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A COMPREHENSIVE STUDY ON EXTENDED REALITY TECHNOLOGY, ITS COMPLEXITIES, AND ITS APPLICATIONS IN VARIOUS SECTORS.

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Abstract : In today's rapidly changing world, advancements in technology have also evolved to fulfill the demands of high-performance communication and agile computations. The advent of emerging technologies like Extended Reality (XR), which is the catchphrase for all immersive and real-world virtual environments, encompasses features of the technologies like Augmented Reality (AR) and Virtual Reality (VR). The objective of this paper is to study the various underlying applications of extended realities, their complexities, and their use cases in the real world. Our core interest will be on two sub-themes, the first being the understanding of the mechanism of these current existing technologies, and the second one, being equally crucial, discussing the characteristics and applications of these technologies in various fields like education, entertainment, etc. and at last, navigate the prospects of these technologies.

Index Terms **- Augmented reality, extended reality, virtual reality, semantics, meta-verse, industry 4.0**

I. INTRODUCTION

"Extended Reality" or, simply "XR" is a universal term that encapsulates various immersive technologies like Augmented reality (AR), Virtual reality (VR), Mixed Reality (MR), and several other technologies which are still to be created. It is named in such a way because it extends reality by stimulating or adding various powerful computational techniques. The technologies use the process of blending the "mixes" of both worlds, i.e., the "Virtual world" and the "Real-world", to generate a holistic and immersive view of the visuals presented.

Imagine a world where we could unconsciously perceive elements and objects while interacting with them through speeches and gestures. This vision could now be achieved with the help of technologies like AR and VR. Augmented Reality and Virtual Reality are the technology that aims to create a next-generation reality-based technique that implements Digital or Virtual information.

1.1 Definition

While both Augmented reality and Virtual reality bring up a simulated environment, intermixing these mechanisms is very much possible. However, both have different underlying significant features and encompass different use cases.

a) Augmented Reality

- Augmented reality augments physical elements into a digital world and partially creates an artificial virtual environment.
- Aligns and Blends Virtual and Real objects.
- Runs concordantly in real-time and is interactive.
- The presence of AR is controlled by users.
- AR is a Quarter virtual, and Three-Quarter real.

b) Virtual Reality

- Virtual Reality is a computer-generated driven simulation, which tries to replace a real-world environment with an entirely simulated one.
- These Virtual environments are often fabricated in such a way that it is often created for Larger-than-life experiences.

- It helps to create immersive simulations and can almost bring any thinkable real-world environment into a virtual one.
- The presence of VR is often controlled by the systems.
- VR is Three-Quarters Virtual, and a Quarter virtual.

II. HISTORY

The first appearance of nearly functioning AR and VR was hinted back in the 1800s when scientist Sir Charles Wheatstone highlighted the concept of "Binocular Vision" and "Stereopsis", where the brain merged one image, each from one eye to generate a single 3D image (Bernard Marr, 2021). Since then, the idea of Stereoscopic lenses and displays has been used in modern VR sets to add depth to images. After this, across the 1950s, 60s, and 70s we began to see these technologies in action. In 1956, a cinematographer named Morton Heilig developed "Sensorama", The first VR machine. Heilig then proceeded to patent the first Head-mounted Display (HMD), combining stereo sound with 3D images (Ana Jovornik,2016). Based on this idea, A team of engineers from Philco created VR set in 1961 for military purposes with motion-tracking capabilities and became the first to feature this. Also, in the same year i.e. 1960-61, a computer scientist named Ivan Sutherland presented a paper citing his concept of "Ultimate-Display", and this was considered the blueprint of modern ARs & VRs.

In 1968, he went on to create his AR-VR headset and named it "The Sword of Damocles" (Bridget Poetkar,2019). The idea then quickly spread to many fields. Fast forwarding to 2000-2020, we could see a massive improvement in this segment, with the introduction of Google Street View, The VR headset creation company called "Occult VR" Snapchat, Facebook, and Instagram filters, Google's Cardboard VR viewer, Microsoft's HoloLens, the very popular POKEMON game, etc.

III. MECHANISM

3.1 Internal Processing

The driving force behind these technologies is unique and most of them at the least are powered by different capabilities of SDKs. *Software Development Kits(SDKs)* are bundles of handy tools which are used by developers to create realistic AR/VR applications and software (Luca,2018).

