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Definitions and Applications of Augmented/Virtual Reality: A Survey

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ABSTRACT

Reality is shaped differently in software environments through Virtual Reality VR and augmented Reality AR, it has a remarkable position and an important background with its role of ensuring contact between the software environment and the user. It was popular in the entertainment sector, in particularly industry, but over time, it becomes apparent that there would be a much greater need for VR/AR technologies in different areas dealing with tasks/issues in the real world. In This article we provide an overview of virtual and augmented reality systems and their principal domains of applications.

Key words : Virtual reality. Augmented reality, Mixed Reality, 3D

1. INTRODUCTION

Augmented Reality (AR) and Virtual Reality (VR) technologies are increasingly popular, as the hardware and software evolve and make them accessible for a wide range of applications. They have been applied to different areas because of their potential to enhance user experiences on learning, training, simulating, playing games or other tasks [1]. The motivation for this technology varies from application to application, but mostly it provides the user with additional information that he cannot obtain using only his senses. Because AR/VR technologies have the potential to address different problems; reputed corporations such as Google, IBM, Sony, HP and many universities have put their efforts to develop it. AR/VR is suitable for applications in almost every subject, especially physics, chemistry, biology, mathematics, history, astronomy, medicine, and even music. These big companies are working to develop suitable technologic devices that can accommodate to any of these subjects and that can ultimately impact the user's life.

The point of this paper is to introduce the idea of Augmented and Virtual Reality and a rundown of the methodologies utilized for this strategy. AR/VR is a strategy that superimposes 3D virtual items into the client's current circumstance progressively. We break down the specialized necessities that are tended to furnish the client with the best AR/VR experience of his encompassing setting. We likewise consider the explicitness of specific spaces and how AR/VR systems communicate with them. The reason for this overview is to introduce state-of-the-art in augmented and virtual reality.

The first section of this paper is devoted to the definitions of these different terminologies, while the second section is dedicated to different uses for the virtual and augmented reality systems in various industrial fields of activity. In the third section we present a limitations of VR/AR devices.

2. DEFINITIONS

2.1 Virtual Reality

Virtual reality can generally be defined as a virtual object in a virtual environment [2], more precisely a simulation or an artificial recreation, computer-generated, real-life environment or situation, immersing the user by giving him the impression of experiencing simulated reality first hand, mainly by stimulating his vision and hearing. A good virtual reality system called The "virtual environment" (VE) will allow users to physically walk around the objects and to touch these objects as if they were real, that is to say an environment in which can be navigated and possibly interacted with, resulting in a simulation in time of one or more of the five senses of the user who is completely immersed in the real world.

Ivan Sutherland, developer of one of the first virtual reality systems in the world, said: "The ultimate display would, of course, be a room in which the computer can control the existence of matter. A chair exposed in such a room would be good enough to sit down. The handcuffs exposed in such a room would be confident, and a ball displayed in such a room would be fatal" [3]. However, let's define the term more precisely. According to [3], the virtual is defined as being the essence or the effect, but not the reality, reality is defined as something that constitutes something real or effective, as opposed to something merely apparent; something that exists independently of the ideas that conceive it, while the virtual reality is defined as an environment created by computers with which one can communicate as if this environment were real.

It is described as a virtual worlds that exist only in computers and minds. A good system for VR would allow users to navigate around objects physically and touch these objects as if they were real.

Eventually, virtual reality can be classified into two different types: **non-immersive** and **immersive** virtual reality, non-immersive VR is a computer simulation of the real world, while immersive VR adds dimensions of immersion, interactivity and user involvement to the former, completely detaching the user from his environment in the simulated reality with a head-mounted device replacing the real world. [4].

2.2 Augmented Reality

The word "augmented reality" was first coined at Boeing in 1990 by the researcher Tom Caudell, who was asked to develop the costly labeling equipment diagrams and devices used to direct employees through the plant [6]. He proposed to replace large plywood panels that contained wiring instructions individually designed for each aircraft, by a head-mounted device that displays the specific drawings of an aircraft thanks to high-tech glasses and projects them on multi-purpose and reusable panels[5], Since that time, AR has been used to enhance user experience in different tasks as it is a technology that overlays computer-generated improvements to an existing reality to make it more realistic significant thanks to the ability to interact with it [6], In other words, the technique of the Augmented Reality (AR) is the combination of real reality and virtual addition to it.

AR covers a form of spatially recorded increase over the physical world. The user can see in real time the world around him, composed of virtual objects. These virtual objects are integrated into the user's world using portable devices. The real-time interactive technology; gives the user the feeling that virtual objects exist among real objects, as if he is in the physical world. For example, the user can see a virtual glass sitting next to a physical glass on a table. The most important aspect of AR is that the location of the virtual glass appears as real, solid and credible as possible than physical glass [7].

