A SEMINAR REPORT ON

Augmented Reality for Remote Laboratories

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By

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CERTIFICATE

This is to certify that the seminar report entitled **“Augmented Reality for Remote Laboratories**” presented by **Subha Biswal** bearing Regd. No: **1704050016** of 9th semester Electrical Engineering branch in Veer Surendra Sai University of Technology, Burla has been successfully delivered during the academic year 2021-22 towards the partial fulfillment of the requirements of the Master’s Degree.

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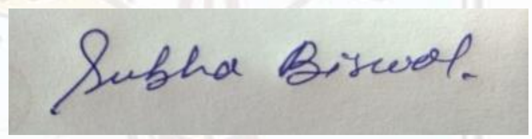
I acknowledge that an assemblage of this nature could never have been attempted without inspiration from the works of others whose details are mentioned in references section.



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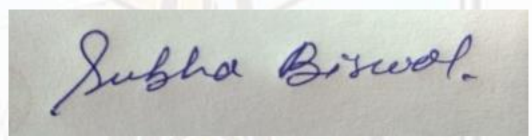
DECLARATION

I hereby declare that the seminar report entitled "**Augmented Reality for Remote Laboratories**" submitted by me to the Department of Electrical Engineering, VSSUT is a record of an original work done by me and the seminar report is submitted in the partial fulfilment of the requirement for award of the Bachelor's Degree from VSSUT, Burla. I further declare that this report will not be submitted, either in part or in full to any other institution or university**.**



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ABSTRACT

Augmented reality (AR) is an enhanced version of the real physical world that is achieved through the use of digital visual elements, sound, or other sensory stimuli delivered via technology. It is a growing trend among companies involved in mobile computing and business applications. But it is also currently being introduced in new application areas such as historical heritage reconstruction, training of operators of industrial processes, system maintenance, or tourist visits to museums and other historic buildings, among others. The academic world has some connection to these initiatives and has also begun to introduce AR in some academic disciplines, although its teaching applications are still minimal. As a student, our concern is to look for AR as Remote laboratories to cope up with the COVID 19 pandemic. The required techniques and basics of AR technology are discussed. Irrespective of its large number of advantages there are certain disadvantages for which it cannot be used in all types of Laboratories.

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1. INTRODUCTION

Augmented Reality provides huge opportunities for online teaching in science and engineering as these disciplines place emphasis on practical training and unsuited to completely non classroom training. As we know there are limited resources in the laboratories, both of software and hardware and also laboratory models are expensive and also very difficult to provide individualized material for each student [1]. These situations can be overcome using the AR techniques.

1.1. WHAT IS AUGMENTED REALITY?

Virtual reality (VR), Augmented Reality (AR) and mixed Reality (MR) are three new technologies in the field of DIGITALIZATION. Augmented Reality (AR) is the process of superimposing digitally rendered images onto our real-world surroundings and giving a sense of an illusion. AR can be also be defined as a system that fulfills three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects [2]. Recent developments have made this technology accessible using a Smartphone and Head-mounted displays and speakers. Examples are Pokémon in Pokémon-Go game (Fig.1) and IPL Stadium Board (Fig. 2).

Fig. 1. Pokémon Go Game

Fig. 2. IPL Stadium Virtual Board

1.2. HISTORY OF AR

Over the last 50 years, **Augmented Reality** technology has reshaped the way we consume content in the real world (Fig. 3). Augmented Reality tech dates back to the 60s. Augmented reality technology was invented in 1968, with Ivan Sutherland's development of the first head-mounted display system (Fig. 4). However, the term ‘augmented reality’ wasn’t coined until 1990 by Boeing researcher Tim Caudell called as ‘The Sword of Damocles’.

