A Case Study on Augmented Reality Techniques

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***Abstract*— Augmented Reality (AR) is a rapidly evolving technology that is changing the way we interact with the world around us. It has the potential to revolutionize a wide range of industries and applications, from gaming and education to healthcare and marketing. As technology continues to advance, it is likely to consist of more exciting and innovative applications of AR in the future. AR techniques are used to enhance the real-world environment by overlaying digital information and virtual objects onto it. This is typically done using a camera-enabled device, such as a smartphone or a tablet, and software that can recognize the real-world environment and superimpose digital content onto it. Overall, AR techniques are used in a variety of industries, such as gaming, retail, advertising, education, and healthcare, to provide an immersive and interactive experience for users. This paper presents a detailed review of various AR techniques for different applications. At first, various AR techniques for different applications are studied in detail. A comparative study is conducted with their merits and demerits for identifying the challenges in those techniques and then this paper is concluded with suggestions of solutions for enhancing the efficiency of AR techniques.**

***Index Terms*— Augmented Reality, Gaming, Healthcare, Marketing, Education**

I. INTRODUCTION

Augmented Reality (AR) [1-3] is a technology that enables the overlay of digital information and virtual objects onto the physical world, in real time. AR enhances our perception of the real world by adding computer-generated sensory input such as sounds, images, and text, to create a mixed-reality experience. The history of AR dates back to the 1960s when Ivan Sutherland developed the first AR system called the "Sword of Damocles". The system used a head-mounted display that projected simple wireframe graphics onto the real world, giving the wearer a sense of being inside a virtual world. Since then, AR technology has advanced significantly, and today it is used in a wide range of applications such as gaming, education, healthcare, and marketing.

One of the most popular AR applications is gaming. AR games, such as Pokemon Go, use the camera and GPS of a mobile device to create an immersive gaming experience that blends the virtual and real worlds. In these games, players can see virtual characters and objects overlaid in the real world around them and interact with them using their mobile devices. The popularity of AR games has helped to drive the growth of AR technology and has opened up new opportunities for AR applications. AR technology is also being used in education. AR-enabled textbooks, for example, can bring learning materials to life by overlaying interactive 3D models, videos, and animations on top of traditional text and images. AR can also be used in museums and art galleries to provide visitors with a more engaging and immersive experience by overlaying digital information on top of physical exhibits.

In healthcare [4], AR technology is being used for a variety of applications, such as surgical planning, training, and patient education. AR can help surgeons to visualize complex anatomical structures and plan surgical procedures more accurately. AR can also be used to train healthcare professionals by simulating medical procedures in a safe and controlled environment. Patients can benefit from AR by using it to visualize their conditions and treatment options and to understand their medical procedures better. AR technology is also being used in marketing and advertising [5]. AR-enabled advertisements can provide customers with an interactive and immersive experience that engages them more effectively than traditional ads. AR can also be used in product visualization, allowing customers to see how products will look and feel in their real-world environments before making a purchase.

AR technology has many potential applications and is likely to become more widespread in the future as the technology continues to advance. However, there are also some challenges that need to be addressed. One of the biggest challenges is the need for more accurate and reliable tracking of real-world objects and environments. This will require advances in computer vision and sensor technology. In this article, detailed information on different AR techniques is studied. In addition to this, their performance efficiency and limitations are discussed to further improve the performance of AR techniques. The remaining part of the article is organized as follows: Section 2 provides the previous research related to AR techniques. Section 3 compares the performance efficiency of those AR techniques. Section 4 concludes an entire discussion and suggests new solutions for future enhancement.

II. SURVEY ON AUGMENTED REALITY TECHNIQUES

An integrated framework of AR, sensing, and machine learning [6] was developed for aquaculture prawn farm management. This framework examined contemporary sensors to determine their appropriateness and utilized them to monitor water quality variables in prawn ponds. Additionally, they investigated new machine learning models using the collected data to accurately predict the pond's status within the next 24 hours. This information enables farmers to anticipate future situations and take appropriate action to prevent disastrous outcomes. Finally, the authors explored augmented reality-based visualization techniques to enhance the data capture process and enable efficient decision-making through interactive interfaces in real time.

