AN OVERVIEW OF AUGMENTED REALITY

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ABSTRACT

Augmented Reality (AR) is a technology that creates an enhanced version of the real world by augmenting it with digital content (such as images, text, audio, and video), thereby enriching the user's sensory experience of their environment. This paper provides a comprehensive overview of AR technology. It distinguishes AR from Virtual Reality (VR) and traces their historical evolution. The study systematically reviews literature to explain AR's working methodology, types, and enabling technologies. The findings reveal that while AR has diverse applications across industries, its proliferation is driven by advances in sensors and processing power, though accurate tracking remains a key challenge. The review recommends integrating AR with other advanced technological developments to yield superior outcomes in future application.

Keywords: AR, artificial, real world, technology, virtual, VR.

1 INTRODUCTION

AR is a technology that combines virtual information with the real world. It superimposes digital contents on the real-world view to enhance the experience of reality [1]. In other words, it provides an improved version of reality [2, 3, 4, 5]. VR is a simulated computer-generated world. It is a fully immersive technology that takes place in a virtual/synthetic world. AR is a partially immersive technology that combines the real world with virtual contents [3, 6, 7, 8, 9]. AR supplements reality whereas VR completely replaces reality. The concept of AR and VR can be clearly explained using Paul Milgram and Fumio Kishino's Reality-Virtuality Continuum [5, 10, 11, 12] as shown in Figure 1. One end of the continuum is the real world and the other end is the virtual environment. The middle region is called Mixed Reality. AR is a subset of Mixed Reality [13, 14]. It lies near the real world, with the predominate perception being the real world augmented by computer-generated data. The term AV was coined by Milgram to identify systems that are mostly synthetic with some real-world imagery added [3]. The availability of devices such as high resolution cameras – which enables accurate image and object identification; high performing processors – which enables faster and reliable image processing and feature extraction; large and cheap amount of memory – for storage of object information; high definition displays – which enables superimposition of clearer images; and high speed broadband, wireless, and wired networking technologies – which enables speedy retrieval of information from AR servers and database for display on the smart devices [15], contributed a lot to the technological advancement in the field of AR. The major challenges of AR are sensing errors and registration issues [1, 9, 16]. The main AR devices are displays (e.g. head mounted display, handheld display, spatial/projection display, etc.); input devices (e.g. smartphones, gloves, wireless wristband, natural gesture, etc); tracking/registration devices (e.g. digital camera, sensors, GPS, accelerometers, solid state compass, etc); and computers/smart devices with powerful CPU and considerable amount of RAM [4, 5, 9, 17, 18, 19].

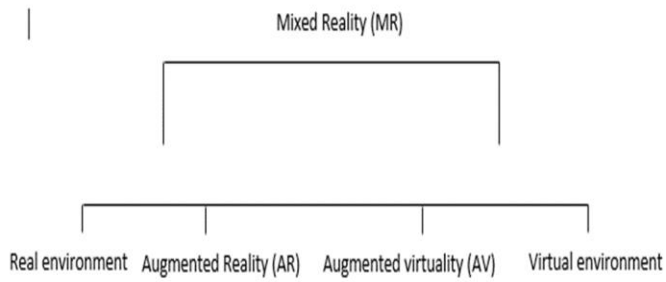

Figure 1. Milgram's Reality-Virtuality Continuum [3, 10, 12]

2 EVOLUTION OF VR AND AR

The historical journey of VR and AR started several decades ago. It started in 1838 when Charles Wheatstone invented the stereoscope. In 1957, Morton Heilig invented the first VR device called the Sensorama. In 1968, Ivan Sutherland and Bob Sproul invented the head mounted display system called the Sword of Damocles. In 1974, Myron Krueger built an AR laboratory known as Video place. In 1987, Jaron Lanier coined the term VR. In 1990, the term AR was coined by Boeing researchers Thomas Caudell and David Mizell. In 1992, Louis Rosenburg created an AR system called Virtual Fixtures for U.S air force. In 1994, Julie Martin created the first AR theatre production called Dancing in Cyberspace. In 1999, Naval researchers started working on Battlefield Augmented Reality System (BARS). In 2000, Hirokazu Kato created an AR Toolkit – an open-source software library. In 2004, Trimble Navigation presented an outdoor helmet-mounted AR system. In 2008, Wikitude made the AR travel guide for Android mobile devices. In 2013, car manufacturers began using AR for getting technical assistance. In 2014, Google launched the Google Glass – which marks the beginning of wearable AR trend. In 2016, Microsoft introduces HoloLens. In 2017, Snapchat launched its AR Lenses, Apple launched ARKit and Google launched ARCore [4, 5, 13, 20, 21, 22].

3 VIRTUAL REALITY

VR technology completely immerses a user in a synthetic environment. Thus, the user cannot see the real world [7, 23, 24]. VR uses VR headset such as, Oculus Rift S, PlayStation VR, etc., to create simulated environment. But there are devices that work with a smartphone, e.g., Google Cardboard. The simulated environment is totally different from reality, but one can perceive it as reality. The distinct characteristics of VR are [19, 25, 26]: Interaction – which refers to the natural interaction between the user and the virtual scenes. Immersion – the feeling acquired by the users, as if they are part of the virtual world. Imagination - refers to the use of multi-dimensional perception information provided by VR scenes to acquire the same feelings as the real world.