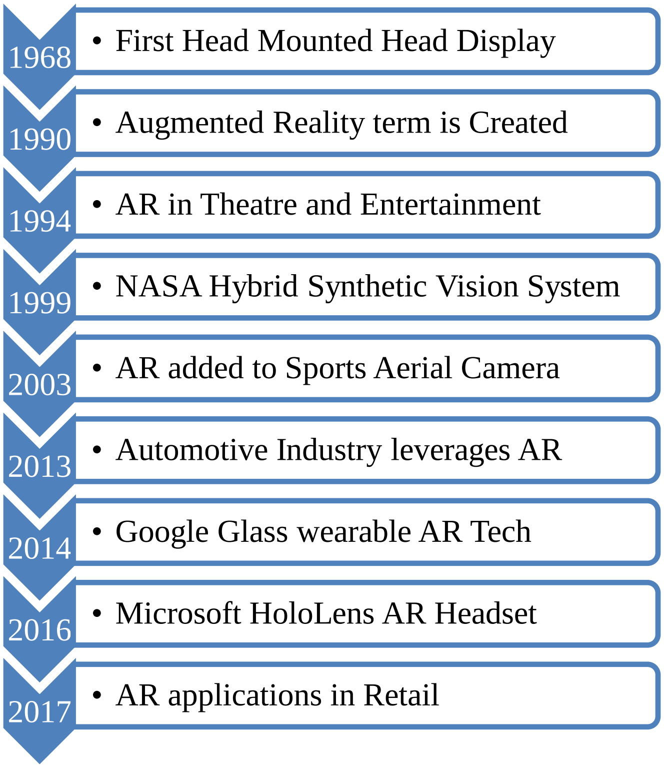

Fig. 3. History of AR

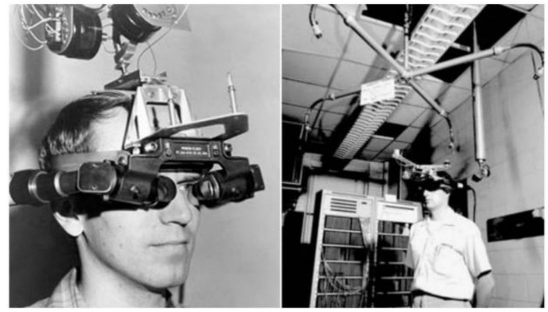

Fig. 4. Ivan Sutherland performing his experiments

Fig. 5. NASA System

In **1994:** Julie Martin, a writer and producer, brought augmented reality to the entertainment industry for the first time with the theater production titled Dancing in Cyberspace. In **1998:** Sports vision broadcasts the first live NFL game with the virtual 1st & Ten graphic system – aka the yellow yard marker (Fig. 6). The technology displays a yellow line overlayed on top of the feed to that views can quickly see where the team just advance to get a first down. In **1999:** NASA created a hybrid synthetic vision system of their X-38 spacecraft (fig. 5). The system leveraged AR technology to assist in providing better navigation during their test flights. In **2003:** Sport vision enhanced the 1st & Ten graphic to include the feature on the new Skycam system – providing viewers with an aerial shot of the field with graphics overlaid on top of it. In **2013:** Volkswagen debuted the MARTA app (Mobile Augmented Reality Technical Assistance) which primarily gave technicians step-by-step repair instructions within the service manual (Fig. 7). In **2014:** Google unveiled its Google Glass devices, a pair of augmented reality glasses that users could wear for immersive experiences (Fig. 8). Users wore the AR tech and communicated with the Internet via natural language processing commands. With this device, users could access a variety of applications like Google Maps, Google+, Gmail, and more. In **2016:** Microsoft starts shipping its version of wearable AR technology called the HoloLens, which is more advanced than the Google

Glass (Fig. 9), but came with a hefty price tag. It’s definitely not an everyday type of accessory. In **2017:** IKEA released its augmented reality app called IKEA Place that changed the retail industry forever [8].

Fig. 6. Yellow Yard Marker in Sports Ground

Fig.7. AR in Automobile Industry

Fig. 8. Google Glass

Fig. 9. Microsoft Holo Lens

2. BASIC PRINCIPLE

2.1. HOW DOES AR WORK?

Augmented reality starts with a camera-equipped device such as a smartphone, a tablet, or smart glasses loaded with AR software. When a user points the device and looks at an object, interpret the angles and distance the AR device is away from the marker, the software recognizes it through computer vision technology, which analyzes the video stream. The device then downloads information about the object from the cloud, in much the same way that a web browser loads a page via a URL. A fundamental difference is that the AR information is presented in a 3D "experience" superimposed on the object rather than in a 2D page on a screen. What the user sees, then, is part real and part digital. Along with it can pass the information through the spatially positioned speakers also. Advanced AR also includes the interaction with the virtual images. Examples are Asian paints wall coloring app (Fig. 10), Microsoft Holo Lens (Fig. 11) and Lens kart 3D try on eye wear (Fig. 12).