As many researchers expand the definition of AR beyond a system that complements the real world with virtual (computer-generated) objects, AR is becoming a growing area of interactive design, with the rise of personal mobile devices capable of creating fascinating AR environments [8].

While several scientists expand the concept of AR beyond this vision, we describe an AR system as having the following characteristics:

- Combines real and virtual objects in a real environment ;
- Acts in real time and interactively;
- Real and virtual objects store (align) with each other.

Finally, to distinguish between VR and AR is that the former uses the real environment and superimposes virtual objects on it, while virtual reality creates a totally artificial environment [8].

2.3 Mixed Reality

MR mixed reality is defined as a hybrid reality, where real and virtual worlds combine to create new environments and visualizations that coexist and interact in real time with physical and digital objects. MR takes place not only in the physical and virtual worlds, but is a combination of reality and virtual reality, which incorporates both augmented reality and augmented virtuality. MR brings the possibility to combine rendered objects digitally in the real environment, also called holography [6].

Mixed reality is an environment where real and virtual content coexist and interact in real time. Aspects of augmented reality and virtual reality merge to achieve this. MR is not only an alternative to augmented reality or virtuality. Rather, it is a unique perspective that enriches the perception of users. In real and virtual environments.

Flexibility, immersion, interaction, coexistence and enrichment are essential aspects of a mixed reality experience. This is achieved by adopting the technological aspects of AR and VR. Thus, an MR experience, provides a real-virtual environment where users feel like they are in an immersed environment and their perception of the real world is improved [4].

2.4 Virtual Reality Continuum

The reality-virtuality continuum is composed of environments ranging from real to virtual and all the possible variations and compositions of real and virtual objects in these environments.

The similar underlying technologies, offering an enhanced experience with full entertainment, are what caused people to confuse AR and VR, considering the two technologies to be identical. This confusion can be revealed by the Reality/Virtuality Continuum proposed by Milgram in 1994. Milgram and Kishino [9] introduced the reality-virtuality continuum that defines mixed reality and identified a series of variations of technologically modified forms of reality that correspond to today's augmented and virtual reality technologies.

2.5 Augmented Virtuality

Augmented Virtuality (AV) is the ability to interactively explore a virtual representation obtained from the real world. AV could be considered as a subcategory of the MR that merges real world objects into the virtual world. Most of the time, this achieved by streaming videos from physical spaces (for example, via a webcam) or by using 3D scanning of physical objects, videos or objects and draped in virtual objects, giving the impression that the virtual world is a bit like the real one, while retaining the flexibility of the virtual world [9] An example of audiovisual is that of an aircraft maintenance engineer who visualizes a real-time model of the aircraft engine in flight, as it appears on a screen with real-world elements that are physically separated [6].

2.6 Comparison

Even though augmented, virtual and mixed reality can be used to reach the objectives mentioned above, our survey shows that Augmented Reality is preferable for the improvement of exhibitions. Similarly, virtual reality seems to be more adapted to virtual museums, and mixed reality is more viable for reconstruction applications at inside and outside.
We provide the following simple working definitions:

- **Augmented Reality**: aims to improve our perception and understanding of the real world by superimposing virtual information on our vision of the real world;
- **Virtual Reality**: aims to enhance our presence and interaction with a computer-generated environment with no way to interact or see the real world;
- **Augmented Virtuality**: aims to increase the virtual world with real world scenes;
- **Mixed Reality**: aims to mix real and virtual environments.

3. INDUSTRIAL APPLICATIONS OF VIRTUAL/AUGMENTED REALITY

According to [10], the industry manufacturing is defined as "the transformation of materials and information into goods and services, for the satisfaction of human needs". With recent advances in information, digital manufacturing is considered to reduce the time and cost of information product development. Digital manufacturing also addresses the need for personalization, increased quality, and rapid mass distribution.
The manufacturing industries (e.g., aerospace, automotive) can be a good example to demonstrate both the need for simulation and the key challenges of product design and process optimization. Thus, this section focuses mainly on the manufacturing industry but many applications can be transposed to other industrial realms such as: military, construction, medical, architecture or commerce.
Inspired by Mourtzis et al. [11], we propose to classify industrial AR/RV applications into four different categories:

- Training applications;
- Requests for assistance;
- Design applications;
- Planning and validation of requests.

