Convergence of the Physical and Digital Worlds

The Metaverse and AR/VR for Training and Education

Augmented reality (AR) and virtual reality (VR) technologies have become accessible and immersive and have a transformative potential for everything from communication and entertainment to education and workforce development.[1] The AR/VR trend is changing the digital landscape at a rapid rate, and the future will be determined by interactions between virtual and actual reality in the metaverse. The education sector has embraced new technological advancements[2] such as AR and VR technologies, as they can be used to change teaching and learning methodologies to improve learners' understanding. Vocational training that acts as the interplay between praxis and theory is advancing with AR and VR technologies. Therefore, AR and VR support the convergence of the digital worlds, training and education services, but it is essential to understand the challenges, risk and mitigation techniques.

The Physical World

The rapid adoption and growth of the Internet of Things (IoT) during the past decade subjected the physical world to a trajectory similar to that of the digital world. The IoT has benefitted from the advancement of fast networks that provide accessibility to remote locations using technologies such as satellite communications. The advancement of software and hardware technologies alongside the IoT transformation resulted in a world highly connected through devices and applications (apps). Physical world entities, including innovative equipment, smart buildings, smart vehicles and smart places, are being implemented via modern technology using artificial intelligence (AI) and machine learning (ML).

The Digital World

Access to the Internet enhanced the technology enjoyed by people across the globe, and the connection between network nodes has also transformed, from cabled to wireless. Furthermore, AI and ML technologies have ensured that modern devices and apps have features that make them smart and exhibit fast processing capabilities. Features and capabilities added to devices and apps have ensured that the real world can be sensed through speech recognition and computer vision technologies. Thus, the current digital world has been elevated to unprecedented levels through the use of these intelligent devices and apps.

The Metaverse

Metaverse is a term used by technology experts to discuss the visualization of the outcomes of the Internet world when digital and physical realities are combined. The functionality of the metaverse is like that of the Internet. The difference is that instead of

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viewing content solely through a screen, as with the Internet, the metaverse can require that users wear a specialized headset. The metaverse is a virtual space shared collectively through the combination of persistent virtual space and enhanced physical reality. VR devices, including HTC Vive and Oculus Rift, can be used to access the metaverse.[3] The metaverse allows individuals to explore learning spaces and virtual workspaces with 360-degree views based on the interaction of the participants' digital avatars.

For example, Mark Zuckerberg, the creator of Facebook, popularized the term "metaverse" after using it during Facebook's announcement that its platforms would be incorporated and rebranded into a single new umbrella name, Meta.[4] Facebook will help introduce the metaverse via 3D virtual gaming, entertainment and exercise.

Because of the absence of linguistic and cultural boundaries, students worldwide can benefit from a unified virtual learning environment in the metaverse.

Benefits of the Metaverse

The metaverse provides a digital platform for the activities of human beings, and can potentially be used to help solve humanity's problems, including the challenges of education experienced during crises such as the COVID-19 pandemic.[5] The technology can assist in expediting meetups, since individuals are only a click away from one another. Further, the metaverse can offer a place of enjoyment with reduced transportation and the associated expenses. Individuals can live in an imaginary world where they exercise and play games with friends.

Metaverse training offers enormous benefits to trainers: convenience, speed, risk and stress reduction; improved performance and practicality; and cost efficiency. Both trainers and trainees can use the technology to experience an immersive program that benefits all parties.[6] Moreover, training is user-friendly and adaptable and has quick onboarding potential. Different sectors can tailor their metaverse training based on their needs. The healthcare, military, education and manufacturing sectors may have unique metaverse training approaches based on individual needs. This flexibility ensures that the training can meet needs at various levels without causing significant problems for individuals and organizations.

Introducing AR and VR

AR and VR are not new technologies. In the 1970s, author and researcher Daniel Vickers created the first VR headset while teaching at the University of Utah (Salt Lake City, Utah, USA).[7] The headset was fully functional, comprising six interconnected subsystems, including:

1. A matrix multiplier
2. A clipping divider
3. A vector generator
4. A head position sensor
5. A headset
6. A general-purpose computer

VR immerses users in a 3D environment. VR users can see internal complexity attributed to data, discover overlooked connections and grasp relationships in different ways. VR boosts abstract information visualization so consumers can easily and quickly comprehend the presented data.[8] In addition, VR has broad applications that include training with simulators, reconstruction of sites, different forms of learning, simulation of architectures, surgical procedures, treatment of phobias and virtual visits to museums.

