

Current and future Extended Reality applications

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Abstract

This article presents how extended reality and its components have revolutionized the industries, educational systems, medical procedures, also this article is going to explain the components of the extended reality, for example what is it, what is virtual reality, mixed reality. Also this article will talk about the most popular topics used in extended reality will talk about the most popular topics used in extended reality.

XR mixes real and virtual worlds, several studies prove that this can improve educational areas, due to its interactive form. As well this technology can improve how students of medicine practice with bodies and identifies their parts, medical students can dive into these immersive experiences, practicing complex procedures and getting a hands-on understanding of the body, all without putting real patients at risk. Even experienced doctors can use XR to fine-tune their surgical skills and stay up-to-date with the latest techniques through lifelike simulations and virtual learning environments.

In other areas like aeronautics it can be very helpful because people can practice using flight simulators, that provides an immersive environment to hone their skills, test scenarios, and experience a wide array of flight conditions. This immersive approach enables aviation enthusiasts to gain invaluable experience, refine their decision-making skills, and bolster their ability to navigate complex situations.

Introduction

Extended Reality (XR) is rapidly reshaping the landscape of education by introducing immersive and interactive learning experiences. XR, which encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), goes beyond traditional teaching methods by merging digital elements with the real world. This technology holds immense potential for revolutionizing education, offering students new ways to engage with content, explore complex concepts, and enhance their

understanding of various subjects.

The realm of gaming and entertainment has undergone a profound transformation with the integration of Extended Reality. By seamlessly blending virtual environments with the real world, XR has elevated the gaming experience to new heights. Virtual Reality transports players into entirely immersive worlds, while Augmented Reality overlays digital elements onto the user's surroundings. This convergence of reality and digital content has created unparalleled levels of interactivity and engagement, redefining how we entertain ourselves in the digital age.

The world of architecture and design is undergoing a paradigm shift, thanks to the integration of Extended Reality. By allowing architects and designers to visualize their creations in three dimensions, XR is transforming the design process. Whether through Virtual Reality models or Augmented Reality overlays on physical spaces, professionals can explore their designs with unprecedented realism, aiding in decision-making, collaboration, and effective communication with clients.

Extended Reality has ushered in a new era of marketing, redefining how brands interact with consumers. Through Augmented Reality experiences, brands can create immersive and interactive campaigns that blur the lines between the physical and digital worlds. This not only captivates audiences but also allows brands to convey their stories, showcase products, and provide unique experiences that leave a lasting impression.

Extended Reality, particularly Augmented Reality, is transforming the museum and cultural sector. AR overlays enrich exhibits by providing context, interactivity, and visual enhancements to artifacts and artworks. Visitors can engage with history, art, and culture in dynamic ways, creating a more personalized and captivating experience. Beyond museums, XR's applications extend to fields like engineering, automotive design, job training, and psychological therapy, showcasing its diverse and

potential.

Extended Reality

Definition

Extended reality (XR) stands for a combination of real and virtual environment technologies, that covers Augmented Reality (AR) and Mixed Reality (MR). This technology is used to create immersive experiences for the user, by combining real and virtual worlds. The term XR initialized when Charles Wyckoff filed a patent in 1960 for his development. Then nowadays the term has moved to the mainstream of videogames and medicine [1].



1. Augmented Reality AR is an enhanced version of the real physical world that is achieved through the use of digital visual elements, sound, or other sensory stimuli and delivered via technology. It is a growing trend among companies involved in mobile computing and business applications in particular.
2. Mixed Reality MR is the merge of real and virtual worlds to recreate and produce new environments and visualizations where physical and digital objects co-exist one with the other. This new reality is based on advancements in computer vision, graphical processing, display technologies, input systems, and cloud computing [2].
3. Virtual Reality the use of computer modeling and simulation that enables a person to interact with an artificial three-dimensional (3D) visual or other sensory environment.