3.1 Training Applications

Despite the fact that training is often a cross-cutting concern of the application territories, we may want to contemplate the work on AR/VR applications for preparing separately, as a few applications focus specifically around this aspect.
With regards to helping portable laborers in assembling, scientists have utilized cell phones or tablets to prepare assembly processes [12]. Aehnelt and Bader [13] utilize outside displays to give assembly instructions. They incorporate context oriented foundation information to teach, guide and screen gathering laborers.
In the field of training, Aehnelt and Wegner[14] concentrate on integrating work with learning experience to enhance cognitive comprehension and task processing in order to align and organize one's own tasks in a smart manufacturing environment.
After participants were trained with either VR, VR on a tablet, HMD-AR (Head Mounted Display-Augmented Reality) or a paper manual as a baseline, they measured the completion time of the assembly process.
The HMD-based AR training resulted in the fastest completion time, followed by the various techniques of virtual reality and the paper guide, according to their findings.
AR/RV training applications have several advantages over a traditional training application. They make it possible to:

- Execute a task without risk;
- Make mistakes without having an impact on safety.
- Reconfigure the environment (terrain, meteorology);
- Model inaccessible training grounds (space, enemy terrain, training paths, etc.);
- Simulate scenarios that cannot be simulated in reality (technical incidents);
- Be free from time constraints and other necessities;
- Use limited space (the volume of the AR/RV system);
- Use the same system for different training applications.

3.2 Requests for Assistance

Operator assistance using guidance tools is generally done within the framework of several manual tasks such as mounting or dismounting objects. A simple way of providing assistance is by using standard manuals that can be used as a guide of construction. In order to continuously increase the production of workers; new techniques have been explored to guide operators in maintenance and repair tasks. Assembly to this end, AR/VR technologies have been introduced in several areas industrial companies.

For AR/VR-assisted applications, Echtler and al. [15] introduced the Smart Welding Gun which helped the users to pull studs with high precision on prototype vehicles. The intelligent welding gun has been designed with an instrument-based approach with a rendering display attached to the gun to give feedback on the task performed. A tracker infrared ART was used to track the gun and components.

Medical operations may be crucial and entail heavy duties on the operator. Therefore computer-aided techniques have been developed to assist surgeons. As an example, Gavaghan et al. [16] built a portable handheld-navigated projection system. The system is based on a laser projector that projects information over the surface of the liver for assisting surgery operations

3.3 Design Applications

Design processes can step in at different stage of a product life-time cycle. Virtual/Augmented Reality have been widely used in product design, in particular VR has proved to provide adequate experiences to designers during the product design process. Early VR systems have been developed for design purposes. The 3DM was developed in 1992 to adapt Computer-Aided Design (CAD) and drawing programs to VR Head-Mounted Displays (HMD). The COVIRDS method [17] (first introduced with a laptop display) puts together the CAD modeling, user interface design and VR technologies.

Several AR/VR design applications have been proposed, the idea is to introduce a complete design process using both AR and VR. It provides tools to create and edit 3D curves and surfaces.

Based on these works, many VR/AR design applications have been proposed. The idea is to introduce a complete design process using both AR and VR. It proposes software for designing and editing 3D curves and surfaces.

For early conceptual design, Israel et al. [18] introduced 3D sketching techniques and carried out a study with experts and users on the efficiency of 3D sketching compared to 2D paper sketching. Regarding 3D sketching, the subsequent work of De Araùjo et al [19] proposes two-handed interaction techniques to sketch and design objects on flat surfaces such as the workbenches. Nevertheless workbench systems propose limited immersion and are adapted to design objects at a reduced scale. For designing large objects at scale the users can be immersed in large projection-based systems. Consequently, Hughes et al [20] proposed CaveCAD; a virtual reality architectural design application for immersive environments displayed on a CELLAR. They have implemented interaction techniques and several functionalities to modify the geometry of objects. Their preliminary study has suggested that a tiredness arm occurs when manipulating the control device in the air for a long period of time compared to desktop monitors. Similar to CaveCAD, the SculptUp system Ponto et al [21] proposes an alternative way to design objects in VR CAVE systems.

3.4 Planning and Validation of Requests

Among the various AR/VR systems, VR systems have been widely used for plant layout planning. Iqbal and Hashmi [22] were among the first to use virtual environments for the planning of plants and to propose alternative layout solutions. Similar work by Calderon et al [23] proposed an online development plan that can help users to explore alternative planning solutions. Nevertheless, these approaches do not propose to insert the virtual environment in immersive screens. Work by Menck et al. [24] introduced collaborative virtual environments for plant layout planning tasks. They proposed an approach for simultaneously view, investigate and analyze plant plans. As to approval, De Sa and Zachmann [25] have acquainted approval instruments with computer generated reality to analyze and confirm get together and upkeep assignments utilizing head-mounted presentations (HMD) in the automotive industry. They directed a review of clients whose outcomes empower the utilization of computer generated reality for the Virtual prototyping in the automotive industry.