AR is a vital technology that changes the basic assumptions of consumers' approaches to data interaction. AR differs from VR by overlaying digital content in 2D or 3D in the real world instead of subjecting individuals to an artificial world. AR functionality is supported by a device that films the real world and overlays live virtual texts, data, animations, sounds or objects viewed by the user from a computer, tablet, headset or any other onscreen display system.[9] Virtual information and the real world are then synchronized through embedded sensors and geolocation that locates the user based on the environment and adapts the display by linking it to the user's movements.

AR technology can see data from several sensors concurrently, and the accessibility and ease of

AR use will foster widespread adoption of the technology.[10] Fields suited to the application of AR include entertainment, education, industry, medicine, architecture and tourism.

AR and VR in Education and Training

Recently, the inclusion of headset-based VR in education has become popular. VR changes how students engage in the learning process in the classroom and outside. VR can be used to practice and rehearse dangerous activities, such as performing surgeries or piloting airplanes. It also creates an opportunity to reenact a counterproductive or inconvenient situation, such as managing school behavioral problems,[11] and execute otherwise impossible things, such as observing the internal organs of a human body. VR is also beneficial to learning and education because it can improve training and increase memory capacity, and it uses stimulating and entertaining conditions to help users learn how to make effective decisions. VR presumes learners can directly understand minimalistic symbols, and a student actually may comprehend the functionality of a machine more readily through the visualization process of VR than via reading a textual explanation.[12] VR has become a vital component that helps students access more than was previously possible via simulations of specific environments. It can lead to a practical understanding of phenomena using less cognitive effort.

The advancement of AR technology has made it suitable for providing instructional materials to students and trainees. In addition, AR gives technicians the opportunity to learn new procedures based on actual conditions. AR makes it possible to interact with an object linked to the real or virtual world, increasing the attention and motivation of the learner and promoting learning via experimentation, interactivity and participation.[13] This allows for practical, enjoyable training and education, especially for understanding and learning complex phenomena or abstract concepts. Because of these benefits, AR and VR have become common in classrooms and homes.[14] They make significant contributions to the safety, emotional well-being and physical well-being of learners. Educators also benefit from AR because it contributes to student creativity and encourages participation in the learning process.

Using VR and AR in conjunction with the effect of the metaverse has elevated the educational experience.[15] More extensive and high-quality educational resources have allowed students to view live experiments. For instance, public school students in New York City, New York, USA, are learning about astronomy on a virtual spaceship rather than in a regular classroom.[16] This is the dawn of a brand-new age in education. Because of the absence of linguistic and cultural boundaries, students worldwide can benefit from a unified virtual learning environment in the metaverse. Microsoft's Mesh, another illustration of a metaverse, is a mixed-reality platform that allows teachers, staff and students to use 3D avatars to engage with one another.[17] In addition, it is likely that in the future telephones and computers may be replaced with immersive devices based on AR and VR, such as the HoloLens AR helmet created by Microsoft.[18]

Educators are experiencing daunting challenges in using these technologies because they are rapidly changing.

Challenges, Limitations and Moral and Ethical Dilemmas

Introducing innovative technologies involving the metaverse is subject to moral and ethical challenges.

One potential challenge of the metaverse is individuals losing focus on the realities of life. People may have less regard and consideration for the physical world. Individuals may also start losing relationships due to spending too much of their time in the virtual world, which could trigger psychological problems.

Another challenge associated with the use of these technologies in education is governance. The education field is intensely focused on the construction of standards, protocols and infrastructure to help govern the metaverse. Large organizations are focused on delivering proprietary software and hardware ecosystems that attract diverse users.[19] Diverging strategies and systematic approaches collide with privacy and openness concepts. The strategies and techniques applied will determine privacy rights for users and whether the metaverse will be inclusive for all students.[20] They

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will also determine if the metaverse will become a mainstream elearning mechanism that includes AR and VR immersive technologies in digital and electronic environments.

Educators are experiencing daunting challenges in using these technologies because they are rapidly changing. Trainers must rethink and restructure their teaching practices to match the changing technological innovations. This reconsideration is necessary to achieve the desired technology end goals in the training and education sector. A key challenge for the metaverse within the education system is the need for more convenient didactical conception models attributed to AR and VR.[21]

Cyberthreats such as sniffing, data manipulation and spoofing can render the content presented to users unreliable, even if the sources are authentic.

Addressing Challenges

There are many challenges attributed to technological innovations that can negatively impact the delivery of education goals. These challenges include mobile connectivity, price of manufacturing, and application of the ecosystem. Various strategies are available to address these challenges, including:

- Educational and learning objectives should be defined and integrated into the AR and VR learning and teaching curriculum.
- How AR and VR are implemented in the educational content informs whether the teaching method is supported.[22]
- The pedagogical benefits of the innovative technologies should be defined and evaluated against the risk.
- The infrastructure and requirements for implementing AR and VR teaching approaches must be analyzed and evaluated.
- A strategy must be formulated to help define and measure success criteria when using innovative AR and VR technologies.