A communication paradigm called ArkaeVision [7] was introduced for the learning process. The ArkaeVision project aimed to enhance cultural experiences by creating an interactive model that resembles a 3D game, reconstructed virtually and featuring digital storytelling elements, VR, and AR. The model emphasized user participation, guiding them through historical scenarios and encouraging engagement with heritage. The paradigm's main objective was to enable the consumption of content from various levels, including records of monuments, works of art, and ancient artifacts.

A fully automatic adaptive-meshing-based segmentation system [8] was created for the automatic segmentation of the ventricular system which can be accessed on AR. Manually segmented, a dataset containing 46 T1-weighted MRI scans, some contrast-enhanced and others not, was established as ground truth (GT). The same scans were also fed into our system to produce a machine-segmented (MS) dataset. To evaluate the accuracy of the segmentation, we used the SørenseneDice similarity coefficient and the 95% Hausdorff distance to compare the GT data with the MS data. Additionally, we measured the segmentation times for all GT and MS segmentations.

AR-based visual-haptic modeling [9] was developed for thoracoscopic surgery training systems. The proposal involved incorporating an immersive AR lobectomy into a thoracoscope surgery training system that utilized visual and haptic modeling to assess the advantages of this crucial technology. The immersive AR experience was created through a cluster-based extended position-based dynamics algorithm for soft tissue physical modeling, and an AR haptic rendering system was designed with multi-touch interaction points that included both kinesthetic and pressure-sensitive points. Based on this theoretical research, an AR interactive VATS surgical training platform was developed. The proposal involved incorporating an immersive AR lobectomy into a thoracoscope surgery training system that utilized visual and haptic modeling to assess the advantages of this crucial technology. The immersive AR experience was created through a cluster-based extended position-based dynamics algorithm for soft tissue physical modeling, and an AR haptic rendering system was designed with multi-touch interaction points that included both kinesthetic and pressure-sensitive points. Based on this theoretical research, an AR interactive VATS surgical training platform was developed.

A multi-camera remote assistance system [10] was presented to support shared workspace awareness between the remote helper and local worker. The goal is to enhance the awareness of the remote helper and the local worker in a shared workspace. The local worker installed multiple cameras in the workspace, which enables the remote helper to explore different viewpoints independently. A new AR-based camera calibration procedure was developed to allow the local worker to reconfigure the cameras as needed during the task, based on requests from the remote helper. Additionally, to improve the local worker's awareness of the remote helper's current perspective and focus during the collaboration, three AR awareness cues were suggested.

A motionless calibration method [11] was presented for an AR surgery navigation system according to an optical tracker. The method solely necessitated capturing a mixed-reality image that incorporates virtual and real marker balls using the forward-facing camera of the AR glasses. By utilizing the camera coordinate system as a transformation medium, the AR navigation system determined the mapping relationship between the virtual and real spaces. The composition and functioning of the AR navigation system were explained, followed by the development of the mathematical principle for calibration.

A mental imagery task [12] was presented for creative mental imagery in reality and AR. Participants were asked to create scenes using physical or virtual objects in either real or augmented reality for a mental imagery task and to effectively create a scene in augmented reality for an execution task. The neural oscillations of healthy participants were recorded while they performed these tasks using a 32-channel wireless EEG system. In both real and augmented reality environments, and for both tasks, the participants showed a similar cortico-cortical neural signature that was based on synchronous or asynchronous beta and gamma oscillatory activities between frontal and parietal, occipito-parietal, and occipito-temporal areas on both sides of the brain.

A prototype of low-cost mobile AR techniques [13] was presented for building information modeling. By creating a prototype for a pipe maintenance scenario, we showcased the effectiveness of building an information modeling AR service, which combines an augmented reality service with a workflow management system and integrates the Internet of Things (IoT) and edge devices with a cloud server that processes extensive building information modeling data.