Likewise in the automotive industry, the middle PSA Peugeot Citröen's virtual vehicle is furnished with a CAVE show where a task group can intelligently approve the plan and plan the get together of the vehicles. Concerning AR approval, Caruso and Re [26] have built up an audit framework AR design. The system depends on a HMD Video See-Through (VST) that assists with picturing and communicate in AR with a virtual item during the virtual prototyping.

3.5 Comparison

The need to simulate most industrial operations has encouraged the use of AR/VR technologies in many industrial applications, based on our researches we can categorize the appropriate utilizations of AR/VR technologies as:

- Immersive environments, such as Virtual Reality (VR), are a good candidate to offer simulations in a training context. Studies have shown that training in a virtual reality environment increases operator performance compared to standard training sessions. VR environments are also suitable for designing objects or processes using imported CAD models and 3D drawing interaction paradigms;
- In terms of planning and validations, systems based on projection (PBS) of VR, such as the CAVE

system, are advantageous because they allow a complete project team to interactively plan and validate the products and operations.

4. LIMITATIONS OF AR/VR DEVICES

There are many developments in the expansion of AR/VR technology, but there are still some problems that need to be tackled, and that serve as the key obstacles to AR-exponential VR's growth to reach out to the market and the common people. In [2], some of the major problems are widely discussed.

In this paper, we summarize the main problems of VR/AR technology as follows:

Dedicated hardware requirement: The main problem is the dedicated hardware requirement; for instance, the necessity for the initial configuration. For VR applications, it needs a particular space and environment.

Need for cheaper technology: with a high price tag, the AR/VR product comes with, which is why customers are not ready for it as of now. That is why some comprehensive solutions are required that will allow use of some cheaper and more powerful hardware and eventually reduce the cost of AR-VR products. To solve this issue, in our previous works [27]–[29], we have presented some VR/AR solutions using cheaper equipment.

Lack of legal use cases: AR/VR faces another major hurdle in the form of innovative and exclusive content, even if the price factor is handled. The current R&D focus is primarily on the world of gaming and entertainment. The content that is produced should be in the context of the viewpoint of the user. While several use cases are currently available, such as entertainment and gaming, applications that will make these technologies important for consumers and business are yet to be identified.

Mobility/Miniaturization problems: Mobility is one of the big issues relating to VR experience. Due to several cords connected to HMDs (Head Mounted Displays) or other wearable devices, few VR items experience minimal free movements. These advances in VR products should be available in miniaturized, lightweight, portable and handy forms that will give users a wireless experience and ease of use.

Low security issue: Another big concern with AR-VR technologies, which is not yet well addressed, is cyber security. There are possible threats that can hack virtual environments which can be accessed, changed, or altered by the attacker and can ruin the virtual environment. Therefore, protective measures will have to be implemented in the future.

The following table shows a comparative analyses of the new existing equipment dedicated to the uses of AR/VR:

Table 1: Comparative analysis of current products for AR/VR

Device type	AR/VR product name and manufacturer	Features
Smart Hololens	Microsoft Hololens	-Remote Instruction -3D computer Aided design - Task gamification - Gaming - Decorating
Wear-able glass	Google glass	-Hands free first person photos and videos - Google search result in front of the Eyes - Virtual reminders - Voice Dictation and Gesture control
VR/3D headset devices	HTC Vive	- Virtual reality experience
	Oculus Rift-Oculus	- Provides 360 degree 3D virtual reality experience - Need to connect headset with PC through USB - Light weight
	Gear VR-Samsung in association with Oculus	- Gives 360 degree virtual reality experience - Smartphone need to be connected to VR headset through wireless communication.
Headset supporting AR feature	Lenovo phab 2 pro with tango by google	- AR games - AR for education - Visualize home appliances - AR home decor and furnishings
	Asus Zenfone AR with Tango by Google	- AR games - AR for Education - Visualize home appliances - AR home decor and furnishings
	AR Kit by Apple (available in iphone 6s and above)	- AR games - AR for Education - Visualize home appliances - AR home decor and furnishings applications

5. CONCLUSION

All through this overview, the AR/VR technologies were introduced, considering both the technology behind it and its materialness. A great deal of work was at that point produced for this technique, yet considering its advancement and its prospects, significantly more will be created in the future years. Similarly as PCs and cell phones changed the existence of the multitude of persons, it is normal that all the wearable gadgets with AR/VR innovation will likewise have a gigantic effect. The future hope of this innovation is the consistent AR/VR experience and a simple to-utilize technology.

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