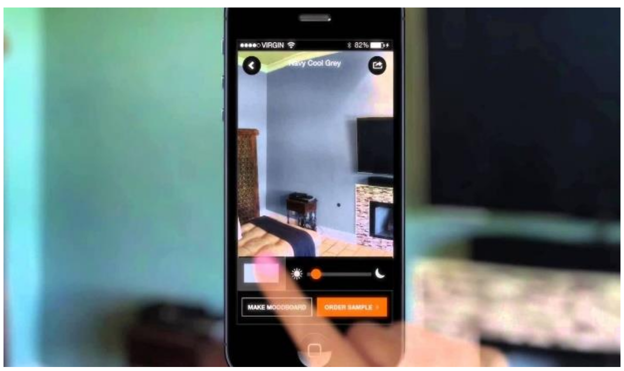

Fig. 10. Asian Paints Wall Coloring App

Fig. 11. Microsoft Holo Lens AR

Fig. 12. Lens Kart Mobile AR Technique

2.2. WHY DO WE NEED AR?

- *Deficiency of Proper Vision:* What will be the output of our process is not known to us, so to have a proper vision before starting a work may bring the necessary changes and implementation to the work. For example, making a house having a 3d model before creating it will bring more clarity to engineer, worker and the owner.
- *Unavailability of Efficient trainee:* It is not same that all the trainee is efficient enough to train the workers or students. But an AR could play the role of a trainee if it is been designed with the help of best Trainer.
- *Limited Resources:* We find many of the colleges and training centers does not have limited amount of resources, so students and workers do not get proper training and sometimes they forget also. For example, in medical colleges the amount of dead bodies for their practice are few. But using AR this problem also can be solved (Fig. 13).
- *Access to Higher Studies:* There are vast number of techniques and vast number of new things are introducing. to walk along with this developing scenario, we have to be fast and learn more. But time, resources are biggest factor opposing the path. So, AR can remove this scenario also.
- *Improving practical Skills:* Practical skills are very much important for each and every person, but the fact is, for practical skills we need resources and trainees to perform number of experiments to know it in every possible way. The absence of these facts can also be fulfilled by Augmented Reality.
- *To have Better Foresight:* For example, while coloring a room we cannot visualize how it will look after we color it with our interested colors. Now we have Paints company with AR included feature to have a look into the room with different color on the wall before painting it.
- *To have a Partner:* People who are physically challenged like dumb or blind or deaf, have always the problem in getting the complete information in comparison to a normal people can get [4]. So, for them AR can be the perfect partner to help them in getting required information.

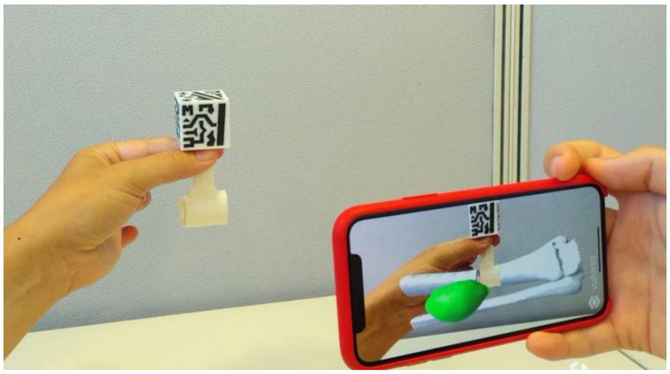

Fig. 13. Virtual Bone from QR Code in Remote Laboratory

3. AUGMENTED REALITY IN LABORATORIES

3.1. WHY AR IS NEEDED IN LABORATORIES?

In the COVID pandemic we all have missed the Laboratory practical sessions, that means for that period we gained zero experience of our used machines. It would not have created problem if only we could have accessed those laboratories from home and could have done experiment with it. We call it remote Laboratories. It is only possible by the use of Augmented Reality. Along with it many problems are there from before also like, Time Management problem, Resource Scarcity, absence of Expertise Trainer. These problems are also can be resolved by using AR. For example, group of more than 10 number of students are performing a single experiment. Some are doing experiment and some are losing interest because they cannot even see the experiment. Sometimes they are unable to understand the experiment and only do it for their grades only. So, all these problems arise because they lose interest because of above problems. Interactive Learning is the missing factor for which they lose interest. Sometimes it is dangerous to perform experiment like in Power System Labs, Chemical Labs because of experimentation. So, for a safe experimental purpose also AR is the best solution.

3.2. HOW AR CAN BE USED IN LABORATORIES?

Augmented Reality Laboratories (ARL) can be divided into two categories now, i.e. Physical AR Laboratory and Remote AR Laboratory. In Physical Laboratory all the machines or the markers for required experiments are placed in a single room, with the help of mobile based application or head mounted displays we can access those machines with downloaded information about "how to use it?, what experiment can be performed with it?, what are the steps for performing experiment?, and also the internal structures also can be viewed". Advanced AR includes interactive environment techniques so that we can perform any work with those 3d models also in case of marker-based model. In case of marker-based experiments "We can connect circuits, we can mix two chemicals, we can make surgery on a body, even we can knowingly make mistakes to know the possible outcomes which are not possible on real models". Along with it no need of trainer to assist you for performing a certain experiment. Similarly, in case of Remote laboratories all the above functions can be achieved by downloading QR codes (markers) from internet and performing all the experiment at home or any type of remote area. For its functionality certain devices are required like camera, PC display (Fig. 15), Head Mounted Displays (Fig. 14), input units like gloves (Fig. 16), keyboards and an application e.g. ARRL Application to manage and perfume required actions.