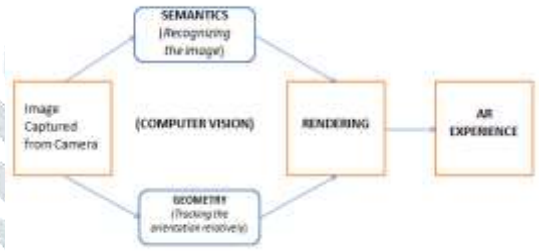

Fig.1: Generation of AR content

i. Firstly, the process starts with Computer Vision. Computer Vision comprehends the environment around users and generates the digital content of the object the user is currently looking at. In this, the raw image is generated, which triggers the image of the object. This digital content is then made to look like a real-world simulation through the process of-Rendering.

ii. Rendering, the second part of the process, augments the primary frames, i.e., the original frames, and ensures a precise and accurate overlapping of structures. This is done with the help of Three-dimensional positioning and orientation systems.

iii. Internal processing of computer vision includes two main traditional approaches, the first is *Semantics*, which identifies the object, and the second is *Geometry*, which looks after the accurate positioning of the object in the 3D world (Program-Ace,2021).

3.2 Displaying of AR & VR content

The enabling technologies of AR & VR are much higher compared to other technologies. However, its key components remain the same since the laying of its blueprint from Ivan Sutherland's work in the 1960s.
Graphic computers, Trackers, and Displays are essential to building these systems. The new additions, being, Real-time sensors, GPS positioning systems, and orientation control systems are introduced to increase its capabilities further (TaoZhan, KunYin, JianghaoXiong, ZiqianHe, Shin-TsonWu,2020). A few of the technologies are-

i. Displays:
Aural displays, True 3D aural displays, Visual Displays, Video see-through,
Optical see-through, Projective Displays, Immersive Headsets, Immersive Walls, and Immersive Hemispheres (Recro, 2019).

Positioning of AR/VR displays may be classified into three categories:

- Head-Worn, for example, "Head-mounted display"
- Hand-held, which includes "Heads-held projector displays", as well as "see-through displays".
- Spatial Displays, for example, "Heads-up Display(HUD)" in games and military purpose.

ii. Approaches for Tracking sensors

Before an AR/VR system displays the content, it must be able to track and sense the movements of objects (D.W.F. van Krevelen and R. Poelman,2010). The following are approaches used frequently in the implementation of these mechanisms:

- Modeling Environments.
- User-Movement Tracking. (Magnetic, Ultra-sonic, Mechanical)
- Global positioning systems (GPS).
- Radio.
- Inertial Sensors.
- Optical Sensors. And, at last,
- Hybrid Tracking systems.

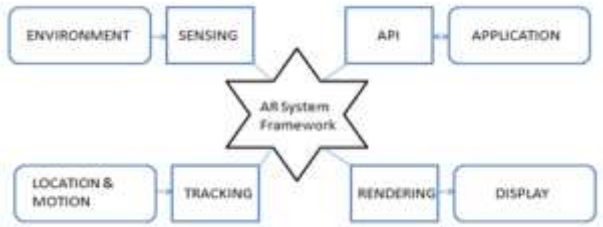

Fig.2: Generic AR system framework

IV. APPLICATIONS

In recent years, Extended Reality has offered its users tremendous possibilities in the industrial sectors. These technologies have also gained attraction due to their multi-faceted properties. The use of these technologies has so far been used in the Entertainment industry only, for example, Movie-viewing experience, and gaming. However, it holds several other applications in various other sectors too, many of which still needs to be explored. It has found its initial applications in the Gaming, Entertainment industry, Medicinal Purposes, Automobile and Manufacturing units, Annotations and Visualization, Military & Defense, and Robotics, followed by new areas such as Education and teaching, Tourism sector, Architecture, and so on (E.Jonietz ,2007).

4.1 Entertainment

The entertainment sector is one of the key drivers of extended reality technologies in the industry. AR and VR technologies are used in various ways in this sector. From playing movies on HMDs to experiencing rich and immersive 3-D, 4-D, and 5-D cinematic experiences, XR technologies proved to be the biggest innovation in this sector. VR enables the creators to create real-time motion-captured animated content. Creators also use platforms such as Facebook, YouTube, and Twitch to live-stream their content and interact with the audience. Apart from this, AR/VR is used extensively in Sports Entertainment as well. Displaying vital information about sports, Real-time capturing of data, and Rendering images of fields, and players' statistics, thus, enhancing the overall viewing experience are some crucial applications of XR technologies. It is also often used in the marketing industry by marketers to promote brands, and products engagingly (Sophie Thompson,2022).