These approaches ensure that it is possible to achieve positive training via the metaverse using AR and VR.

Threats Associated With AR Technology

Privacy is one of the most significant concerns when it comes to AR technology use in education and training. Users' privacy is at risk because AR technology gathers large volumes of data when it is being used. It is essential to understand the threats to user privacy related to AR technology.

Unreliable Content

Although AR browsers are useful, developers and apps outside the AR system are responsible for producing and distributing the actual AR content.[23] This presents the issue of trustworthiness because AR is a new field, and techniques for authenticating material generation and transmission are still developing. Highly skilled cybercriminals might easily replace a user's AR with their own, giving misleading public data, which can have significant negative effects in miseducation or dangerous impacts on training high-risk roles/skills.[24] It does not matter how trustworthy the source is if the content has been compromised by one of the many cybersecurity threats, including denial of service (DoS)[25] and ransomware attacks. Cyberthreats such as sniffing, data manipulation and spoofing can render the content presented to users unreliable, even if the sources are authentic.

DoS

For example, in a DoS attack, individuals who rely on AR at work can abruptly lose access to the data they need to do their jobs or complete their job training. Specialists employing AR/VR technology in life-or-death circumstances would have good reason to be concerned if they lost access to vital data. Potential scenarios include drivers losing their field of vision through an AR windshield or surgeons missing access to crucial real-time data on their AR glasses.

Ransomware

In a ransomware attack, hackers can access AR gadgets and record users' activities and interactions.[26] They may demand extortion payments in exchange for not exposing records to the public domain. People who prefer to keep their AR activities private may find this unsettling.

Threats Associated With VR Technology

There are many types of threats that can negatively affect VR technology users and leave their information vulnerable. Cyberattacks target VR technology to collect sensitive information that could harm users and negatively impact the education and training they receive from this technology.

Finger Tracking

Hand movements in the virtual world mimic actions in the actual world. By using fingers to write code on a virtual keypad a user could trigger the recording and transmission of finger-tracking data depicting fingers inputting a personal identification number (PIN). A user's identification number could be recreated from the information stolen by an attacker.[27]

Fake Identities

Videos and voices can be manipulated using ML algorithms to sound and seem entirely natural.[28] An intruder might compromise VR security by duplicating an experience in VR based on a user's motion capture data. This could be used as a social engineering tool by superimposing it on another person's VR experience or providing false information, which can lead to miseducation when being used in training.

Ransomware

VR platforms are vulnerable to attacks in which deceptive features are implanted to trick users into disclosing sensitive information.[29] Like AR, this opens the door for ransomware attacks in which criminals lock systems before demanding payment to restore them.

Possible Solutions to Mitigate AR and VR Risk

With the growth of AR and VR technology use, safety has also become important. To protect users from privacy breaches when using the technology, there are several solutions available.

Using a VPN

Using a virtual private network (VPN) service is one approach to protect an individual's online anonymity and privacy.[30] A VPN creates a secure connection to send or receive sensitive data. A person's identity and data are hidden due to the combination of a proxy IP address and strong encryption.

Reviewing Privacy Policies

Data privacy policies can be long and exhausting reads.[31] However, it is essential to learn how the developers of AR and VR platforms safeguard and use information. This may protect users from falling into the traps of cyberattackers who may manipulate their data.

Keeping Firmware Up to Date

Maintaining updated firmware on VR and AR gadgets is essential.[32] Updates repair security problems and provide new features to address new threats.

Utilizing a Comprehensive Antimalware Software

Proactive cybersecurity provides an efficient way of ensuring online safety on both AR and VR platforms. For example, using Kaspersky's security suite can prevent online threats because it provides robust protection for data.[33] It protects against malware, viruses, phishing, ransomware and spyware.

The solutions and data protection measures must address ethical dilemmas regarding the use of AR and VR to realize a balance between their efficacy and user expectations.

Conclusion

The convergence of the digital and physical worlds is happening at a rapid rate. Thanks to software and hardware improvements, AR and VR can be considered modern computing platforms. The radical changes in these technologies make them effective teaching models that can edify learners. However, despite the contributions, these technologies also pose significant challenges and risk that leave users and their data vulnerable. Because of this, users have grown skeptical of these technologies. Finding solutions to mitigate these concerns enhances the utility of the technologies. In addition, the solutions and data protection measures must address ethical dilemmas regarding the use of AR and VR to realize a balance between their efficacy and user expectations.

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