A Review on Augmented Reality Application in Industrial 4.0

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***Abstract*—**
Augmented reality is an interactive experience that combines the real world and computer-generated content. Internet of things, Machine learning, cloud network multimedia and computer vision transformed science fiction in to reality. Basically, this paper deals with basics of AR is and the components of AR, the devices that are used in AR, its application in various fields and the way it can be used to visualize the faults that have occurred in the device or

system.

Index Terms—**Augmented Reality, Robotics, Applications, andVisualization**

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I. Introduction : Augmented reality (AR) involves superimposing computer pictures on the physical world. One of the finest summariesof the technology was one that defined the topic, listed numerous issues, and summarized previous advancements. AR is a technology that sits in between virtual reality and telepresence. While the environment in VR and telepresence is entirely made up, the user sees the actual world enhanced with virtual items in AR. The usage of augmented reality(AR) combines digital and physical observations. Users can interact with virtual things in addition to seeing them appearin the user's environment. Simply described, augmented reality (AR) is a technique that involves presenting computer graphics in the real world. Fig.1 suggests that there are many differences between Augmented Reality, Virtual Reality & Merged Reality. Even though Augmented Reality has been around for less than a decade, it has made incredible advancements in recent years.

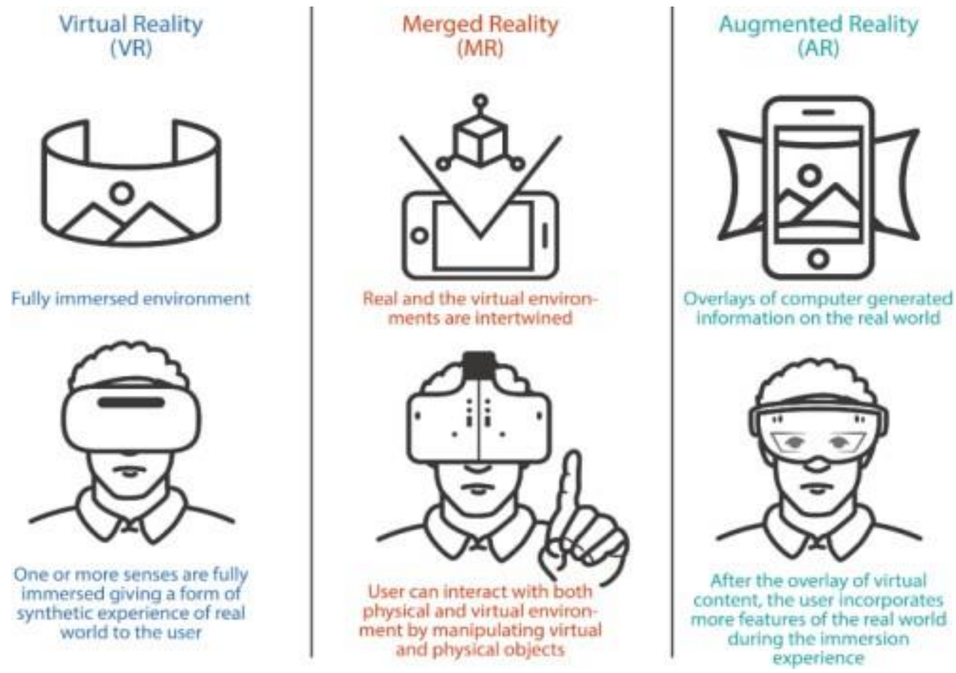

Fig. 1: AR vs VR vs MR

II. COMPONENTS OFAUGMENTED REALITY

a. Scene Generator and tracking system

The tool or program that creates the scene is known as the scene generator. The system which take care of the registration issues are known as tracking system. This system helps precision registration.

b. Display:

The technology for augmented reality is still being developed, therefore design choices will affect the solutions. Although head-mounted displays (HMDs) make up most AR displays, there are alternative options. There are two main options when fusing the actual and virtual worlds: optical and video technology[1-2]. Depending on several variables suchas resolution, flexibility, field-of-view, registration procedures, and others, each of them has some drawbacks. Furthermore, many technologies that start to approach these objectives are still too large, heavy, and expensive. But as we'll see in a moment, there have been some developments in see-through display technology in recent years[3-5].

