the virtual object and real world perfectly that the user feels that they are in the real world. In typical scenarios with head mounted displays the user moves his head continuously to see objects around him. AR continuously looks for markers that can help system to identify the view. The process of mapping the markers with the virtual view is called as **Registration**. If the there is an error in registration the virtual image would be placed in wrong place with the real view. For some AR applications for e.g. in health accuracy is very important.

Registration can be again divided into subcategories as

- Tracker- Tracker mainly identifies the video frames with markers, calculates, and tries to match 2D images with the known 3D points from the database and sends it to Mapper.
- Mapper- The mapper collects the 3D points and tries to estimate the 3D location on the video frames and generate a 3D map.
- Relocalizer- When no marker or feature is identified the relocalizer tries to reset the camera to look for the markers again.

For any real-time application to work continuously and un-interrupt there should be a minimum speed of 20-30 frame per second for the tracking and rendering module. The typical registering happens with the help of optical motion tracking, sensors and many other tracking devices. Various object recognition algorithms [46] are there for registration. Some systems have implemented hybrid tracking techniques with multiple arrays of camera and magnetic sensors. Today systems with accelerometer and video tracking provides more definite registration even when the user is moving his head frequently or in a fast pace. The registration becomes more difficult when the field is not known for example an open field. Extensive calibration is required for giving an accurate registration of the view. It is generally based on different parameter like the camera, location, sensors input, field of the view distortions etc. Prediction of the view and use of calibration free renderers are some methodology to reduce calibration overload for registration [15].

4.2 Processing

Lot of processing is required to render a virtual object, continuously reading from the sensors and other input devices. AR devices are small computers as wearable, mobile or handheld device. The computing power of this devices are generally limited though sufficient enough to carry out normal AR application. Generally, the processing is done with computing device that is connected to the AR device but due to limitation like mobile device processing power, or complex rich media, data analysis application, processing is shifted to cloud. Moving to cloud is always not a solution due high WAN latency for application where there are real time problems. T. Verbelen, P. Simoens, F. D. Turck, B. Dhoedt [45] have proposed an architecture where the cloud computing can brought near to the mobile where the user is located. The application projects the virtual objects to the real view with the help of projection display or through the hologram lenses.

4.3 Projections

The processed information can be displayed to the user on a display of a mobile screen, on lenses of the HMD's or on the monitor. The device calculates the location where the virtual object should be placed and renders the combined view. Various factors need to be considered for rendering the view such as occlusion, depth perception, alignment of the object with the view etc. HMD's uses the technique of reflection to show for the 'see through displays'. Mirrors are used to show the image from the side mounted display to the user. In Microsoft HoloLens lights are projected to different layer of holographic lenses. The light hits those layers and reflects to the eye with different angle, intensity and color creating a real image. Some devices like google glass have projection on one side of the eye piece. More about the projection is discussed in section 5 Type of devices.

4.4 User Interaction

In earlier day's users were only able to see device augmented image in the monitors. But today in AR environment user can interact with the systems. The most popular way

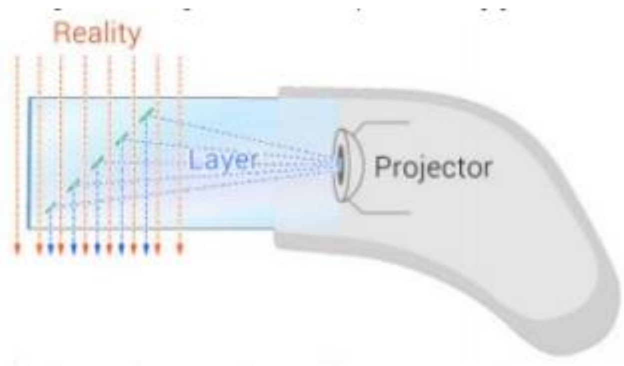


Fig. 8-Google Glass- Mini projector projecting on the semi reflective surface that allows the user to see through. Figure taken from [16]

of interaction today is the one with the devices that is connected to the AR like the handheld devices or digital board, or with the tangible devices which can understand the hand signs, gestures or eye movement or grasping the virtual object with hand [17]. Each technique is selected according to the suitability of the application for example it would be easier for an interior designer to use gestures to move things out or change something with his hand and vice versa. The devices are also using voice as an input from the user for interacting. Some other type of user interaction with AR are Face Recognition, Speech Recognition and learning, devices ability to learn user's preference using machine learning.