Applications

Education. Augmented reality has been helpful in the education field, but when it really starts to help students and kids is when the Covid 19 begin. When teachers try to teach students with

normal methods they get bored and lose easily their concentration, and that's when the AR comes in. When the students learn by using interactions and uses technologies they start to get interest in the topics the teacher teach.

Integrating augmented reality into the learning process will be helpful and will bring to the students an interactive dimension that strongly resonates with students, specially in situations where learning occurs remotely or through a hybrid approach. The fusion of tangible real-world and digital overlays nurtures an immersive learning environment that captivates students attention and incentivates their interests in subjects that are being presented.

Now knowing this, there are some ethical concerns that are associated with the use of virtual reality in the field of education, be it school, college or university, these include the following [3].

1. Manipulation: VR can be misused to manipulate students, as the high level of realism in VR environments can have divergent effects depending on the spatial ability of students. Safeguards need to be implemented to prevent the manipulative use of virtual reality experiences.
2. Privacy concerns: Virtual reality raises privacy concerns due to the collection of a large amount of data, including motor and behavioral profiles. These data can be exploited for identity theft and personalized virtual advertising.
3. Autonomy: Virtual reality represents a threat to the autonomy of users, since it can be addictive and allow surveillance. There is a risk that users will be brainwashed or have a distorted view of the world. Peer pressure, conformity and escapism are additional risks.
4. Equal access: allowing children and vulnerable groups to regularly access virtual reality without adequate data protection rules and informed consent is ethically dubious.

Gaming and Entertainment

Nowadays, augmented reality has gained recognition due to video games and industries that produce technology linked to the VR concept. For example, Meta with the Oculus Quest, PlayStation with its own VR headset, and now Apple joins the battle with the Vision Pro. All these devices have something in common: virtual reality [4].

Have you ever thought about what you can do in a video game with augmented reality? For example, Racing Simulation, also known as sim racing, is a very popular term when pilots from various categories use a VR headset and a sim racing combo to play and improve their times in games. By training in a virtual environment, they can test things that in real life can be very expensive, such as crashing a car, changing weather conditions, and testing different cars and their behaviors. This helps them improve their times, and their teams, who cover the costs of cars, fuel, tracks, etc., will not face any risks.

Another important use of Augmented Reality is entertainment. For example, using an Oculus Quest, you can easily watch movies, series, and YouTube videos by searching for what you want. It's very immersive, as all you see is a big screen with the media you're playing. By combining this with mixed reality, you can adjust the size of the screen and interact with other people in your environment.

Exercise using VR is also a significant topic. In the world, there are many different body types, for example, muscular and slim. Using a VR headset, you can play games that involve moving around, which causes your body to stay active and burn fat. This is important because some people don't enjoy traditional exercise, making it a great way to stay active and burn fat.

It's crucial to know that you should use this kind of technology in moderation, as it can be very addictive. It's recommended not to use it excessively during the day, as it can lead to eye damage and addiction.

Healthcare

The integration of digital technologies has leading a new paradigm shift in teaching methods, for example in augmented reality and mixed reality has a potential to transform the medical education, why? because with this kind of technology people can learn the procedures, surgical planning and guidance.

The review of 26 studies that used augmented reality and mixed reality in medical education, found that VR and XR can improve in the training of professionals in health.

One of the key strengths highlighted in the review is the versatility of AR and MR applications across various subjects and learner types. The studies covered diverse healthcare disciplines,

such as anatomy and anesthesia, catering to learners of different levels and specialties. These technologies offer an interactive and immersive learning experience, enabling participants to engage with virtual and real-world elements simultaneously. Moreover, the studies showcased a rich diversity in research focus, ranging from introducing novel applications to evaluating their impact on training and learning outcomes.

There are some weaknesses in the VR and XR, for example, a lot of studies showed early versions of things without really checking how helpful they were for learning, as well they said that using AR and MR was really good for improvement and learning, but others didn't find clear proof of this. Because of these mixed results, it's important to have better ways to do the research, like using the same methods for everyone, checking lots of different aspects, and including more people in the studies.