III. Augmented Reality Devices

a. Optical See-Through HMD:

So many augmented medical systems are excellent examples of an optical see-through AR systems. Brain surgery has been the focus of MIT Image Guided Surgery. Using an AR-enhanced ultrasound system and other techniques, UNC has been experimenting with how to superimpose radiographic pictures on patients [6-7]. Numerous optical see-through devices exist which is shown in Fig.2 and Fig.3, as this appears to be the primary approach for augmentedreality.

Fig. 2: Working of Optical See-Through HMD

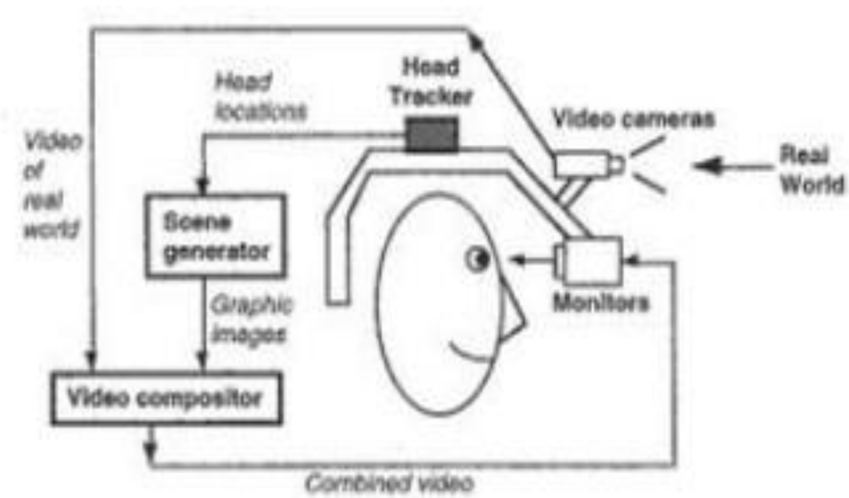

Fig. 3: Block diagram of Optical See-Through HMD

b. Virtual Retinal Systems:

In 1991, the Human Interface Technology Lab (HIT) at the University of Washington created the VRD (Virtual Retinal Display). The goal was to create a virtual display that had full color, a broad field of view, high resolution, and high brightness and was inexpensive. The VRD technology will only be sold under an exclusive license held by Micro Vision Inc. This technology has many potential applications, from head-mounted displays (HMDs) for military/aerospaceapplications to medical purposes [8].

A modulated light beam (originating from an electrical source) is directly projected by the VRD onto the retina of the eye, creating a rasterized image. The source image seems to the viewer to be visible from two feet away when seated in front of a 14-inch display. The retina ofits eye, not a screen, is where the image is located. Heor she is viewing an excellent-quality image with stereo vision, full colour, a large field of view, and no flickeringfeatures that can be seen in Fig.4 and Fig 5.