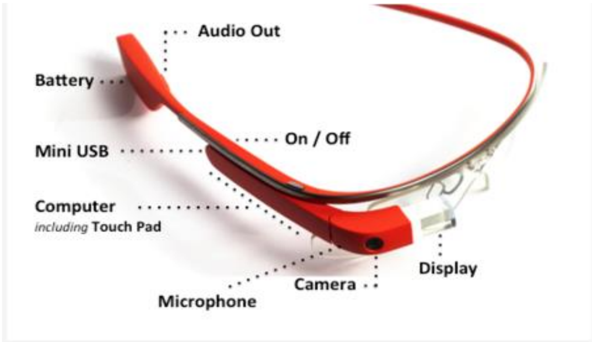

Fig. 14. Head Mounted Display with Speaker

Fig. 15. Mobile and Monitor Display unit

Fig. 16. Manus Gloves for working with Virtual World

3.3. FRAMEWORK OF AR FOR AREMOTE LABORATORIES (ARRL)

Augmented Reality systems require several core components in order to provide the augmented visual services. The minimum set of services may vary from installation to installation, but for visual AR systems the set can be broadly defined as:

• *Video Capture of Live Video Streams:* Real-time video stream interception is an essential component of all AR systems. Without proper processing of the video stream, numerous errors become introduced into the resultant feedback. The primary difficulties include many hardware and software induced issues. The capture of live video streams requires timely and accurate processing to avoid as many introduced errors as possible. Computer vision systems undertake analysis of the individual frames, either as discrete instance or as sequence.

• *Real Object Identification (ROI):* Without the ability to interpret the scene from a video stream, AR capabilities become ineffectual. Interpretation of objects within the video scene comprises the bulk of the image processing workload. Computer vision techniques, such as probability density functions, frame subtract and clustering, are used to extract meaningful information from the sequence of live video frames. Object identification hinges on techniques that filter all but the items of interest. Sensing moving or changing scene objects through algorithms such as frame subtraction, fail to appreciate the complexity in the image parameters between one frame and the next. Single point solutions only solve problems for specific experiment configurations.

• *Object Tracking:* Identifying an object is only part of the AR key aspects, and identification must work with object tracking. Without the ability to track the identified object, recognize it if it should move in and out of the scene, or adjust its visible surface area, then the results are also ineffectual. Object tracking must continue to recognize the object and changes its position or orientation between frames.

• *Image Overlays:* Visual AR systems provide the augmentation through image overlays, combining the real and virtual dataset into one seamless visual information stream. Overlay data services need to ensure that important objects with the video stream are not occluded by any virtual objects draw to the frames. Occlusion affects both the real and virtual data, and strict rules are necessary to keep tracked objects, virtual feedback elements and secondary data objects clear from each other.

• *Control and Management System:* All data are needed to processed and prepare and virtual output for which control and management system are fully required. E-instructor prepares the program and control management system arranges each data according to their order.

• *Interactive Output:* The key aspect of AR is the interactive nature of the technology. Feedback to the user, in visual AR systems, requires images or text to be placed over the existing live video. Image overlays form a source of feedback, but also in a form that allows interaction

→ *Natural User Interface (NUI)-* Many experiments require operating instruments without using a keyboard type interface with buttons only. This involves complex hand movements to manipulate physical objects and observe the resultant behaviour of the objects. While implementing such experiments, the hand movements are replaced with some form of automations and the users never get the real hand-on experience as they would have in an on-site laboratory. The NUI has the potential to address this issue.

→ *Suitable Gestures-* Natural user interface (NUI) requires a suitable gesture library for each experiment that defines what can be recognized as a valid set of movements with respect to the experiment.

→ *Gestural Control-* A suitable devices needs to be chosen for capturing NUI data. This could be wearable devices e.g. Sixsense Hero, Razer Hydra, remote recognitions devices e.g. Leap Motion for hand gestures or Microsoft Kinect for full or upper body gestures.

→ *Types of Display-* The output of the gestures along with the graphical representations of the gestures can be displayed either on a wearable display device e.g. smart glass or on a computer desktop as well.

→ *Timings/Delays-* The discrepancy between the live video data appearing from the RAL experimental rig, and the image overlays supplied by the AR services, are finite and influence the user's immersion in the AR experience. Any delays introduced by the AR services must be kept to a minimum so as to maintain the AR synchronisation.

• *Security:* it is the most required thing in any type of application for the reason of data theft, data manipulation and data saving from virus attack. Proper firewall is included to each AR application for the security purpose to save the program.