5. Type of Display and devices used in AR

5.1 Head mounted devices

Head mounted display is device that is attached to the head with a harness. It allows the user to see videos. In the early 90's the AR headset used to be very huge. They used to be HMD device with a wire connecting the backpack with a laptop inside it for processing [11][18]. But today the head mounted devices are just equivalent to the size of eye glasses [19] [20]. These devices are equipped with multiple camera, audio equipment's, mics, motherboard, GPU, CPU, RAM, WIFI Chip and Bluetooth chip as shown in Fig. 10. The HMD's are considered for a particular task on various factors like weight, field view, power and optics [21]. Field of view is one important factor which decided the area that would be covered by the device. It is also decided on the factor that how much the user would rotate and translate according to the movement of the head of the user [22]. HoloLens uses field of view to manage the application that the user has been using and the location of the application at that spot.

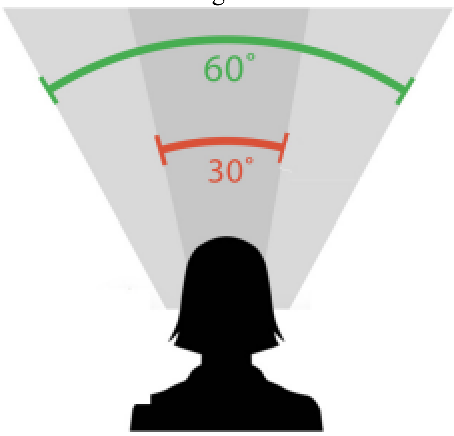


Fig. 9-Field of View for the HMD's. Figure taken from [21]

The HMD's are classified into the following groups:

Video See-through. In this the type the virtual objects are added to the live video which is captured by the camera and shown to user through the device itself. The user will not be able to see the world and is restricted to the video from the device. These AR applications are easy to integrate because the application only need to know the coordinates where the 3D image must be superimposed. The application performance would also be high depending on the video input, framerate etc. [23]. The major drawback with video see through is that the video input depends according to the location of the camera and not according to user's eye. Field of view is also limited because camera won't be at the location of the user's eye though today this issue can be handled by using an array of camera around the user's head and process the images to give a correct view.

Optical See-through - In the second type, virtual objects are shown over the physical objects through the see-through lenses. The images are more parallax free because the user is not seeing through the camera, no delays, no orientation problem etc. Though the camera is not required for the user to view the physical view, it is required for registration of the view and for interaction. The image is holographically combined with lenses making the view dimmer for user because of different layers of lenses. This technique is more difficult to implement because the registration of the physical world, HMD and the eyes is difficult as compared to the previous one. User can see both the physical object and the augmented object through the glass.

Retinal display- in this type, the virtual objects are directly projected to retina. This type of frames does not require eyepiece lens [24]. User sees the objects same way as in the optical see through lens.

Contact Lenses-There are not much research paper available for using contact lens for AR but there are some research going with contact lenses for AR according to IEEE Spectrum [47]. In this concept though the data would be collected through the RF transmitter connected to separate device. The display would be consisting of LED's and LCD's which would be transparent to allow user to see real view. A bio sensor would be connected to external computer for computations. The main limitation for such type of display would be with power source to lenses, effects on the eye etc.

