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Augmented Reality- An Exciting Experience of Real World in Future

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Abstract -- **Augmented Reality (AR) is a new technology that combines the view of the real environment with additional virtual content created through computer graphics. Augmented Reality adds, or augments computer-generated graphics, sounds, smell, etc., to the natural world as it exists. This new technology blurs the line between what is real and what is computer-generated. This is achieved by enhancing what we see, hear and feel in the real world, with the help of technologies like computer vision and object recognition. AR also uses computer animation and 3D interaction techniques to bring objects to life. AR is a variation of Virtual Reality (VR). While VR replaces the real world with an artificial world generated by computer, AR only adds computer-simulated effects to the real world, allowing the user to see the real world along with the virtual world superimposed upon it. The biggest advantage of Augmented Reality is in its ability to bridge the gap between the digital and real worlds. Recent studies predicted that in 2014, approximately 864 million mobile phones will be AR-ready. This means AR systems will be everywhere in the world in future. AR systems have the potential to alter the basic nature of our everyday life. This paper aims at describing how AR can be used to make real-world environments computationally interactive and exciting. In particular, this paper discusses how AR systems are going to affect and improve our lives in the future.**

Keywords : **Augmented Reality; Virtual Reality; Computer graphics, Intelligence amplification; Mixed Reality.**

I. INTRODUCTION

Morton Heilig, the "Father of Virtual Reality," invented in 1957, the **Sensorama Machine** [1], a simulator that provides the illusion of reality using a 3-D motion picture with smell, stereo sound, vibrations of the seat, and wind in the hair to create the illusion (Figure1). Over time, the idea of using technology to create a layer over the real world has been refined and put in our palms, with the advent of smart phones. Augmented reality (AR) is a live view of a real-world environment whose elements are *augmented* by computer-generated sensory input such as sound, video, graphics or data obtained from Global Positioning System [11]. AR combines real world environment with computer generated information, thus, *Augmenting* the *reality*. AR is a variation of Virtual Reality (VR). Virtual Reality *replaces* the real world with an artificial world generated by computer, thus making the user immerse in the virtual world. While immersed, the user cannot see the surrounding real world. In contrast, AR only *adds* computer- simulated effects to the real world, allowing the user to see the real world with virtual world superimposed upon it [3]. The virtual objects display information that the user cannot detect directly with his/her senses. It creates the illusion that the virtual and real objects co-exist in the same place. AR uses computer animation to bring objects to life. Information about the surrounding real world becomes interactive and digitally manipulable. Section 2 of this paper presents the criteria required for any AR system, section 3 describes the technology involved, section 4 introduces the software part, section 5 discusses the numerous applications of AR, and section 6 explains the impact of AR on our life in future.

Figure 1: Sensorama Machine
Source: Reference (1)

II. CRITERIA FOR AR SYSTEMS

The goal of Augmented Reality is to enhance our perception of the surroundings by combining sensing, computing and display technologies. Its convincing effect is achieved by ensuring that the virtual content is aligned and registered with the real objects. An AR system is required to fulfill the following three criteria [2].

A. Combining real and virtual worlds

AR requires display technology that allows the user to simultaneously see virtual and real information in a combined view. Traditional displays can show only computer-generated images and are thus insufficient for AR.

B. Registering in 3-D

AR relies on an intimate coupling between the virtual and the real that is based on their geometrical relationship. This makes it possible to render the virtual content with the right placement and 3D perspective with respect to the real.

C. Interacting in real time

Since the real world is three dimensional, AR must support 3D interaction techniques for users to be able to interact beyond merely moving the tracked display. To enable both translation and rotation in 3D, an input device must support at least six degrees of freedom (6DOF) interaction. AR system must run at interactive frame rates, so that it can superimpose information in real-time and allow user interaction.

III. TECHNOLOGY

AR techniques exploit the spatial relationships between the users' synthetic and real environments. There are three key technologies upon which an AR system is built: Tracking, Registration, and Display.

A. Tracking

The system must know the user's viewpoint to retrieve and present related virtual content. More precisely, it must know the position and orientation of the display in a physical coordinate system with known mapping to a virtual one. The objects in the real and virtual worlds must be properly aligned with respect to each other, otherwise, the illusion that the two worlds coexist will not be achieved. The establishment of position and orientation parameters is known as *tracking*. AR system tracks the position and orientation of users' head or hand, so that visual content can be aligned.

B. Registration

Registration is the final alignment of real and virtual information that is presented to the user. The geometrical relationship between the user's viewpoint, the display, and the environment needs to be known accurately. Registration must be made with pixel accuracy at interactive frame rates to preserve the illusion of real and virtual coexisting in the same domain. Registration is directly dependent on tracking accuracy, making AR tracking a very demanding task.