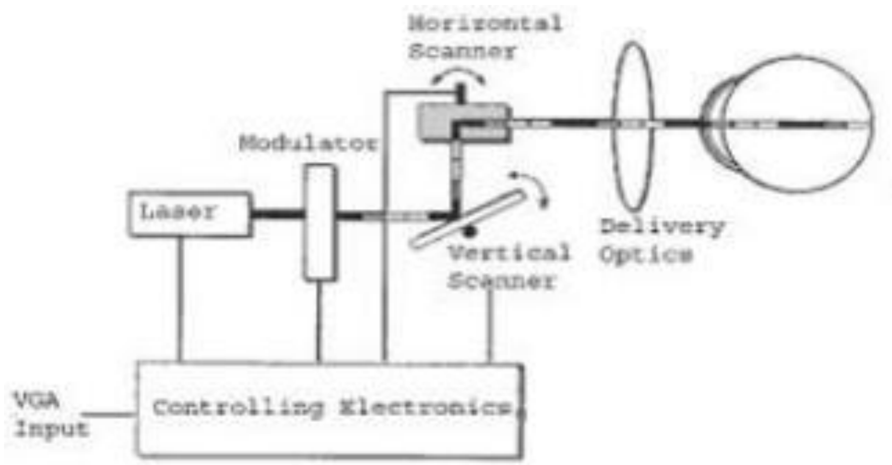

Fig. 4: Blocking diagram of Virtual Retinal Systems

Fig. 4: Working of Virtual Retinal Systems

c. Video See-Through HMD:

This method requires that the cameras be placed properly, making it a little more difficult than optical see-through AR. However, it is considerably simpler to create videos that combine the actual and virtual worlds[9-11]. There are numerous options, including depth mapping and chroma-key. At ISAR 2000, the Japanese Mixed Reality Systems Lab (MRSL) demonstrated a stereo video see-through HMD. This gadget addresses part of the parallax caused by the distance between the cameras and the users' eyes.

d. Monitor Based:

Although the display is a more typical desktop monitor or a handheld display, Monitor Based AR also uses merged video streams that can be seen in Fig 4 and Fig 5. Given that HMD problemsare no longer a concern, it may be the easiest AR setup. The company Princeton Video Image, Inc. has created a method for fusing graphics with live video broadcasts.

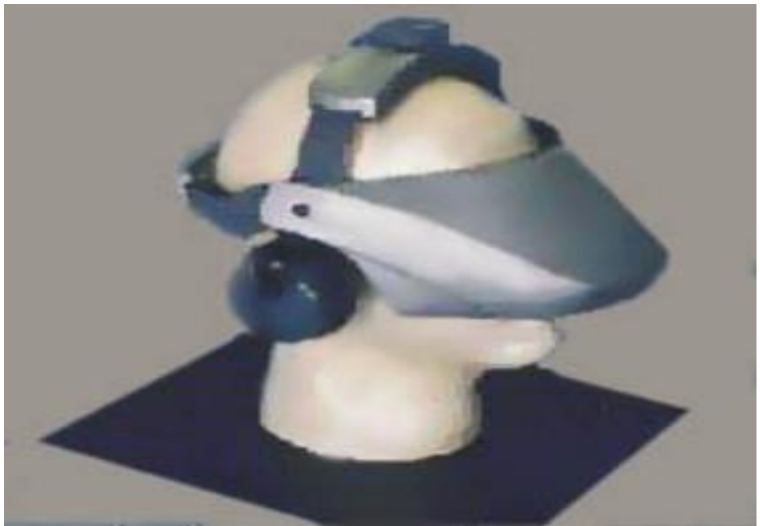

Fig. 5: Working of Video See-Through HMD

Fig. 6: Working of Video See-Through HMD

They frequently perceive their work as the first down line in American football contests. Additionally, it is utilized to insert advertising logos into other broadcasts.