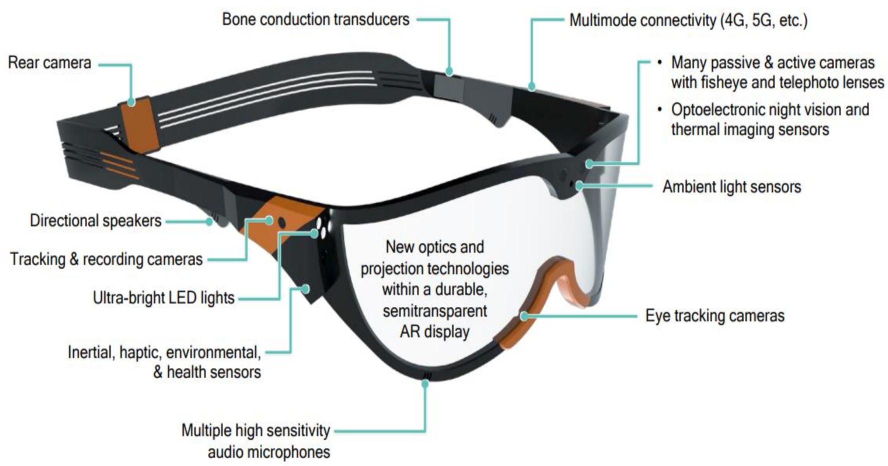


Fig. 10- AR Glasses prototype from Qualcomm. Figure taken from [25]

5.2 Mobile or Handheld devices-

With the increase in the computing power and all the features that are required by an AR, mobile devices are becoming more usable for AR. With invent of ARToolkit [26] and other tools which allows the calculation of relative placement of the image over the camera video mobile device have become a favorite place for AR.

The main issues faced by the Mobile AR initially was tracking (Inertial [27], Visual [28]) and secondly where would the computation be done. The mobile devices today can do high computation in most cases, otherwise they transfer most of the computation to the remote device with internet. For tracking over the period many improvements have been done using hybrid tracking [29] mechanism which would correct the error if any in the visual fields are disoriented with the real view.

5.3 Projection or Spatial

The output of the view is projected on to some wall or any large surface area. User is not required to wear any device. Often multiple projectors are used to show multiple field integration of the virtual object with the physical object. The limitation with these type of projection is that they can be only used indoors and not outdoors because of the light affects. They are highly used in the medical fields where the monitors are used to see through for any surgery is carried out.

5.4 Other devices used in AR for Calibration and tracking.

AR devices mainly HMD's and Handheld requires tracking of the movement of the user and places with 6 degrees of freedom. A single sensor or camera won't be able to give accurate and robust positioning of the object. So many sensors are used together to give the perfect view. In fact, many a time's redundant sensors are used to check for errors. GPS is mainly used for positioning. Magnetic compass and inertial sensors like gyroscope and accelerometer are used for orientation [30]. These devices tell the application where the user is looking or moving his head.

Eye tracking device is used by the HMD's to point to object where the user is looking. They are also used to select any object with the voice commands, or combination of many sensors to take input from the user.