A mobile-based tool [14] was proposed for the real-time counting and measuring of Abalon. This tool integrated object detection and AR to assist farmer decision-making. To accomplish this goal, the initial step would involve identifying the appropriate vision-based methods for counting abalone on smartphones instantly and without relying on a network connection. The selected methods should possess the ability to recognize abalone during different stages of its life cycle, exhibit efficiency, and portability suitable for real-time use on mobile devices, and be self-contained enough to function without any external communication, allowing for use in any environment.

A co-design methodology [15] was used during a semester-long maker space course attended by 18 students in a graduate school of education, the usefulness of AR was investigated for education in maker spaces and the impact of co-designing AR technology on students. This exploration resulted in the development of six prototypes in various areas, including design, fabrication, programming, electronics, and training, with the participation of seven student co-designers. In addition to identifying practical considerations for integrating AR in maker spaces, we also discovered potential benefits of AR technology, such as facilitating construction activities, teaching science, technology, engineering, and mathematics (STEM) skills, enhancing contextualization of learning, and debugging.

III. COMPARATIVE ANALYSIS

A comparative analysis is presented in terms of the merits and demerits of different AR techniques whose operational details are studied in the above section. From the following Table 1, both merits and demerits of the above-studied techniques used for AR are investigated and the best solution is suggested to overcome those drawbacks in AR techniques to obtain better accuracy.

Table 1 Comparison of Different AR Techniques

Ref No.	Techniques	Merits	Demerits	Performance Metrics
1.	Integrated framework	By using this framework farmers gain knowledge of future circumstances and can implement precautionary measures to prevent disastrous outcomes.	High cost	Accuracy = 89.2% symmetric mean absolute percentage error: For dissolved oxygen= 6.1 %, For pH = 9.6 %, For temperature = 8.5 %
2.	Arkae Vision	It was easy for users to understand this structure for displaying events and content.	Limited to testing the Mobile App in this specific case.	80% of the users completely agreed that the application promotes learning and appropriation of cultural heritage.
3.	Fully automatic adaptive-meshing-based segmentation system	Time efficient automatic segmentation of the ventricular system.	More sensitive to thin boundaries.	Accuracy = 98% Mean SørenseneDice similarity co-efficient score = 0.83
4.	Immersive AR lobectomy	Improving novice and surgical skills that can be retained after a certain period of time	Needs improvement in terms of training time.	Visual perception: Mean = 2.39 Standard deviation = 1.04
5.	Multi-camera remote assistance system	Not restricted to a space with an installed tracking system.	Yet under-explored and important for improving remote assistance in large workspaces.	Standard Deviation =7.46 Cumulative Index = 0.18
6.	Motionless calibration method	Calibration accuracy is not dependent on the user experience.	Causing instability of virtual object location.	Average registration accuracy = 5.80 mm
7.	Neural signature	Consistent with hypothesis.	Efficiency is affected when the data may include irregular features for both beta and gamma oscillations.	For RMI: Significance value, p =0.945
8.	Low cost mobile AR technique	Reduced effort for operation and maintenance, Easy integration with relevant software and sequencing	Time consuming	-Nil-
9.	Mobile based tool	The accuracy and speed of counting and measuring of juvenile and matured abalone are enhanced by it.	It operates only on Android platform, so future work could look to expand this to a multi-platform version.	Number of Abalone =24 Accuracy = 60% Image = 31 Time =800 ms
10.	Co-design methodology	Improve student understanding and future engagement with educational technology	The effect of co-designing with a single type of technology was explored using high-fidelity prototyping.	Considerable time investment is required when a student learns about a new technology.

IV. CONCLUSIONS

AR is a technology that overlays computer-generated sensory information, such as graphics, sounds, or haptic feedback, onto the real world in real time. AR integrates digital information with the user's environment to create a composite view. AR typically involves the use of a camera or other sensors, such as a GPS or accelerometer, to capture real-world images and data, which are then processed and enhanced by a computer to generate virtual objects or information that can be superimposed onto the real world. AR has a wide range of applications, from entertainment and gaming to education, training, and healthcare. In this paper, a survey on AR techniques is presented in detail. Also, the merits and demerits of these techniques are discussed to suggest future directions toward increasing the performance of AR techniques. From the comparative analysis, it is concluded that the Co-design methodology [15] has better performance. The effect of co-designing with a single type of technology was explored using high-fidelity prototyping. In the future, the co-design methodology will be improved by developing multi-type technology.