Fig. 7: Working of Monitor Based HMD

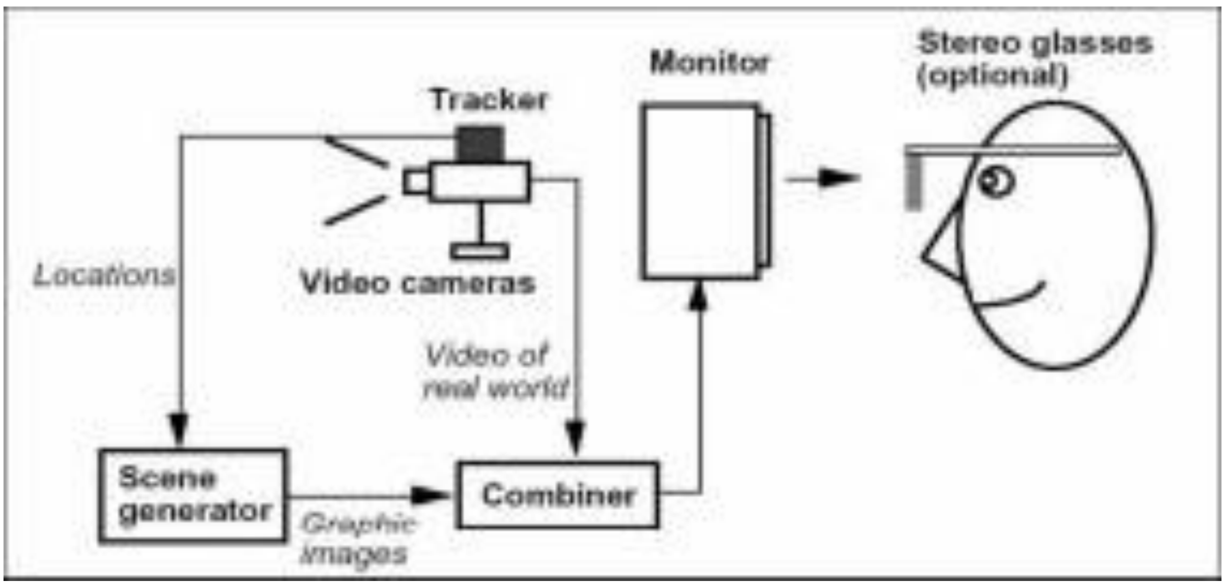

Fig. 8: Working of Monitor Based HMD

e. Projection Displays:

Projector Based AR uses real-world objects as the projection surface for the virtual environment which is explained in Fig .6. It can be used for product visualization, industrial assembly, and other things. Additionally, numerous user scenarios are ideally suited to projector-based AR. For successful applications, projector and projection surface alignment is essential.

IV. APPLICATION OF AUGMENTED REALITY

a .Medical:

It is not unexpected that the medical industry uses imagetechnology so extensively that this sector is thought to be one of the more crucial ones for augmented reality systems. Image-guided surgery is the focus of many medical applications. In order to visualize the path through the affected area's anatomy (where a tumors needs to be removed), a 3D model made from the preoperative study's numerous views and slices is first created. To aid in the surgical procedure, the model is then projected over the intended surface.

Ultrasound imaging is a further use for augmented reality in the medical field. The ultrasound technician can examine a volumetric generated image of the foetus superimposed on the pregnant woman's abdomen using an optical see-through display. As the user advances, the image is accurately rendered and appears to be inside the abdomen[12-13].

Fig. 6: Augmented Reality in Medical Field

Fig. 6: Augmented Reality in Medical Field

b. Entertainment:

In the media and news industries, a basic kind of augmented reality has been in use for a while. When you watch the evening weather report, the weather maps that the speaker is standing in front of are always shifting. The reporter is facing a blue screen in the studio. Using the chroma-keying technique, computer generated maps have been added to this genuine photograph. Game development is another entertainment industry where augmented reality is being used which is shown in Fig 7 and Fig 8..

Fig. 7: Augmented Reality for Industries

Fig. 8 Augmented Reality for Entertainment

c. Military Training:

Military soldiers can visualize the actions of other participating units by providing them with helmet mounted visor displays or a specialized rangefinder. During a training session, for illustration, the soldier wearing the display could see a simulated chopper ascending over the tree line while scanning the horizon. Another participant might be simulating the flight of this helicopter. In times of conflict, the depiction of the actual battlefield scene could be enhanced with annotation data or highlighting to drawattention to concealed enemy units.

d. Robot Faults:

Faults are categorized in four classifications:

(i) Defects in the sensors: measured results may be erroneous even if the actual quantity being measured by the sensor is not impacted by mistakes.

(ii) Motors and motor drivers may sustain damage as a result of actuation system malfunctions.