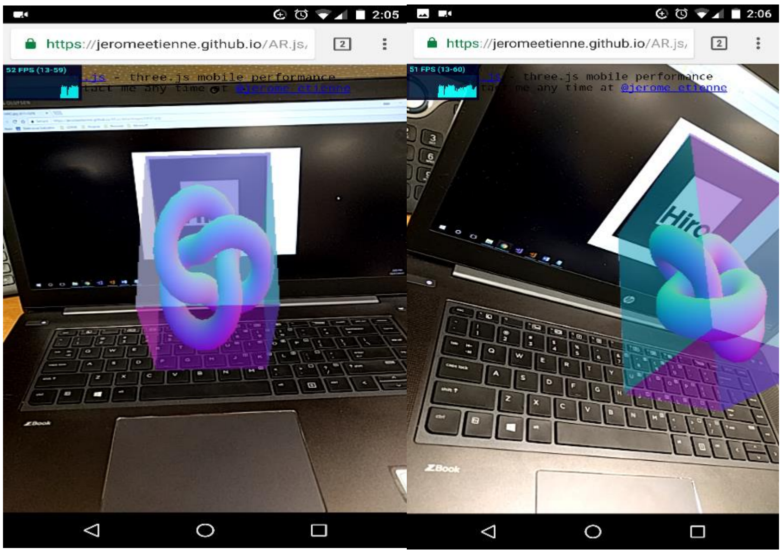
6. Types of AR

For any AR to be instantiated the device must identify the view to appropriately, process the information and then show the virtual object. AR uses certain categories to do certain tasks. They are as follows.

6.1 Marker based

In marker based AR the augmented object will be only imposed to the user once it identifies some mark. This technique basically uses camera for image recognition to identify the marker. The marker can be anything which can identify itself such as QR code, marked paper or a real-world object itself for example a system made to identify as a printer.

Once the computer identifies the location it then locates the coordinates where it should put the computer-generated object. This method works best when the application is looking for a known object to do a certain task. Most marker based AR are application specific such as used in the manufacturing industry like an AR system build to identify a printer and display the internal tray structure [23]. Below is an example of browser initiated marker based AR. The image is a revolving object when it identifies the Hiro Marker on the screen. The web application is run by ar.js which is used for AR through browser [42]



(a) (b)

Fig. 11- Marker based AR with JavaScript framework (a) Front View from the chrome browser on android phone. (b) Side view from the phone.

6.2 Non-Marker based

In this type of applications, no markers are used for identification, rather other information from devices like GPS, velocity meter, accelerometer and camera are accumulated, processed then provided to the user in some form of information. Today because of the high computing power in the smartphone non-marker based application are much easier to make as compared to the earlier days where user had to carry a laptop in the backpack for computing [11]. Main application of this approach is used mainly for finding directions or location centric application that can show information about any place that is seen thought AR device. The limitation of this application is that they would require a lot of database to process what they are looking for or would have to use information from the internet to process. An example for this type of application is pointing a mobile device towards any building to know information about it. This is also called as a Mixed Reality which is popular today. Another example would be using a HMD to do watch a YouTube video in the spatial projection.

6.3 Imposed or Projection based

In imposed based AR the application works by projecting light into real physical object. This type of AR application also takes user input with Gesture control or through hand held devices. The impositions are not restricted to identification of any physical object and can render information of any type anywhere through the device. User can interact with system with these devices and work on various projection for any kind of projects.

This technique is mainly used in entertainment industries for projecting animations and graphics over to surface which looks real. In this type, the application needs to identify the objects and replaces it with the new augmented image. Many social and entertainment applications use this type of AR technology to add superimposed images [31].

6.4 Outlining based

This can be said as a subset of Non-Marker based. The AR special cameras typically can see things that humans cannot in special condition for example in night AR can use infrared camera to understand the view and then help human to take any action. A typical scenario for this is parking a car in the night where the car AR would assist us by showing markers where to park the car.

7. Applications of AR

7.1 Education

Well each one of us is learning something new every day. AR would help in learning in a faster way by giving more visual representation of the things that we want to learn or create. Students can create 3d objects with the AR today using HoloLens. Google AR Project Tango have created AR enabled device to explore the Detroit Institute of Arts museum where the user can view inside the sarcophagi to see buried mummies. In medical colleges the students are using AR to do surgeries and to learn the human body in a more interactive. In the field of physics, chemistry AR would be really helpful to understand. With the advent of Smart Schools AR can be used in schools to show the kids with 3D view on any object which will give better understanding of anything.