REFERENCES:

[1] Nasser, D. N. L. (2018, November). Augmented reality in education learning and training. In *2018 JCCO Joint International Conference on ICT in Education and Training, International Conference on Computing in Arabic, and International Conference on Geocomputing (JCCO: TICET-ICCA-GECO)* (pp. 1-7). IEEE.

[2] Stübl, G., Heindl, C., Ebenhofer, G., Bauer, H., & Pichler, A. (2023). Lessons Learned from Human Pose Interaction in an Industrial Spatial Augmented Reality Application. *Procedia Computer Science*, *217*, 912-917.

[3] Roth, A. (2011, October). The Arlab and Cave libraries: On authoring augmented reality and virtual reality experiences using a graphical programming language. In *2011 IEEE International Symposium on Mixed and Augmented Reality-Arts, Media, and Humanities* (pp. 101-102). IEEE.

[4] Gerup, J., Soerensen, C. B., & Dieckmann, P. (2020). Augmented reality and mixed reality for healthcare education beyond surgery: an integrative review. *International journal of medical education*, *11*, 1.

[5] Wedel, M., Bigné, E., & Zhang, J. (2020). Virtual and augmented reality: Advancing research in consumer marketing. *International Journal of Research in Marketing*, *37*(3), 443-465.

[6] Rahman, A., Xi, M., Dabrowski, J. J., McCulloch, J., Arnold, S., Rana, M., ... & Adcock, M. (2021). An integrated framework of sensing, machine learning, and augmented reality for aquaculture prawn farm management. *Aquacultural Engineering*, *95*, 102192.

[7] Hincapié, M., Díaz, C., Zapata-Cárdenas, M. I., Rios, H. D. J. T., Valencia, D., & Güemes-Castorena, D. (2021). Augmented reality mobile apps for cultural heritage reactivation. *Computers & Electrical Engineering*, *93*, 107281.

[8] van Doormaal, J. A., Fick, T., Ali, M., Köllen, M., van der Kuijp, V., & van Doormaal, T. P. (2021). Fully automatic adaptive meshing based segmentation of the ventricular system for augmented reality visualization and navigation. *World Neurosurgery*, *156*, e9-e24.

[9] Tai, Y., Shi, J., Pan, J., Hao, A., & Chang, V. (2021). Augmented reality-based visual-haptic modeling for thoracoscopic surgery training systems. *Virtual Reality & Intelligent Hardware*, *3*(4), 274-286.

[10] Rasmussen, T., Feuchtner, T., Huang, W., & Grønbæk, K. (2022). Supporting workspace awareness in remote assistance through a flexible multi-camera system and Augmented Reality awareness cues. *Journal of Visual Communication and Image Representation*, *89*, 103655.

[11] Wan, X., Shen, L., Fang, Z., Dong, S., Zhang, S., & Lin, C. (2022). A novel motionless calibration method for augmented reality surgery navigation system based on optical tracker. *Heliyon*, *8*(12), e12115.

[12] Giannopulu, I., Brotto, G., Lee, T. J., Frangos, A., & To, D. (2022). Synchronised neural signature of creative mental imagery in reality and augmented reality. *Heliyon*, *8*(3), e09017.

[13] Um, J., min Park, J., yeon Park, S., & Yilmaz, G. (2023). Low-cost mobile augmented reality service for building information modeling. *Automation in Construction*, *146*, 104662.

[14] Napier, T., & Lee, I. (2023). Using mobile-based augmented reality and object detection for real-time Abalone growth monitoring. *Computers and Electronics in Agriculture*, *207*, 107744.

[15] Radu, I., Yuan, J., Huang, X., & Schneider, B. (2023). Charting opportunities and guidelines for augmented reality in makerspaces through prototyping and co-design research. *Computers & Education: X Reality*, *2*, 100008.