Architecture and Design

In architecture design education, XR technology is used as a new representation tool in the early design studio to enhance student engagement with their surroundings and to allow students to experience their design project in real scale, this can be really helpful for the students because they can see their model in 3d, test it and know possible errors that could occur. This technology can improve the students spatial ability levels in architecture design education

XR technology can help students to understand the relationships between objects and to formulate mental images, which are essential skills in architecture design. Additionally, XR technology can help students to identify possible errors in their design and to test their models in a more efficient and cost-effective way. This can lead to better design outcomes and a more effective learning experience for students. Overall, the use of XR technology in architecture design education has the potential to revolutionize the way students learn and practice design [5].

The versatility of this software and user interfaces harnessing extended reality holds the potential to profoundly reshape various global industries. By providing immersive and interactive experiences, extended reality opens up new avenues for training, product design, entertainment, and more. For instance, in the field of medicine, professionals can practice intricate procedures in virtual environments

before performing them in the real world, thereby enhancing precision and reducing risks. Similarly, the tourism industry could enable travelers to virtually explore destinations before making travel decisions, offering a more realistic insight into what they can expect. As these technologies continue to evolve over time, it's exciting to contemplate how extended reality could revolutionize the way we engage with the world around us.

Marketing

Based on the conducted study [6], virtual reality (VR) holds significant implications for marketing tourist destinations, particularly in the post-COVID-19 landscape. Integrating virtual reality into marketing campaigns can prove highly advantageous for tourism companies, especially those centered around attractions such as cruise trips. By immersing potential clients in the cruise experience, VR can substantially enhance their inclination towards purchasing tickets. This strategic advantage over traditional non-immersive marketing approaches highlights the pivotal role of delivering exceptional experiences in retaining customers. Consequently, this approach positions brands at the forefront of the market, potentially establishing them as market leaders or innovators.

Of course, but how can tourism companies take advantage of the full potential of this virtual reality tool? The study suggests that the key lies in prioritizing user engagement over mere photographic precision or sensory stimulation. The primary goal in crafting the VR environment should be to enable substantial user interaction, greater participation, and individual control of experiences. This deliberate emphasis significantly impacts the emotional response of the user, effectively fostering a greater desire to participate in the experiences presented through virtual reality. In essence, the emphasis should be on investing in the overall user experience rather than just showcasing the charm or opulence of the cruise. Without a doubt, the solid promotion of this interactive dimension is of paramount importance.

A particularly receptive demographic for targeting comprises millennials. This group, immersed in social media and drawn to appealing visual content, holds the potential to exert substantial influence over their peers and family members. Their engagement with and enthusiasm for the enticing aspects of virtual reality can effectively motivate

their loved ones to partake in such captivating experiences, such as a cruise trip. This not only offers millennials a chance to break away from routine but also fosters quality time for families to relish shared moments together.

AR Museum

As virtual reality technology continues to expand its presence in the digital realm, its remarkable potential extends to revolutionizing the cultural sector, particularly in the realm of museums. The incorporation of augmented reality (AR) within this industry is particularly awe-inspiring. An innovative endeavor in this direction involves the creation of an application called ARmvoil, designed to immerse users in a virtual museum environment. By seamlessly integrating AR technology, this application offers users a captivating opportunity to interact, engage, and explore an extensive collection of historical artifacts within a confined physical space. Furthermore, a comparative analysis between traditional museums and AR-based museums was conducted within the framework of this article, shedding light on aspects of workload and user preference. The study's findings in this regard can be distilled as follows [7]:

1. **Workload:** The study underscores a noteworthy discrepancy in terms of workload between the two museum formats. Remarkably, AR-based museum's exhibit a notably lower overall workload in comparison to their traditional counterparts. Conventional museums often entail challenges in navigation due to their reliance on a taxonomy system. In contrast, the AR-based application's approach significantly streamlines travel and content consumption, occupying minimal spatial considerations.
2. **Preference users:** The study indicates a significant shift in user preference towards AR-based museums. Over 71 percent of respondents favored the proposed AR application over traditional museums. Impressively, the AR-based application garnered a high average preference score of 4.74 out of 5. This substantial preference underscores the growing appeal of AR technology in shaping the future of museum experiences