• *Error Handling:* With the improvement of time the techniques will develop and error will be generated to match with the new techniques developed, and also in case of any error due to system mishandling need to be solved to avoid discontinuity. So, proper expertise teams need to be allocated for this purpose only. [7]

3.4. DISTRIBUTED SYSTEM ARCHITECTURE OF ARL

Augmented reality starts with a camera-equipped device such as a smartphone, a tablet, or smart glasses, loaded with AR software. When a user points the device and looks at an object, the software recognizes it through computer vision technology, which analyses the video stream. For e.g. in Fig. 17, A video camera takes the picture of a simple experiment kits. The data and instructions about the related experiment are previously stored in the cloud by the e-instructor and management components. CPU unit regularly makes conversation with these two unit to prepare the program unit and to control the ARL System. The data are protected using the internal strong firewall system so that no one can manipulate it or use it for wrong purpose. The data are then uploaded to the internet. The AR device then downloads information about the object from the cloud, in much the same way that a web browser loads a page via a URL. A fundamental difference is that the AR information is presented in a 3-D "experience" superimposed on the object rather than in a 2-D page on a screen. What the user sees, then, is part real and part digital. The output can be seen or listened using different output units like printer, desktop, mobile, HMD or any speakers. AR can provide a view of the real-time data flowing from products and allow users to control them by touchscreen, voice, or gesture. For example, a user might touch a stop button on the digital graphic overlay within an AR experience or simply say the word "stop" to send a command via the cloud to a product. An operator using an AR headset to interact with an industrial robot might see superimposed data about the robot's performance and gain access to its controls. As the user moves, the size and orientation of the AR display automatically adjust to the shifting context. New graphical or text information comes into view while other information passes out of view. In industrial settings, users in different roles, such as a machine operator and a maintenance technician, can look at the same object but be presented with different AR experiences that are tailored to their needs. A 3-D digital model that resides in the cloud the object's "digital twin" serves as the bridge between the smart object and the AR. This model is created either by using computer-aided design, usually during product development, or by using technology that digitizes physical objects. The twin then collects information from the product, business systems, and external sources to reflect the product's current reality. It is the vehicle through which the AR software accurately places and scales up-to-date information on the object.

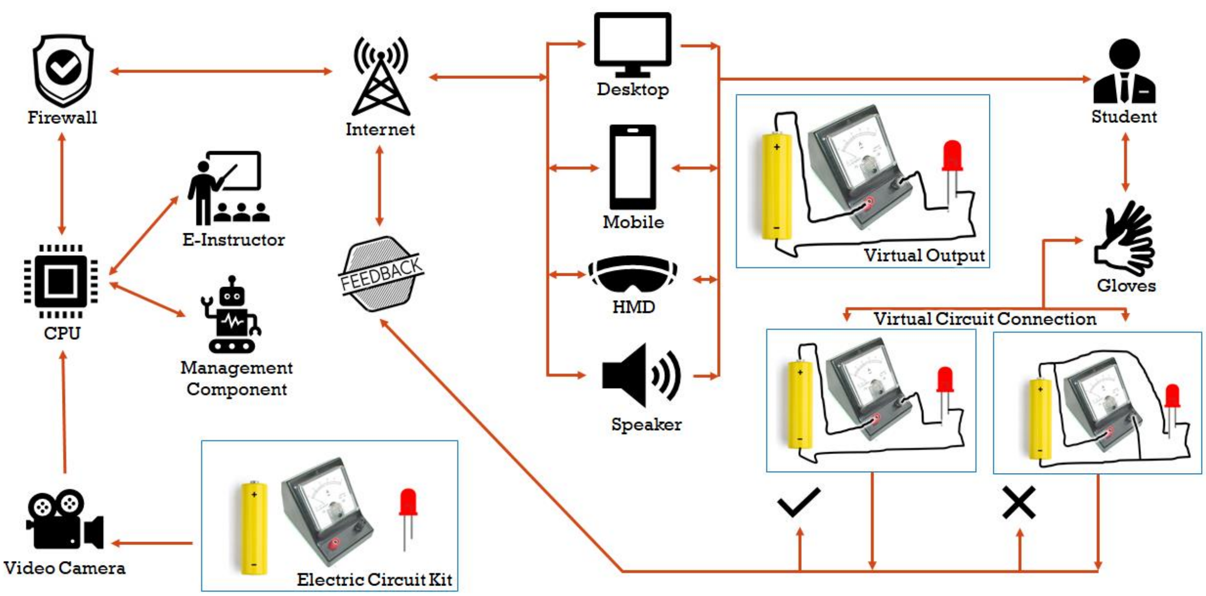

Fig. 17. Architecture of AR with an Example

3.5. IMPLEMENTATION EXAMPLE OF ARRL

As shown in Fig. 18 the person is having Real-time visualization system for 3D magnetic field distribution. QR codes (markers) of specific Experiment is Provided. Scanning the QR code downloads a 3D model to the screen along with instructions. Not only we can see them but we can perform experiments using those 3D models. Feedback to the experiment is also loaded with QR code to get result after performing experiment. Fig. 18 is a simple experiment that is performed using ARRL Application. [6]