4 AUGMENTED REALITY

AR technology combines virtual information with the real world. It is a combination of the real scene viewed by the user and a virtual scene generated by the computer. Basically, it creates an augmented/enhanced version of reality by superimposing digital information (like text, images, sound, etc) onto the real world [27, 28, 29]. This can be done using AR apps in smartphones. Using AR technology, the virtual objects seem to coexist in the same space as the real world. AR is not limited to sense of sight, it potentially applies to other senses (such as hearing, touch, and smell). Apart from adding objects to a real environment, AR has the capability to remove objects from the real environment [2]. This is referred to as mediated or diminished reality [18, 19]. The characteristics of AR systems are [1, 2, 9, 10, 30]: Combining real and virtual objects in the real environment. Interactivity in real-time. Registered in 3D – seamlessly align virtual and real objects.

4.1 AR Enabling Technologies

The AR enabling technologies are those advanced basic technologies that are needed to build compelling AR environments, i.e., they make AR possible [19]. They are the backbone on which all developments and advancement rely. Examples of these technologies are: Display Technology, Tracking and Registration Technology, Interaction Technology.

4.1.1 Display Technology

They are categorized into Headworn, Handheld, and Spatial/Projective displays. In the Headworn displays, the users mount the displays on the head or as part of a helmet. In the Handheld display, the users can hold and operate in the hands e.g., smartphones, tablets, etc. The spatial/projective displays do not require a user to hold or wear the display. It makes use of video projectors, holograms, optical elements and other tracking technologies to display graphical information onto physical objects e.g., wall [5, 18].

4.1.2 Tracking and Registration Technology

This enables the virtual objects to be accurately superimposed onto the real environment. This can be achieved through the use of hardware trackers (e.g., sensors), computer vision, or mixed registration technology [17, 31].

4.1.3 Interaction Technology

These enables intuitive interaction between the user and the virtual objects in the real scene. User interaction can be via haptic (touch), gesture (eye gaze), voice (speech), etc.

4.2 Types of AR

There are different types of AR. They include [13, 20, 32, 33]: Marker-based AR, Marker-less AR, Projection AR, Superimposition based AR.

4.2.1 Marker-based AR

This type of AR is also called Image Recognition or Recognition based AR. It detects the object in front of the camera and based on the marker provides a 3D image on the screen.

4.2.2 Marker-less AR

This type of AR is also called Location-based or Position-based AR. It makes use of data from the mobile's GPS, digital compass, and accelerometer to provide information on the user's focus. This method is the most widely used [34].

4.2.3 Projection AR

It is the simplest form of AR, that use light to project a virtual image. The method can be used to create deception about the position, orientation, and depth of an object.

4.2.4 Superimposition based AR

This form of AR provides a replacement view of the focused object with an augmented view.

4.3 How AR works

AR works in conjunction with headsets and/or digital devices such as: tablets, smartphones, smart glasses, or PCs. The AR software uses computer vision or location-based services (e.g., GPS) to process the video stream captured by the camera and to recognize objects in the environment. The digital devices then compare the data from the camera to other data, usually image-based data stored in a database. The system pulls data from the web-based sources and overlay on the real environment [4].

4.4 Tracking in AR systems

Tracking is the process of obtaining the geometric relationship between the users' viewpoint or position, the display, and the environment, to enable accurate alignment of the real and virtual world [35]. It is an important aspect of AR system. The performance of an AR system is often determined by the performance of the tracking technology. There are different categories of tracking techniques. They include [16, 31, 36, 37]: Sensor-based – which uses sensors such as magnetic, inertial, acoustic, mechanical, optical, etc to track the position ad orientation of a camera (camera pose). Each sensor has merits and demerits. Vision-based – which is based on image processing principles. Hybrid – which combines several sensors and vision technologies. The technique tends to be more efficient, but complex and costly. In AR, tracking methods mostly depends on the type of environment (Indoor, outdoor, or combination of both) the device will be subjected to and the type of AR system - mobile or static [5] in use. Accurate and robust tracking is still a significant challenge in AR technology, as evidenced in the field of AR surgical navigation [38].

4.5 Application areas

There are variety of areas that are adopting the application of AR. They include [9, 17, 18, 27, 33, 39, 40, 41, 42]: Medical/Healthcare – for training, surgery, and diagnosis. Pharmaceuticals – for visualizing complex molecule structure in drug formation process. Retail – for visual merchandising purpose, retail showcasing, and to provide a better shopping experience. Education – for visual illustrations and enabling more engaging and interactive learning. Entertainment – for entertainment and gaming purposes. Travel – for tourism and navigation purposes. Logistics – to increase efficiency and reduce transportation/ warehousing cost. Manufacturing – for assembly process, fast prototyping, training, maintenance and repair. Military (Defence) – for training purpose.

5 CONCLUSIONS

In recent years, AR technology has attracted extensive attention from researchers. It is increasingly being adopted for a variety of uses. The technology has truly enhanced the way people interact with the real world, making it more fun and engaging. AR technology is being driven by the technological advancement in the field of computer vision and Artificial Intelligence. The integration of AR technology and smart wearable devices with advanced technological developments like AI/ML, IoT, Haptic technology, 5G and Edge computing, is expected to yield a better outcome in different application areas in the future.

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