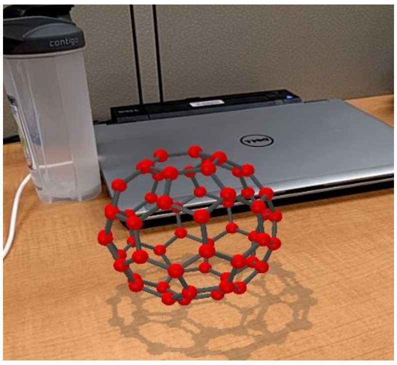


Fig. 12 - A molecular structure created using an Android mobile App called "Augment"

7.2 Health

AR has taken a leap into the healthcare domain. Many surgeries are carried out with AR. With the help of different diagnostic machine, the imagery is stored into the system. The AR then during any process use those imagery to create the view. The laparoscopic surgery began back in 2004 with the help of AR [32] [33]. This year in MUHC in Montréal, Canada a cancerous tissue was removed with AR [34]. The complete path through which the thin laparoscopic instrument was to be passed was shown to the surgeon on the screen. The system even gave a warning if the laparoscope deviated from its path. HMD's are also being used by the doctors today to get a clearer picture of the patient's internal structure or while doing a surgery.

Fig. 13 AR Assisted Surgery for removing a cancerous tissue. Figure taken from [34]

7.3 Defense

Many research is being done in AR in the Defense area. The US Naval Research Lab have developed and still developing a system called as BARS (Battlefield Augmented Reality System). The main idea is to develop a tool that can used by different member in a combat situation. The application would show the location and other important information to the army personal during any mission. There are many challenges that is being faced by the BARS today which include depth perception, basic filtering and many more discussed over here [35]. Many military units have already implemented AR in the defense factory for manufacturing. Different military application such seeing the field in 3d view using HMD's are being incorporated into the military of different countries today.

(a) (b) (c)

Fig. 14- AR in defense (a) An army official using HMD in the field [35] (b) AR for training purpose with Augmented Enemy. Figure taken from [35] (c) Australian Army using AR for overview of the field Figure taken from [36]

7.4 Entertainment

7.4.1 Gaming

Incorporating the AR into games is the process of converting the real world with Gaming graphics and also check on the high graphical interface that the user is seeing through. Seems little complex but a lot of new games are getting introduced with AR today. The most famous game POKEMON GO was also based out of AR with real maps and camera view. The AR gaming started back in 2002 when the game AR Quake [37] was introduced. Not only in mobile but with the HMD's are also coming out with new games. MS HoloLens give its user to play the game Minecraft with opponent.

7.4.2 Social Apps

Social mobile apps like Snapchat, Instagram, and Facebook are using AR today in an immense way. The apps mainly work for detecting the facial expression as well as spatial augmentation of the graphical object in the view.

7.4.3 Television

Most of the games that we see today on television are loaded with so much information like players positions, strategy etc. AR started on television back in 2004 but today television is doing more than just showing information. InAiR a San Francisco based company is creating a television which would show the 3D augmented object in the tv itself which gives a feeling that the object is out in 3D with preferences to the user [43]. This information based out of the website and internet and not from any research paper.

7.5 Manufacturing and Industrial Use

AR was first introduced into manufacturing than any other field. Modern Manufacturing involves lot of procedures small parts to assemble into a unit. AR is helpful in providing the user with more precise information about the manufacturing unit instead of the user going through the manual book for doing a small simple fix. Boeing is investing lot of money in VR and AR. In August 2017 Boeing made a deal with C360 Technologies which is leader in VR and AR. Below is the image of the Boeing engine on the table.

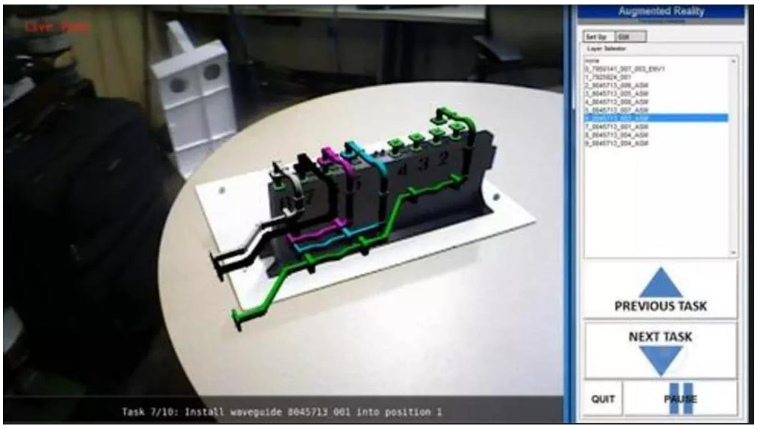


Fig. 15- Boeing's AR Tablet Tool for Assembly Lines. Figure taken from [38]