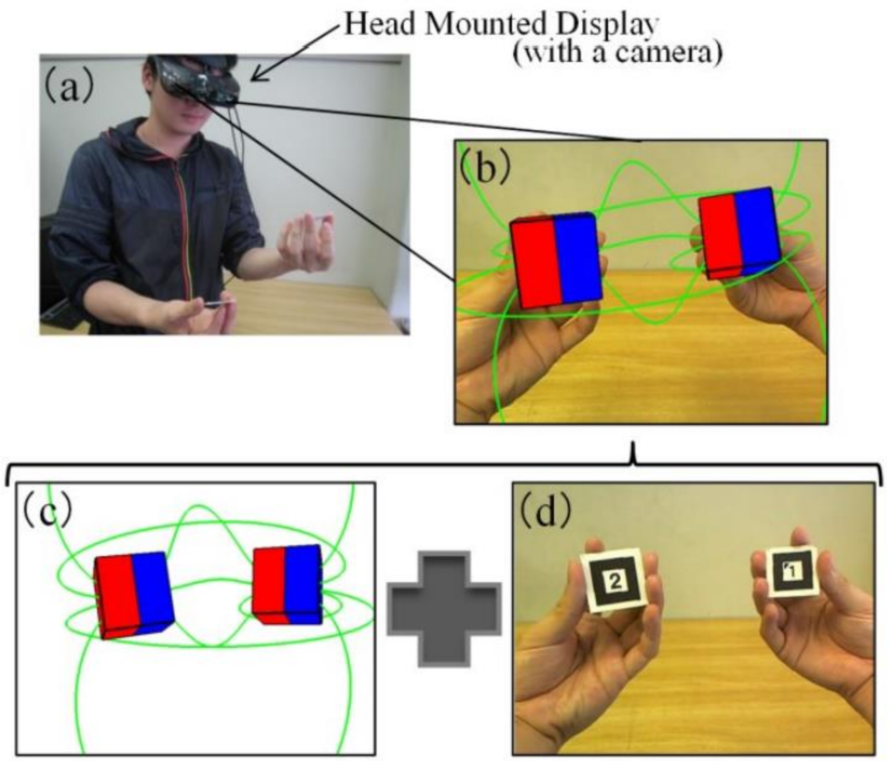

Fig. 18. Real-time visualization system for 3D magnetic field distribution. (a) Overview of proposed system and the HMD with a camera. (b) The composite image displayed on the user's HMD. (c) The simulated magnetic flux lines in 3D space. (d) The markers which

4. STATISTICS OF ACCEPTANCE

Table 1. is based on the 2020 survey report [5]. The percentage use of AR in different important areas are recorded for the year 2018 and 2020 and also calculated for the 2025. Its year wise growth graph is shown in fig. 20. Along with its growth rate for 2-year gaps i.e. from 2018 to 2020 and 2020 to 2025 are compared in graph shown in fig. 21. We can observe from the graphs shown in fig. 19. that at present time (considering it to same as 2020) the Entertainment Sector has the highest involvement in the AR technology following it Gaming Sector then E-Commerce. But looking at the 2025 we expect to have Retail/E-commerce Sector at the top in using AR techniques.

2020 SURVEY REPORT		YEAR				
		2016	2018	2020	2025(Expected)	
IMPORANT AREAS	Video Game	10	25	52	70	PERCENTAGE
	Entertainment	5	45	63	80	
	Retail/E-Commerce	3	32	45	90	
	Education	1	5	13	50	
	Healthcare	1	14	29	70	
	Engineering	2	16	25	65	
	Military	5	3	10	30	

Table 2. 2020 Survey Report including data of 2016, 2018 and expected data for the year 2025