(iii) Mechanical construction flaws: Brake malfunctions or crashes can cause joints, for example, to stop moving.

(iv) Overloading issues: Due to the manipulator's inherent lifting constraints, issues may arise if the robot attempts to lift too heavy objects.

The correct operation of the manipulator is jeopardized when one or more defects arise; as a result, its motions and operations must cease for safety. The factory's production may be significantly impacted by this behavior, hence effective fault-solving techniques should be pursued. The following workflow illustrates one popular method used today to manage and resolve industrial robot faults:

(i) Activities of the manipulator are stopped.

(ii) A log file contains the description of the issue.

(iii) When looking at the log file, technicians use their knowl- edge and technical documents to try to fix the mistake.

e. The Working Flowchart:

The overall working flowchart is composed by four different steps:

a. Fault Representation (FR)
b. Fault Icon Placement (FIP)
c. Experimental Tests (ET)
d. Result Analysis (RA)

The FR stage focuses on the method used to determine which 3D metaphors depict industrial robot flaws the best. A set of 2D icons has been chosen to depict the most prevalent defects after first identifying them. Then, in order to be used with the AR system, the 2D set has been transformed into 3D representations. Two distinct placement modalities (non- adaptive and adaptive) for the 3D virtual metaphors have been developed in the FIP stage. The second dynamically inserts the assets in the actual environment, whereas the first relies on the use of pre-determined parameters. The adaptive modality defines the areas not occupied by the manipulator in the FoV of the AR device and calculates the closest free area to the fault location, visible by the user. In the ET step, a comparison with the non-adaptive modality is made in order to evaluate the adaptive modality's efficacy. The RA step has finally finished analyzing the results that have been gathered.

f. Fault Representation:

To make the type of defect in the manipulator instantly evident, a graphical representation of the flaws should be included. Since faults are frequently represented by 2D icons (such as motor vehicle faults, smartphone battery warnings, etc.), it has been determined to select a set of 2D icons that as closely as possible evoke defects on industrial manipulators in order to establish the 3D virtual metaphors. Then, due to the AR device used, a 3D representation has been chosen over the use of a conventional 2D UI made up of a 2D icon dataset. 3D models of the chosen 2D icons have been created. The Fig 9 shows the complete process.

A thorough design technique has been used to determine which 2D symbols best depict industrial manipulator faults:

a. semantic analysis
b. 2D icon design
c. 2D icon selection

A semantic analysis approach has been used to determine the most common robot errors and how they are described in the study literature. By manually extracting the most important robot defect-related utterances, ten separate fault typologies known as base list sentences have been identified. The following procedure has been applied to each element of the base list sentences set:

a. S1: removing of prepositions and articles
b. S2: generation of synonyms
c. S3: generation of word permutations