There are many different technologies that can be used to recover the position and/or orientation of users, displays and objects in AR systems. Common techniques use ultrasonic, electromagnetic, optical, or mechanical sensing.

C. Display Systems

Display systems merge the view of the real and virtual worlds since AR systems should allow the user to see a combined view of virtual imagery and real objects. An image plane with virtual imagery can be generated directly on the retina by a laser beam. At the other end of the scale, the image plane coincides with the augmented object. Between these extremes, a display is needed for the image plane. Such a display can be either optical or video see-through and be head-worn, handheld or stationary. There are three classical AR display technologies: Optical See-through, Video See-through and Direct projection display systems [2].

1)Optical See-through displays: Optical see-through displays (figure 2) consist of an optical combiner to mix real and virtual. Light from the real environment passes through an optical combiner such as a half-silvered mirror. The combiner can transmit light from the environment, while also reflecting light from a computer display. The *optically combined* light reaches the user's eyes. Real environment is viewed directly. Factors such as resolution, image quality and system responsiveness do not affect the view of the real environment. But, however, having to reflect projected graphics, these displays reduce the amount of incoming light; hence the real world appears with reduced brightness.

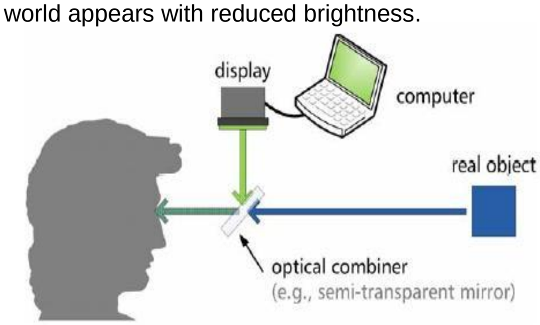

Figure 2: Optical see-through display
Source: Reference (2)

2)Video See-Through Displays: Video see-through displays (figure 4) consist of an opaque screen aligned with a video camera. The view of the real environment is acquired by a camera; it is then combined with virtual imagery by a computer. The combined video is presented to the user on a computer display. Head-worn displays can use video see-through techniques by placing cameras close to the eye positions. Camera-equipped mobile phones are particularly attractive devices for AR. The camera on the back of the device captures video of the real environment, which is used by software on the device to recover the phone's pose relative to tracked features in the environment. This makes it possible to render 3D objects that are registered with the real environment, overlaid on the video that is shown on the phone's display [2].

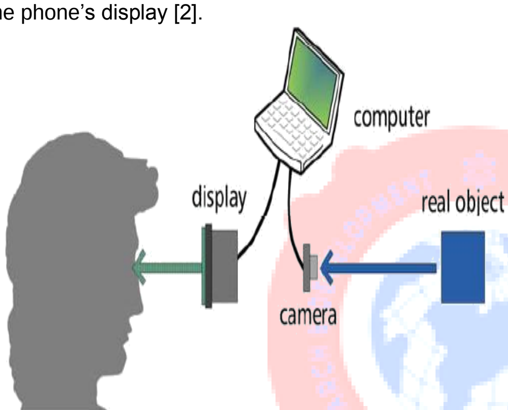

Figure 3: Video see-through display
Source: Reference (2)

3)*Projection-Based Systems:* Augmentation can also be achieved by directly projecting graphics onto the real environment. Projection-based systems (figure 4) use the real world as display by projecting graphics onto it. This makes them good at providing a large field of view. Projector based AR is also well suited to multiple user situations. Alignment of projectors and the projection surfaces are critical for successful applications.

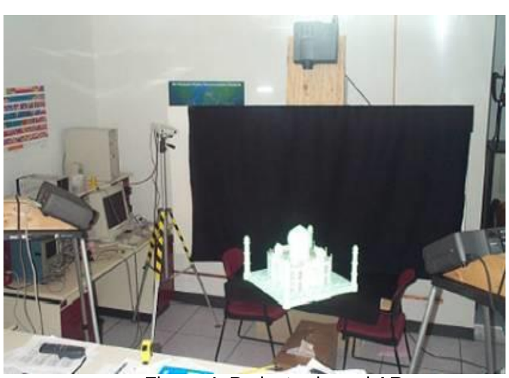

Figure 4: Projector-based AR
Source: web.media.mit.edu/~raskar/Shaderlamps/Taj

4)Display Devices: The display hardware used in all these systems can be *head-worn*, *handheld* or *spatial* [4].

i) A head-mounted display (HMD) is worn as a pair of "glasses". This enables bi-manual interaction since both users' hands are free; for many industrial and military applications, this property makes HMDs the only alternative. In mobile/wearable applications they are the dominant display type (Ex. retinal displays, Google Glass).

ii) A handheld display is used as a magic lens, magnifying information content. Mobile phones with camera are being used for handheld displays (Ex. mobile phone displays and projectors).

iii) Stationary displays act as "windows" facing the augmented world. Since they are stationary, no tracking of the display itself is required. Stationary displays range from PC monitors to advanced 3D spatial displays. A simple approach to AR is to connect a web-cam to a PC and augment the video stream. Projectors can be used to augment a large area without requiring the users to wear any equipment (displays or projectors in the environment).