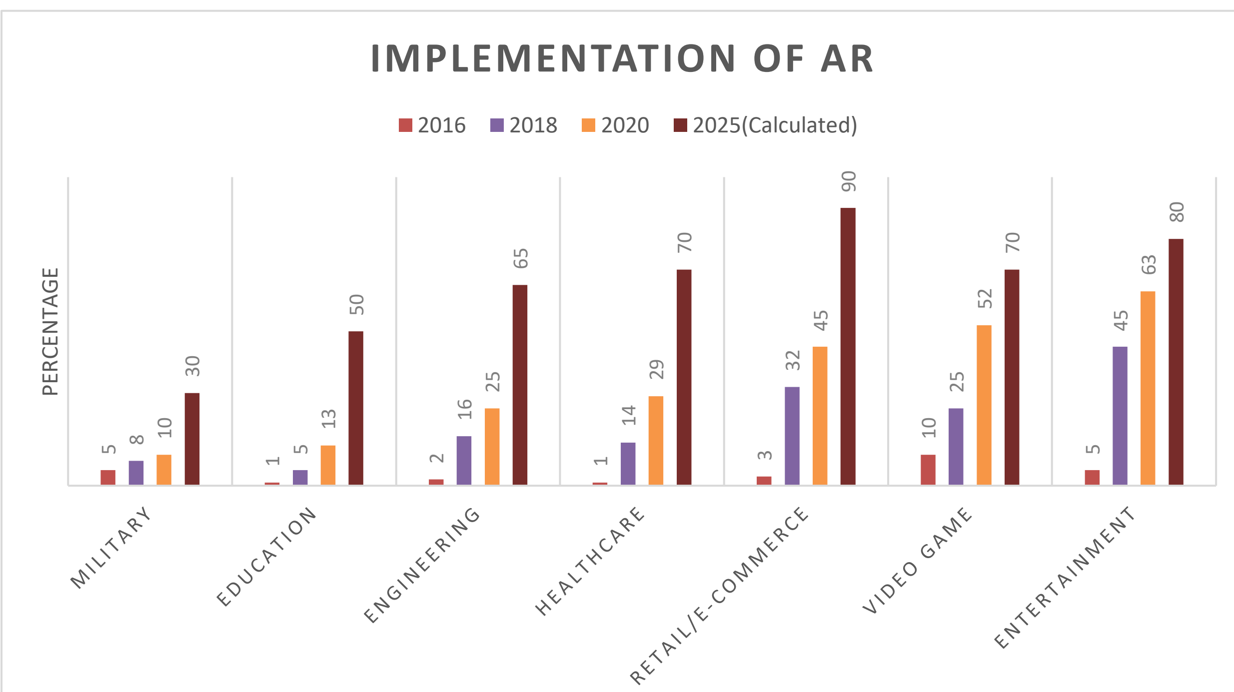

Fig. 19. Bar Graph of Statistics of Implementation of AR

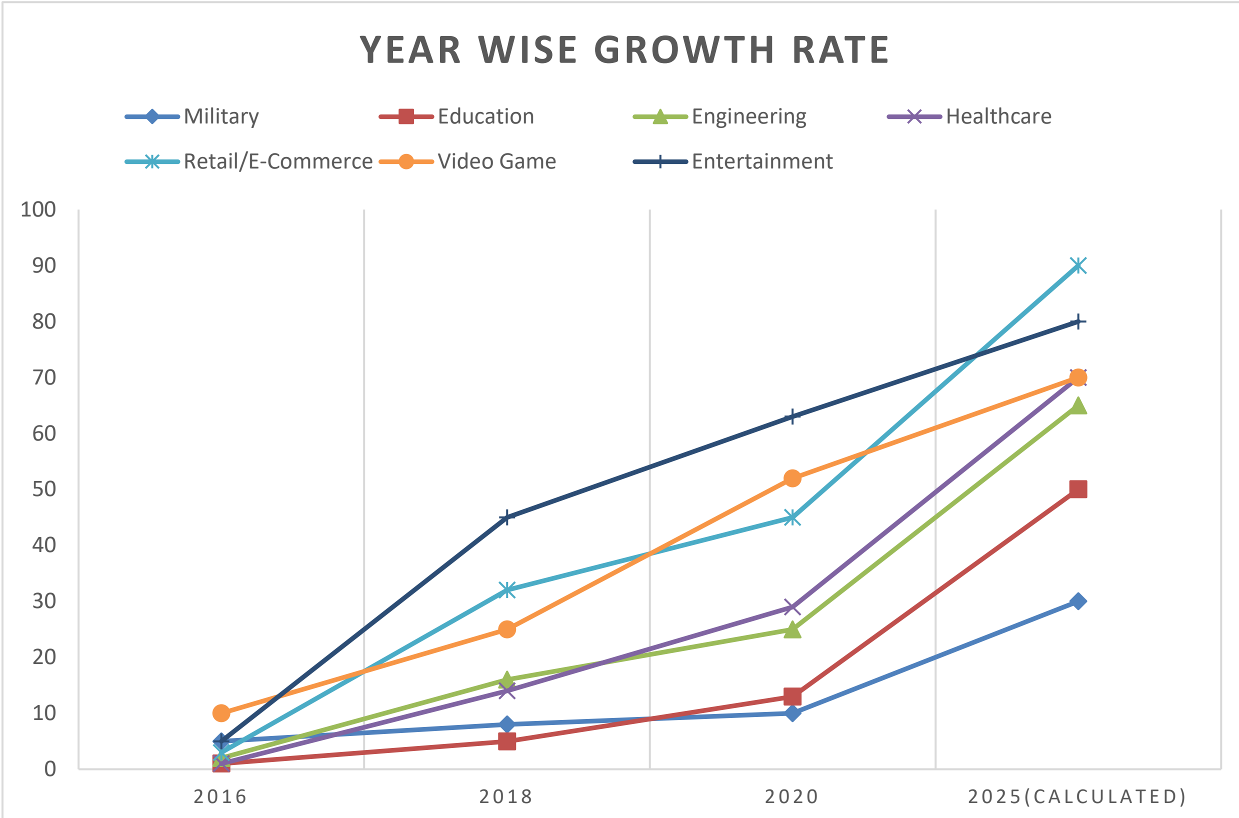

Fig. 20. Year Wise Growth Statistics

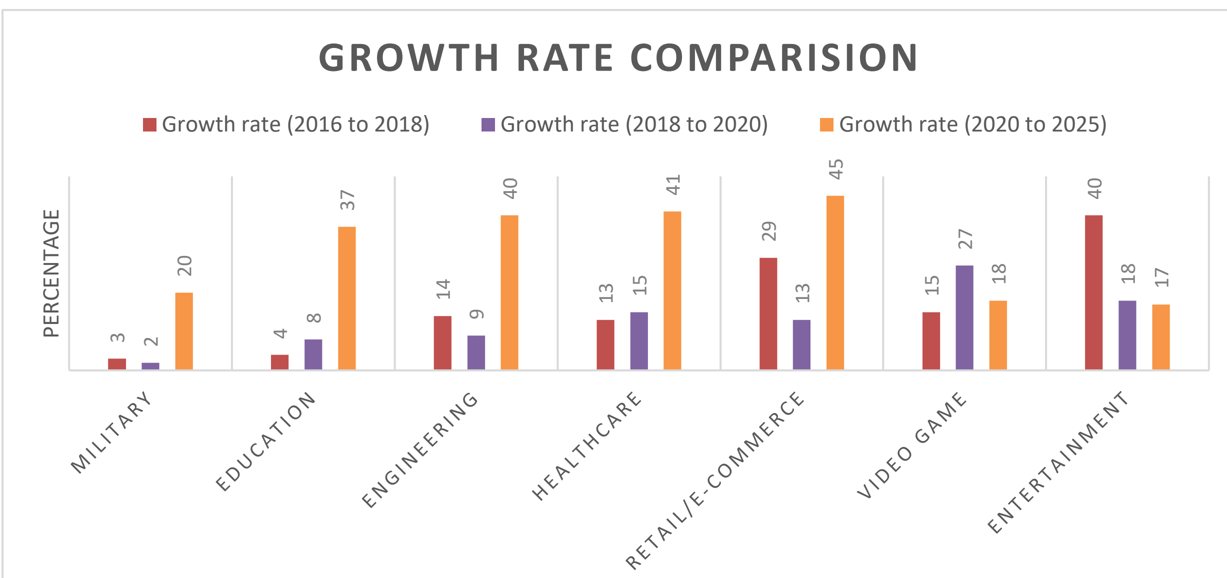

Fig. 21. Growth Rate Comparison

5. DISADVANTAGES OF ARL

- *Lack of Privacy and Security* - Till date its security system is not made that much strong so that the privacy can be maintained, anyone can access the files and can change the data in it. So, it is dangerous in situation like data leakage and data theft.
- *Costly & Time taking for Program Development* - Its devices like Head Mounted Devices are not yet easily accessible to each and every person because of its high price. Its programming time is also very large. Its price will go down when its preparing and programming cost will be low.
- *Lack of Physical Contact in Remote Laboratories* - Physical contacts like sense of touch, smooth or roughness can only be seen as a number in a remote laboratory using AR. On the basis of numbers only we have to decide the surface is smooth or rough or watery, anything else.
- *Laboratories like Chemical Labs are unsuitable for Remote Testing* - Some labs like chemistry labs need the sense of smell to perform some sort of experiments in that case it is not possible while doing experiments from remote lab.
- *Wrong use may bring Accidental Scenarios* - In July 2016 Pokémon Go game was released in India by a Japanese Company which has the small features of AR but gamers has to search Pokémon looking at their nearby areas. In which people faced many accidental scenarios like road accidents, fall from room etc. So, wrong use may create dangerous situations.
