Application & Implementation Issues of AR/VR/MR in the E-Commerce Industry

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***Abstract*— The e-commerce sector is progressively utilizing augmented reality (AR), virtual reality (VR), and mixed reality (MR) technology to improve the user experience and offer a more immersive purchasing experience.AR allows e-commerce companies provide to let clients view how a piece of furniture might appear in their own house before making a purchase, for instance, by superimposing digital information over the actual environment. VR provides an entirely immersive digital experience, such as virtual product demonstrations or store tours.MR combines the real and virtual worlds, allowing customers to interact with virtual objects in a real-world setting. This can be useful for retailers in the home improvement industry, giving customers a chance to see how a new appliance would fit in their kitchen or how a new paint color would look on their living room wall. However, their implementation faces several challenges such as technological limitations, high implementation costs, and the need for specialized skills. This abstract explores the potential uses of AR/VR/MR in e-commerce and the implementation issues associated with their adoption. This paper provides information on the existing and potential uses of VR, AR, and MR in the e-commerce sector.**

Keywords*— mixed reality, virtual reality, augmented reality, e-commerce, shopping

I. INTRODUCTION

Emerging technologies like augmented reality (AR), virtual reality (VR), and mixed reality (MR) are revolutionizing how e-commerce companies interact with their customers. AR/VR/MR technologies enable e-commerce businesses to create immersive and interactive experiences that can improve customer engagement, increase sales, and reduce returns. By allowing users to digitally browse things, these technologies have the power to completely change how consumers purchase online, try on clothing and accessories, and experience products in a simulated environment. E-commerce businesses that adopt AR/VR/MR technologies can set themselves apart from rivals and provide a more enjoyable and lasting consumer experience. However, the implementation of AR/VR/MR in e-commerce also poses significant challenges, such as high implementation costs and technological limitations. E-commerce businesses need to carefully evaluate the potential benefits and challenges of AR/VR/MR before implementing them in their operations.

With a projected revenue CAGR of 35%, the worldwide market for augmented reality (AR) and virtual reality (VR) is anticipated to reach USD 237.80 billion in 2028. The global market for AR/VR in e-commerce is predicted to reach $5.5 billion by 2025, rising at a CAGR of 32.2% from 2019 to 2025, according to research by Grand View Research. According to a Retail Perceptions poll, 40% of consumers claimed they would be ready to pay extra for a product if they could experience it through augmented reality, and 61% of consumers prefer to shop at stores that provide augmented reality experiences. According to Gartner research, 25% of corporations will have placed immersive technologies into production by 2022, while 70% of businesses will be testing them out for consumer and business usage.

E-commerce giant Amazon has already started to integrate AR/VR/MR technologies into its operations. For example, Amazon's AR View allows customers to virtually place products in their homes before making a purchase, while its VR experience allows customers to virtually explore a curated list of products. The adoption of AR/VR/MR in e-commerce is not limited to large enterprises like Amazon. Smaller businesses are also starting to adopt these technologies to stay competitive and improve the customer experience. For example, Warby Parker uses AR to enable customers to try on glasses virtually, while Ikea uses AR to allow clients to picture furniture in their homes before buying.

Due to increased user engagement and a higher recall rate, augmented and virtual reality devices are becoming more and more popular, which is driving the industry. When the idea of e-commerce was widely adopted, the commerce sector saw a significant upheaval. When individuals started making purchases online, well-known businesses like Walmart and Blockbuster struggled, and competitors like Amazon, eBay, and Netflix seized the bulk of their market share. The use of virtual and augmented reality could expand e-commerce. This would hasten the decision-making process for purchases. Even if it is not anticipated that this technology will achieve the same levels of success as e-commerce, it will nonetheless be crucial to moving ahead.

II. LITERATURE SURVEY

A review of the literature on augmented reality (AR) and virtual reality (VR) in e-commerce will look at the most recent studies and research on these technologies' applications to online shopping and e-commerce. This could include topics such as the effectiveness of AR and VR for product visualization, the impact on consumer behavior and purchase decisions, and the technical challenges and limitations of implementing AR and VR in e-commerce platforms. Other areas that may be covered in a literature

review include the use of AR and VR for product personalization, virtual try-on, and virtual storefronts, as well as the potential future developments and trends in this field.

The VR software foundation may be expanded so that it can be utilized for AR applications, according to Florian Annubn. Similar elements, such as degrees of freedom, visual data, and certain engines to simulate virtual scenes, are defined as being necessary for VR/AR settings. When creating a modular design for the frame, numerous factors should be considered, including AR, IO device requirements, many layers to categorize the scene as needed, display setup, data storage, and graphical execution, e combined elements will be merged into the video stream together with the simulated sceneries. To go from virtual reality to augmented reality or vice versa, the software's setup settings must be changed, but this must be managed schematically in an organized manner by including supporting development methods [1].

The Internet has transformed commerce with the advent of e-commerce, but traditional physical commerce still dominates. To bridge the gap between online and offline shopping, the Pocket Bargain Finder is a handheld device that enables consumers to scan barcodes in physical stores and compare prices online. This innovative technology, known as augmented commerce, enables customers to examine things in-person and find the best prices online. As a result, physical retailers may face challenges as consumers can easily compare prices and potentially find better deals elsewhere. The Pocket Bargain Finder represents a breakthrough technology that has the potential to transform the landscape of both online and offline retail [2].