Now, some application to this technology highlights the following:

1. Accessibility for visitors with hearing problems: AR technology implemented in museums can enhance inclusivity by catering to visitors with hearing impairments. Through features like language translations and subtitles, AR provides a visual avenue for accessing information. This ensures that individuals with hearing difficulties can engage fully with museum content, fostering a more enriching experience.
2. Future adoption by interested persons, educational institutes and researchers: Experts predict that augmented reality will find future adoption among history enthusiasts, particularly those intrigued by fossils, paintings, statues, and various historical artifacts. This technology is regarded as a potent tool for enhancing the user experience, effectively harnessing its potential to provide an immersive and enriching encounter with diverse historical objects [7].

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Other uses

Extended reality could also improve the lives of disabled people, for example, despite how odd it might seem, mixed reality can help people affected by blindness or visual impairments. In this case, the

approach involves creating a program on a device compatible with spatial sensing such as the HoloLens 2. This program would be capable of recognizing the surroundings and providing auditory alerts about the environment. This is especially useful for people who depends of a white cane, as the cane helps perceive the ground but not the area above their pelvis.

By implementing what was described before, blind individuals could gain the ability to recognize the entire surroundings, giving them more security and protection. Another method to achieve this is through vibrating warnings, for example from a smartwatch that would send more intense warnings depending on how far objects are [8].

Improving Mirror Fitness through augmented reality technology

According to [9] the global fitness industry suffered significant impacts as a result of the pandemic. In the US, numerous fitness gyms abruptly closed in mid-March 2021, leading to substantial layoffs affecting nearly a million fitness instructors. Prominent establishments like Gold's Gym also faced financial setbacks. Both the local and international fitness sectors faced challenges as businesses suspended operations, disrupting revenue streams, while fixed costs such as rent, salaries, and operating expenses persisted. This situation led gyms to explore bankruptcy restructuring in order to survive.

At the start of the pandemic in the winter of 2020, there was a greater emphasis on physical activity due to its potential benefits against COVID-19. This led to remarkable growth in the fitness industry, giving rise to new professionally oriented home exercise methods. These ranged from platforms like YouTube, where trainers shared videos for subscribers, to major gyms and industry players looking for interactive and efficient alternatives to help people with their workouts.

An exemplary case is the introduction of Cuban's MAGIC SPORT intelligent holographic interactive system. This innovation integrates artificial intelligence visual recognition technology and Internet of Things technology to improve user experience and operational efficiency. According to sources in China, the goal is to involve 435 million people in physical activities through this initiative.

This objective is pursued by implementing AR

(Augmented Reality) to improve the Mirror Fitness system. AR technology merges virtual information with the real world, offering users more information without disconnecting from reality. AR integration into Mirror Fitness allows users to receive real-time visual feedback and corrections, enhancing exercise benefits and reducing injury risks. In addition, AR facilitates natural and immersive interaction with virtual objects, improving the user experience and the effectiveness of the system.

Medical Training

Performing the first surgery is one of the most stressful experiences for a medical student. Even the first time they enter an operating room to witness their initial surgical intervention, it doesn't provide the best feeling. The issue may be that people is not familiarized with such images, which can be shocking when seen them in real life for first time.

On the other hand, in recent years, several Virtual Reality applications have been developed to simulate various medical activities, including those performed in operating room. This allows, medical students to gain their first experience before an actual surgery.

In the same context, there is a VR application called Tersus, an application developed using Unity and the SteamVR plugin. Tersus aims to reduce anxieties among medical students related to their medical training experiences in operations room. Tersus VR program consist in various steps that prepare students for surgeries, for example:

1. Disinfection process: the simulation begins in a hospital hallway, where students gather all the necessary items for the surgery, such as clothes and gloves. They then proceed to a washing station to get fully disinfected.
2. Operating room preparation: once the first step is completed, now is time to prepare the operation room, in order to do this, students have to move to the room without touching non-sterile surfaces. Once in the room, they have to answer some questions in a medical quiz.
3. Minor tasks: Following that, medical students perform minor tasks like disinfecting the part of the area of patient's body that will be operated. This simulates preparatory washing before the medical procedure

After completing these steps, students are required

to observe the surgery. The program also provides feedback to students, highlighting their strengths and pointing out areas for improvement, even compelling them to repeat tasks if a mistake occurs [10].