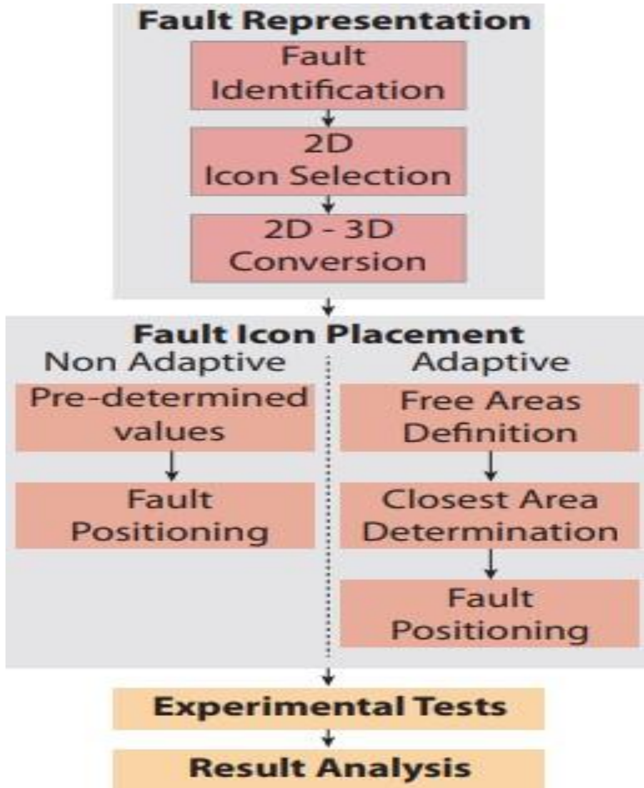

Fig. 9: Flowchart of Augmented Reality

V. OPTICAL MODELLING OF AUGMENTED REALITY

The principles of convex and concave is used in Augmented reality. Concave lenses spread out light rays while convex lenses focus them. For AR we'll be interested in the Convex lens [14]. From the Fig.9 we can arrive Eq.1.

$$1/f = 1/O + 1/i \quad (1)$$

Eq 1: f is the focal length, O is the object distance from the lens, and i is the image distance from the lens.

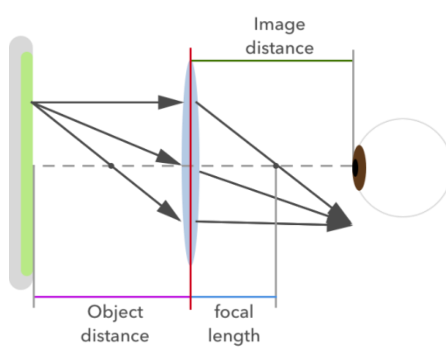

Fig. 9 Vector diagram of Augmented Reality

VI .DETECTION OF FAULT IN ROBOTS USED IN INDUSTRIAL 4.0

AR can improve the performance of the robots in many ways. It is possible to adjust the path of the robots with the help of AR. This technology can also be used to highlight components of an industrial manipulator or to display task information. On a touch-enabled table, a projected list of available programs is displayed. Programs can have data added to them by users to complete tasks. Mal et al. created a wearable AR system to improve various robotic arm partsutilizing various 3D shapes.

Possible faults occurs in robots in industrial 4.0 are defects in the sensors, motors, motors and drives, brake malfunctioning, mechanical construction flaws and overloading issues. The above defects can be reduced with the help of AR. A thorough design technique has been used to determine such faults with the help of semantic analysis,2D icon design,2D icon selection

VII. VISUALIZATION ISSUES IN AUGMENTED REALITY (AR)

a. Visualization Errors:

- Registration errors can be major and unavoidable in some AR systems. An object's measured location in the environment, for instance, might not be known with sufficient accuracy to prevent obvious registration error. Using a probabilistic function to progressively fade away the hidden virtual object along the margins of the occluded zone is another method for presenting virtual objects that should be obscured by real objects reduces the objectionableness of registration failures.

b. Removing real objects from the environment:

More than just gathering depth data from a scene is involved in the issue of deleting real things. In that setting, the system must also be able to segment specific objects. a method that uses silhouettes to semi-automatically identify objects and their locations in a scene. This makes it possible to remove real items and replace them with virtual ones without explicitly reconstructing the environment in three dimensions.

c. Photorealistic Rendering:

The capability to automatically capture the environmental illumination information is a crucial prerequisite for enhancing the rendering quality of virtual objects in AR applications. For instance, a technique is provided that enables the capture of object geometry and appearance using simply an un calibrated camera, followed by the rendering and overlay of augmented reality (AR) into a new scene.

Conclusion

In this paper, the complete and detailed survey of the advances in augmented reality, components of AR, the devices that are used in AR, its application in various fields and the way it can be used to visualize the faults is provided. The role AR is very important in real world and it will change our day to day life. Internet of things , cloud computing, wireless sensor network play a major role to achieve the full potential of AR It is possible to connect mobile devices with Augmented Reality and use it for various application in a better way. Google Glass, Microsoft Hololens and Madgaze can further accelerate the usability and performance of the Augmented Reality.

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