IV. SOFTWARE AND ALGORITHMS

A key measure of AR systems is *image registration* which describes how realistically they integrate augmentations with the real world. The software must derive real world coordinates from camera images. I*mage registration* uses different methods of computer vision. Usually these methods consist of two parts.

First stage detects *points of interest*, in the camera images. It uses image processing methods like corner detection, blob detection, edge detection or thresholding. The second stage restores a real world coordinate system from the data obtained in the first stage. Some methods assume objects with known geometry present in the scene. If part of the scene is unknown, Simultaneous Localization and Mapping (SLAM) can map relative positions. If no information about scene geometry is available, structure from motion methods are used.

Mathematical methods used in the second stage include geometric algebra, projective geometry, and rotation representation with exponential map, nonlinear optimization, and robust statistics.

V. APPLICATIONS

Augmented Reality technology has many applications in a wide range of fields that include Entertainment, Education, Medicine, Defense, Sports, Tourism, Engineering and Manufacturing, etc [5]. Several AR *apps* (*app* is a short form of *application* - a software program) are already in wide spread use in these areas.

A. Medical

Most of the medical applications deal with image guided surgery. A 3D model is created from the multiple views of CT, or MRI. 3D sensed data can be studied for surgical paths to be followed by a surgeon or a robot. With AR, the model is then projected over the target surface (patient's body). The surgical team can see the CT or MRI data correctly registered on the patient in the operating theatre while the operation is progressing (Figure 5).This enables them to accurately register the image during the operation, and thus enhance the performance of the surgical team. In the future, real-time sensing and registration can be used for feedback in the process.

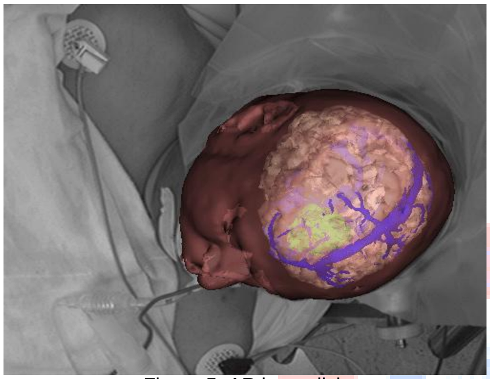

Figure 5: AR in medicine
Source: www.cs.rochester.edu/~brown/Images/brain_ar.gif

B. Defense

AR helps military by providing crucial information such as movement of friendly & enemy troops in the proximity to field soldiers. Air Force has been using displays in cockpit that present information to the pilot on the windshield. Army trainees can directly interact with simulated data overlaid on the physical. In wartime, display of the real battlefield scene could be augmented with annotation information to emphasize hidden enemy units.

C. Entertainment

Games, Movies and Weather reports are extensively using AR where synthetic objects are combined with real objects (Figure 6).

Figure 6: Game using a real table and augmented objects Source: Ref: 4

D. Sports

A form of Augmented Reality is widely used in sports broadcasting. For example, the colored trail showing location and direction of the puck in TV broadcasts of hockey games, or even the distances plotted from the ball to the flag in a golf broadcast, etc.

E. Tourism

Augmented Reality will form the backbone of next generation audio visual guides and visitor experiences. AR uses technology to engage the visitor in a natural way. AR browsers *attach* information to the art pieces in the museums etc., which makes the experience interesting**.**

F. Business

Many companies are using AR as their promotional tool. Users can browse the stores virtually, using their smart phones. Using AR, people can pass their waiting time at parks and airports and turn them as shopping destinations, which is a smart way for businesses. Technology allows shoppers to virtually wear garments, try their products — smelling, hearing and feeling the product as if it were real.

VI. IMPACT OF AR

Augmented Reality – as both a concept and an emerging technological field, has the potential to impact our future. It presents an interactive framework that has the potential to constructively affect all aspects of routine life. Indeed, a recent study by **Semico Research** predicted that by the end of 2016, revenue produced by the AR Industry will total more than $600 billion. This study also determined that in 2014, approximately 864 million mobile phones will be AR-ready, and in excess of 100 million vehicles will come equipped with AR technology [8]. In this section, we describe how AR systems will become indispensible in our lives, while introducing some of the existing AR *apps* that are developed by various companies. We trace how our day-to-day works become easier and exciting with the help of AR.