7.6 Advertisement and Commercial Use

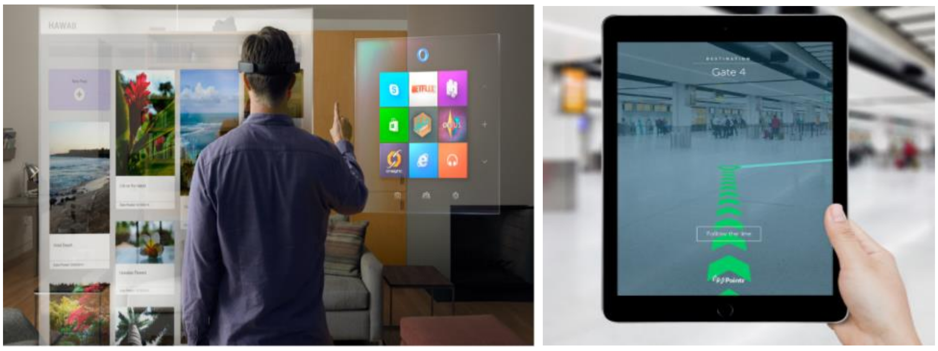
Many companies are coming up with their application to try their product using AR. For example, IKEA has developed an application to try the furniture at home before buying it. Many wallpaper companies give the ability to try the wall paper on your wall before buying it. Leading Car manufacturer like AUDI, Mercedes have come up with mobile applications that helps the user to understand the functionality of the car.

(a) (b)

Fig. 16-(a) An Augmented Trolley bag from the "Augment Mobile App" (b)Augmented Lamp and fan in the room

7.7 Personal Use

With invent of smaller HMD’s and powerful mobile devices people can use AR for their personal use. Many navigation companies have developed devices that shows direction to users with AR. Microsoft HoloLens give the user the ability to use AR for running all the application from your personal computer, from browsing, playing games to creating 3D objects for your work is incorporated in AR today.



(a) (b)

Fig. 17-(a) MS HoloLens user working with personal application such as Netflix, skype. Figure taken from [39] (b) User using mobile phone to find the path in Airport. Figure taken from [40]

8. Limitations and the Future of AR

8.1 Outdoor Use

Though a lot of AR applications have moved to mobile still does not have sufficient computing power that they can process information required by AR applications. The existing mobile AR devices require heavy laptops as backpack for processing along with the HMD's and sensors. Some devices that are intended to use for indoor activity are not good at all for outdoor purpose.

Another problem that could be discussed would what will happen if the user is under low light or dusty condition. Does the AR have enough power to process such scenarios? There are still some questions that are unanswered.

8.2 Tracking

Recognizing the views that are not known to systems is a challenge still now. Any open environment or outdoor views would require lot of processing to track the objects and identify. Calibration of these devices is another problem. The fast movement of the devices require extensive calibration to adjust and understand the view which sometimes lead to error in registration and creates a distorted view. Delays of even 10 milliseconds can cause a significant impact on the performance of the device.

8.3 Depth Perception

Depth perception is problem that causes the virtual object to either appear away or dim than they really are. Consistent registration with moving device may affect calculation of the depth perception and in fact the movement of the eyes also affect the perception of the images that is perceived and augmented.

Eye Strain- Some displays cause discomfort to the user. If the user is seeing the same image in both the lenses with a Video see through display that will cause more discomfort to the user than seeing a stereoscopic image.