- *Addiction & Psychological Effects* - We can see now AR features are in most of digital platforms known as filters in social platforms like Instagram, snapchat. It is funny at the same time addictive. So, it may create psychological effects to people addictive to it.

6. CONCLUSION

Augmented reality (AR) systems are far behind VR systems in terms of maturity Augmented Reality is a relatively new field, where most of the research efforts have occurred in the past few years Because of the numerous challenges and unexplored avenues in this area. AR will remain a vibrant area of research for at least the next several years. AR is similar to the mobile technology, we don't need it now, but once we start using it, then it will be a part of our day to day life. Everybody has mobile phones today and we carry it all the time with ourself like wearing dresses daily, and Augment Reality Technology going to replace mobile phone in some 5 to 10 years. The Head mounted Displays going to a part of our daily wear. It has some disadvantages but looking at its advantage side, disadvantages can be neglected or corrected. Its Statistics shows its need in this Pandemic situation. In this Pandemic most of the activities are digitalized. Therefore, the calculated data for the year 2025 reaches a high margin. Along with all other areas AR is also going to reach heights in education section and going to replace mobile laptops in upcoming years. A common conclusion of several studies is that augmented reality (AR) applications can enhance the learning process, learning motivation and effectiveness. Despite the positive results, more research is necessary. After the basic problems with AR are solved, the ultimate goal will be to generate virtual objects that are so realistic that they are virtually indistinguishable from the real environment

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