4.2 Healthcare

AR/VR technology is making a significant impact on the healthcare sector. Healthcare professionals are now using these technologies through various possible use cases in this field be it training, educating, demonstrating, etc. Not only these technologies would aid in student education purposes, but they would also impact significantly patients' treatment through enhanced techniques. Owing to the high costs, safety, and complexities of medical education, emerging technology like that AR and VR technologies are used to stimulate these environments virtually so that students could grasp the concepts in an an efficient way. Not only this but medical tools and apparatus are also implemented and demonstrated through the help of AR/VR technologies. For example, Healthcare workers can use VR systems to better understand operation theaters, or, Senior doctors can teach the complexities and details of Human Physiology to juniors and practice medical operations on virtual bodies and help them attain proficiency in it. A few more applications of Extended Realities in this sector are Visualization of Human anatomy, Laparoscopic procedures, and pieces of training, etc. (Design Tech,2015)

4.3 Retail

In recent times, the way brands promote their products, and the way customer purchases it has drastically changed. With the advent of XR technologies, consumers could now test the products without even purchasing them, or moving into the retail store. This has proved to be the biggest innovation in the field of the Retail Industry. Various brands are now experimenting with VR shopping because not only is it time-efficient, but it's also more sustainable and richer in experience. Some Furniture brands are now leveraging the power of AR & VR which enables consumers to choose suitable furniture and experience in their homes. This

has also been proven useful in the clothing and styling industry as well. Popular working examples of AR/VR technologies are Lenskart, Myntra clothing, etc.

4.4 Architecture and interior designing

The architecture and interior designing business are gradually changing. With the introduction of AR/VR, designers, and architects are now leveraging these technologies to benefit their businesses. The most prominent feature of VR in this sector is the "Presentation of designs". This helps clients and customers to feel the designs or, products more closely, and the designer to implement changes in the prototype rather than implementing it actually, thus saving a significant amount of Cost, Time, and Reduced errors. The ability to present designs with AR as 3-D models of actual versions is also a popular use case. Some more use cases of it are Virtual tours of interior designs, Real-time collaboration between multiple designers, etc. (Elena Canorea,2022)

4.5 Automobile

The Automobile sector also includes various use cases of extended reality technologies. VR helps automobile designers and engineers to build an immersive prototype of vehicles and based on this prototype, build the desired product, thus saving time and cost. It can also be used to demonstrate product specifications to customers by replacing cumbersome manuals with "AR specifications and instructions". It thus helps engineers in the process of manufacturing and maintenance of vehicles more efficiently. Companies like BMW have started using these technologies in the designing phase to ensure that the product passes through various early design reviews and obscurations associated with them (Carolien Kamphuis, Esther Barsom, Marlies Schijven & Noor Christoph,2014)

4.6 Gaming

The gaming industry was one of the first in the line to witness the advent of Extended Reality technology. As AR/VR completely immerses the experience, gaming companies are putting a high stake in these cutting-edge technologies. It is flourishing at a rapid pace. The market cap for AR/VR in the gaming industry is expected to be a massive $11 billion by 2026, scaling at a CAGR growth rate of 18.5% in the span of five years (2021-2026) (IndustryARC,2021). Game Developers have now shown a keen interest in developing AR/VR-supported games as they attract a large audience due to their rich and immersive nature. From the audience's point of view, the games are visually appealing, offer players to play in a real-time environment, enhance user engagement among players, etc.(Jyoti Gupta,2019).

V. Areas of Concern

The transformation of Extended reality technologies has changed the way we operate products and businesses. But in this process, is adopting these emerging technologies an easy task? Analogous to every technology, XR technologies also have some concerns attached to them. Some of them are:-

- XR technologies market is fragmented at the moment. HMDs usually differ in functionalities and are also costlier. XR tech is still early in age and supporting devices usually are not in-situ with standard procedures, i.e., some are platform dependent.
- It is still a costly business to implement XR technologies. Content creation is customized, and sometimes expensive. It is fairly new in the industry and lacks the supervision of senior developers.
- AR/VR is becoming quite an isolating experience, favoring escapism, and is proving to be contradictory, since the whole idea of technology is to bring people together and not distance them away. Moreover, the lack of privacy also needs to be worked on.
- The low-performance level is still a concern to be worked on. Basic learning of AR devices is also required to operate them, which takes time to configure, slow to initiate. Apart from this, it is only applicable to some specific businesses and industries and not applicable to a wide range of sectors (Jorge Azurdy,2020).

VI. Future scope

The digital wave has now proliferated in every industry. With the gradual surge in technologies like Internet-of-things (IoT) and automation techniques, technologies like Augmented Reality, and Virtual Reality have now emerged as eminent players in the field of New-Era Technologies and drive a wide range of applications as well. These technologies have not only attracted the general public but have gained significant interest from investors too. These technologies are also expected to play a significant role as frontiers in the upcoming "Meta-verse" Or "Industry 4.0". Although AR/VR is popular in the entertainment and gaming industry, it has a vast potential to transform other sectors such as education, tourism, etc., as well.

VII. Conclusion

We surveyed these emerging technologies, applications, and limitations related to Extended Reality. although we know that both Augmented and Virtual reality work on the same fundamental principle, i.e., Immersing the environment with virtual information, both systems have their own working mechanism, and most importantly, have different use cases attached to them. There is still, some room for improvement in its functionalities, and thanks to new-era technologies, it is still possible that these may be corrected with time. Extended Reality is becoming more widespread and cheaper. We can thus, expect vast innovations in these technologies in the near future.

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