Military pilot training and flight simulations

It is known that flight training includes two phases: simulator-training and in-flight training. While those are commonly used methods for training new pilots, the first phase is inefficient and the second one is excessively expensive. The reason why the first phase is considered inefficient is because some studies indicate that the psychology during flights and simulated flights is different, while the second is expensive because in-flight training involves all the costs associated to a regular flight.

On the other hand, when talking about military flight training becomes even worse, because the second phase involves combat training that includes the use of two aircraft and potential risks, such as mid-air collisions. This is where Augmented Reality may be used, one aircraft can be physically present, while the second one is displayed using this technology, replicating all the essential aspects of regular training. This offers several advantages, including:

1. Mitigating the risks of a real in-flight combat training.
2. Reducing training cost for military pilots by half, as only one aircraft is needed, similar to regular in-flight training.
3. Prepare pilots to various situations and show them the field where they will be working.

To achieve all these advantages, a specific process is employed to train pilots using this technology. The process consists of several steps:

1. Initial Familiarization Flight: This step involves a 10-minute flight session, during which the pilot is guided to perform various tasks to become familiar with the technology
2. Training Sessions: This step involves three distinct subjects:
 1. Short autopilot guided flight.
 2. Supervised 15 minutes flight.
 3. Unsupervised 30 minutes flight [11].



Figure 1. Running training, with the leader aircraft projected

Hospitality and hotel personnel training

Extended reality also has a significant impact on hotel and tourism industry. Well-trained personnel are indispensable for this section. For example, employees need to interact with customers and provide them the best services. Additionally, because hotel industry is constantly evolving in social, technological and economic terms, ongoing training is of great importance.

To improve hotel personnel training, XR (Extended Reality) could be employed, here are some reasons why:

1. Through the utilization of this technology, employees can be immersed in various scenarios and exposed to different types of customers they may attend, giving them more experience and knowledge.
2. All employees are different, some of them could be fast learners, while others need more time to learn. Utilizing XR technologies can facilitate interactive and personalized learning. This way everyone can learn at their own pace.
3. Also, hotel personnel can be evaluated by their performance in virtual scenarios provided by XR, allowing hotel superiors to give employees different recommendations and identify areas they should improve. [12]

Conclusion

As we are well aware, the march forward of extended reality (XR) technology is transcending a multitude of spheres within society, setting in motion a profound transformation in the way we engage with our surroundings and acquire novel proficiencies. From education to the realm of tourism, extending

to professional development and healthcare, XR is fundamentally reshaping our understanding and interaction with the world around us.

In the realm of education, the infusion of XR technology is imbuing spatial comprehension with renewed vitality and facilitating interactive learning by affording students the means to delve into architectural designs in real-time. This dynamic approach not only fosters a deeper comprehension but also serves as a catalyst for identifying and rectifying errors, thereby enhancing the capacity for well-informed decision-making. In the domain of marketing, the ascendancy of virtual reality (VR) is poised to emerge as a strategic cornerstone for captivating potential travelers and consumers. By engineering immersive and emotive experiences, VR stands as a pivotal tool to demarcate brands and hold sway over an increasingly diverse array of audiences, thereby infusing fresh dynamics into the landscape of destination promotion and marketing.

Concurrently, health and well-being are undergoing a renaissance propelled by XR. From integrating auditory alerts for individuals with visual impairments to optimizing the efficacy of fitness regimens, this technology is bestowing a boon upon individuals by offering customized and accessible solutions that resonate with personal circumstances. In the realm of professional training, XR is proffering pathways to innovation across myriad sectors, including medicine and aviation. From the simulation of complex surgical procedures to the training of military aviators through the prism of virtual reality, XR is definitively diminishing hazards, curbing expenditures, and elevating the overall standard of preparedness.