8.4 User Interface

Advancement in interaction with the data in AR is still a work in progress. For example, the AR in mobile application today shows only the information to the object that is pointed and does not take much input from the user again or you have to restart the process. In HMD's thought there is some progress for example the HoloLens uses the gesture control to click an event on the display and the app also tracks the eye pupil of the user to point out. The HMD's are still not so advanced to accommodate the user queries and responses affectively. It may take some years to affectively interact with an AR device without much difficulty.

8.5 Information Filtering

When there is lot information in the field and situation demands a fast real time operation like the one for military operation AR might give too much of information today. What information should be shown to the user and what not is something that has to be defined by the complex algorithm that would be defined for any particular task. Lot of work is in progress for outdoor real time AR research mainly from the defense area.

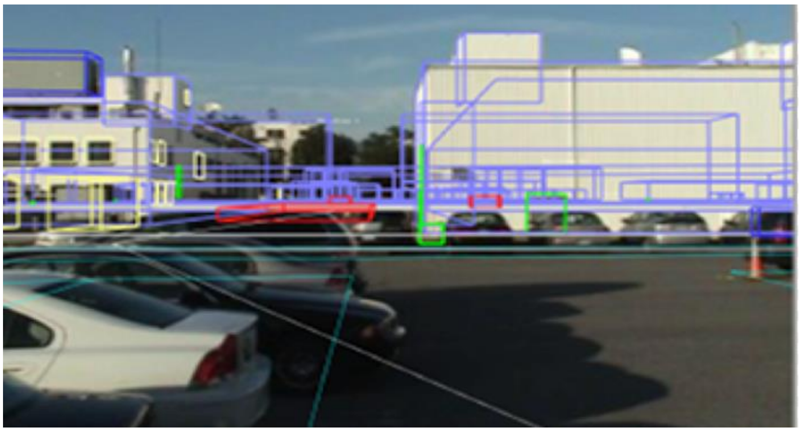


Fig. 18 Lot of information shown to the user about the building obstruction. Figure taken from [35]

8.6 Internet Connectivity

The vast amount of data for non-marker based AR device need to be processed by internet. The connectivity of internet is still restricted to urban areas. For example, in a warzone if would be difficult to process data of an unknown plane.

8.7 Human Acceptance

Though the device is becoming smaller and smaller for HMD's and other wearable devices it is still question whether the society will accept this devices in their life as they have accepted mobile because of privacy issues or doing gestures in public places where other have no idea what you are trying to do.

Many places banned google glass earlier because of the privacy issue they faced.

9. Conclusion

In this paper we have seen a comprehensive overview of AR in terms of technology, user interface and interaction, types of devices and concluded with the challenges that are faced today. Many companies have already created application with mobile and doing lot research to HMD's in other useful areas. With lot of advancement in remote computing, sensors and cameras we are looking that AR is going to be highly used in the next 5 years. Many companies are predicting that more than 30% people will be using AR in the next 5-6 years at work. Though AR is giving a new paradigm for user interaction with system there are still some areas where lot of research has to be carried out. Also, the social acceptance is a bigger issue because everybody would not like to carry their computer (ubiquitous computing) with them all the time where ever they go.

10. Future Work

Today we have started using AR in good range of field, but we are still dependent on the many factors like the devices, computing power etc. In future with the development of Artificial intelligence, Machine learning brain-computer interfaces and other technologies that supports AR, it would not be difficult to predict that we would have an environment where we would not be having any devices, yet we would be connected to the world or we may open the world to ubiquitous computing [41]. There is numerous possibility of using AR in different fields. Today we can say that the day is not far when we will be also able to use AR like Robert Downy JR did it in the movie "IRON MAN".

11. Signature

I acknowledge that copying someone else's article or essay, in full or part of it, is wrong, and declare that this is my own work.

Print Name: John Kuriakose Date: 27 October 2017

Signature: John Kuriakose

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