A. Learning driving

Car navigation systems that merge AR with a Heads-Up Display unit combine projected mapping and navigational data on a plastic sleeve mounted before the driver-side windshield

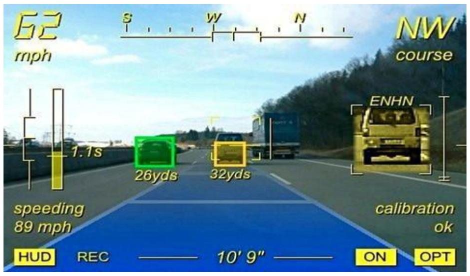

Figure 7: AR helping people while driving
Source: www.zdnet.com

B. Locating nearby stations in a new city

There are some *apps* that help users finding the nearest railway stations. (Ex: Next Tube is an *app* that provides information about stations nearest to London subway. When held flat, the app displays arrows indicating the nearest stop for each of the 13 tube lines in London. When held up vertically, icons pop-up displaying more information about these stations and their location.) *Apps* like this help us in finding nearby stations when we are in a new city.

C. Shopping

Shopping with AR will result in sophisticated immersive experiences. Augmented reality lets its users browse a virtual catalog of clothes from their favorite brands, shop directly within an AR magazine or head to a virtual pop-up store and avoid the queue lines [10]. People can even *feel* these items through their phones.

D. Travel and History

AR provides inexpensive "travel" options, where a user need not be physically present at the sites, yet experiencing the real travel. AR can provide *trips around the world*, adds information to the monuments, and lets a person even pose for a picture at the places of interest. Using AR in this way would be a great experience at home and in classrooms.

E. Customer Service

Future AR *apps* can let the support team access the user's camera, so the support team can in real-time give instructions through the camera. So, instead of depending only on audio instructions, now, users can get the virtual presence of support team. AR enables the customer service person to point things out in more detailed, visual way and helping the problems get solved in a more efficient manner.

F. Safety and Rescue Operations

During emergency situations, first responders, police and firefighters often need to understand the environment and navigate to a place where they have never been. AR lets them see a virtual map of the site and also have "X-ray vision" to see hidden things like underground water and power lines.

G. Moving to a new location

AR can help any person while in a foreign environment, showing and giving directions to nearby places of interest such as a coffee shop, restaurant or museum.

H. Home decoration

Augmented reality brings a whole new way about the transportation of physical goods — they can be previewed as real goods before we actually move them (figure 8). Using the cell phones, people can search through an app and select the furniture for their home and virtually position them in their home so they can decide whether they would actually fit — all *before* they go to the store and pay.

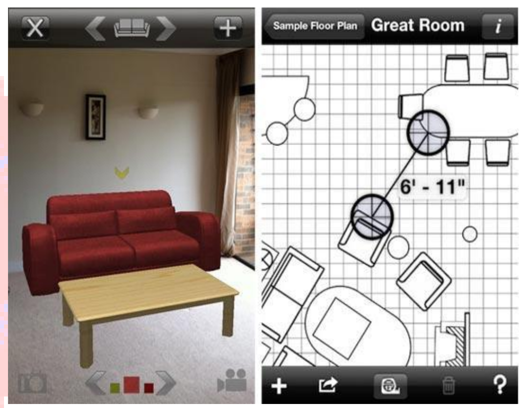

Figure 8: A real room with a virtual/augmented sofa Source: www.apartmenttherapy.com

I. Health

Medical implementations of AR include visualization techniques for patients undergoing invasive surgery. AR may even enable surgeons to detect key medical data with a naked eye. For example, information about exact location to drill a hole into the skull, or information about heart blockage, while performing surgery. Experimental *apps* are available for correcting color-blindness, and for self-diagnosis.

VII. DEMERITS OF AR

Though AR has many applications and advantages, it also comes along with a few disadvantages such as follows.

Lack of privacy:

The content shared by people on social-networking sites becomes easily accessible to complete strangers.

Still new:

A lot more research needs to be done in this field for it to be widely-used.

Missing real world:

Using AR devies and technology for more period of time makes the user miss what is present right in front of him (the real world).

VIII. CONCLUSIONS

Augmented Reality is a new technology that blurs the line between what is real and what is computer-generated [6]. Both video games and cell phones are helping the development of augmented reality. It presents an interactive framework that has the potential to constructively affect all aspects of routine life. AR has been intensively researched over several decades and is all set to reach the broad audience.

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