Turning our gaze to the Costa Rican context, the “Amón RA” project unveils the potential of augmented reality to deepen the comprehension of cultural and historical heritage. By means of an interactive application, users are invited to navigate virtual elements within their tangible environment, thereby enriching their affiliation with the storied legacy and vibrant culture of Costa Rica. Collectively, the inexorable progression of XR is etching an expansive canvas painted with limitless prospects, redefining our interface with knowledge, ingenuity, and the world at large. While propelling ahead, this technological advancement offers to push the envelope, revolutionizing our mode of existence, edification, and engagement with the ever-evolving world that envelopes us.

- [1] A. Hayes, "Augmented reality (AR) defined, with examples and uses," *Investopedia*, May 2023.
- [2] Qianw, "What is mixed reality? - Mixed reality." Jan-2023.
- [3] A. Skulmowski, "Ethical issues of educational virtual reality," *Computers & Education: X Reality*, vol. 2, p. 100023, 2023.
- [4] PCMag, "The best VR headsets for 2023," *PCMAG*, Jul. 2023.
- [5] M. Darwish, S. Kamel, and A. Assem, "Extended reality for enhancing spatial ability in architecture design education," *Ain Shams Engineering Journal*, vol. 14, no. 6, p. 102104, Jun. 2023.
- [6] R. Yung, C. Khoo-Lattimore, and L. E. Potter, "VR the world: Experimenting with emotion and presence for tourism marketing," *Journal of Hospitality and Tourism Management*, vol. 46, pp. 160–171, 2021.
- [7] H. Vardhan, A. Saxena, A. Dixit, S. Chaudhary, and A. Sagar, "AR museum: A virtual museum using marker less augmented reality system for mobile devices," in *2022 3rd international conference on issues and challenges in intelligent computing techniques (ICICT)*, 2022, pp. 1–6.
- [8] H. Schieber, C. Kleinbeck, C. Pradel, L. Theelke, and D. Roth, "A mixed reality guidance system for blind and visually impaired people," in *2022 IEEE conference on virtual reality and 3D user interfaces abstracts and workshops (VRW)*, 2022, pp. 726–727.
- [9] M. Ueta, "Improving mirror fitness through augmented reality technology," in *2022 3rd international conference on big data, artificial intelligence and internet of things engineering (ICBAIE)*, 2022, pp. 186–194.
- [10] A. Gruenewald, R. Schmidt, L. Sayn, C. Gießer, T. J. Eiler, V. Schmuecker, V. Braun, and R. Brueck, "Virtual reality training application to prepare medical student's for their first operating room experience," in *2021 IEEE international conference on artificial intelligence and virtual reality (AIVR)*, 2021, pp. 201–204.
- [11] D. H. Arjoni, I. de Souza Rehder, J. M. Pereira Figueira, and E. Villani, "Augmented reality for training formation flights: An analysis of human factors," *Heliyon*, vol. 9, no. 3, p. e14181, 2023.
- [12] C. R. Cunha, C. Martins, and V. Mendonça, "Using extended reality in experiential learning for hospitality management education," *Procedia Computer Science*, vol. 219, pp. 634–641, 2023.
- [13] J. Gerup, C. B. Soerensen, and P. Dieckmann, "Augmented Reality and Mixed Reality for Healthcare Education Beyond Surgery: An Integrative review," *International Journal of Medical Education*, vol. 11, pp. 1–18, Jan. 2020.
- [14] J. P. Bulgarelli Bolaños and M. del C. Valverde Solano, "Procesos participativos como base para el contenido y desarrollo de la aplicación móvil de realidad aumentada: Amón_RA, costa rica," *Trama, Revista de Ciencias Sociales y Humanidades*, vol. 8, no. 2, pp. 43–94, Dec. 2019.