Author Xueshi et al. discuss the possibility of a handheld mobile VR experience connected to a remote rendering edge/cloud computing device. It was vital to create the HMD device lighter, more comfortable, and portable because the HMDs (Head Mounted Displays) that are now on the market are still quite heavy, cumbersome, and lack the mobility of the 854 S. Kumari and N. Polke when coupled to a computer. The rendering will be placed on edge/cloud servers, enabling widespread VR/AR. The difficulties with the cloud/edge strategy relate to bandwidth and latency problems, which will have an impact on rendering and video streaming. The total bitrates of the cloud-rendered video streams from various users can be reduced without sacrificing the video quality to transmit the FoV (field of view) video as one potential method of resolving these issues. For servers and cloud/edge users, a new encryption and transmission technique can be implemented to achieve this. Second, by lowering the rotation delay by the head rotation, body motions, and control instructions, the latency issue in streaming 360-degree movies may be resolved. These are potential methods to address low latency requirements, enable cloud/edge-based wireless VR/AR, and fix bandwidth concerns [3].

The digital world experienced a decade's worth of e-commerce growth in just 90 days in 2020, with 100,000 physical stores expected to close within five years due to changing consumer habits caused by Covid-19. Online experiences and higher expectations for shopping convenience and personalization have led to immediate changes in consumer consumption patterns. Even Gen Z, who enjoy virtual interactions, with 80% of their friends being people they have never met in person, are contributing to the increased momentum of virtual experiences. However, despite the significant growth in e-commerce, the average conversion rate remains low, with only 3% of visitors making purchases on e-commerce platforms. Understanding the behavior of the remaining 97% of visitors who do not make purchases is crucial for ensuring a sustainable digital future. To determine if e-commerce has reached its full potential and how customers react to Extended Reality (XR) in the context of commerce, brand makers and merchants must do so. This elucidative research, involving 335 participants, aims to discuss consumer prospects regarding the condition of e-commerce today and look at how they feel about XR Commerce. The results of this exploratory study provide insights for brand manufacturers to prioritize elements in enhancing user experience, prompting a rethinking of prospects for online shopping [4].

Technological innovation has led to increased complexity and accessibility of information and communication devices, resulting in significant changes in user behavior and relationships. Users feel both liberated from materiality through the virtualization of contacts and friendships but also trapped in the ever-evolving trends of technology consumption, communication, and relationships. The rise of e-commerce, which grew by 17% in Italy in 2014 with a value of 13.3 billion euros, particularly through mobile devices, is an example of this evolution. Predictions for mobile e-commerce indicate continued growth in the market of smartphones, tablets, and PCs with approximately 2.5 billion units in 2019, with smartphones likely to account for the majority of shipments of smart-connected devices [5].

The proposed system "KidLand" is an augmented reality (AR)-based virtual toy store that offers unique features to enhance the online shopping experience. These features include an interior navigation system for huge shopping malls, a virtual tour to improve remote purchasing, and a 3D toy generation for visualizing certain products. One of the main issues with existing e-commerce platforms is the lack of image search functionality, which "KidLand" addresses by implementing an image search engine that uses machine learning methods to recommend nearby branches and add-on-related products. Additionally, a chatbot with artificial intelligence that uses reinforcement learning and natural language understanding (NLU) offers potential answers for the toy business. Another innovative feature of "KidLand" is its ability to chat in both English and Sinhala languages, overcoming language literacy problems. Overall, "KidLand" aims new way of shopping experience using AR technology, advanced technologies, and marketing strategies, addressing the limitations of traditional e-commerce platforms in Sri Lanka [6].

To integrate the design process in a first-person viewpoint and perceptual size, Design3R, a computer-aided design (CAD) system for E-Commerce interior architectural design, uses augmented reality (AR) and virtual reality (VR) technology. This enables designers to work immediately within a realistic image of the intended space, directly with furniture and other interior pieces in their actual dimensions. As a cross-platform software, Design3R also involves collaboration with 3R Studio Mobile E-Commerce company

for research and development. The project intends to make use of HTC Vive and Google Tango's capabilities to provide a design environment that seamlessly combines the interiors of actual buildings with the burgeoning interior designs of e-commerce [7].

The creation of new collaborative interactions in 3-D virtual worlds has been made possible by the arrival of Web 2.0. This evaluation focuses on the usage of p-health, a customized immersive e-therapy that leverages inter-reality to combine the real and virtual worlds. According to the research, using 3-D virtual worlds can improve clinical communication, increase group processes and cohesiveness in group-based therapies, and foster higher levels of interpersonal trust between therapists and patients than traditional telehealth applications. However, issues with addiction, privacy, and personal safety must also be addressed [8].

Modern e-commerce technology falls short of delivering personalized descriptions to users. However, existing marker-based tracking technology poses challenges for AR in business. A new approach that utilizes markerless visual tracking with image capabilities, and features point-based neural network images, can be used for AR e-commerce applications. Using SIFT, which is invariant to picture scaling and rotation as well as largely invariant to changes in lighting and perspective, this method includes extracting features from reference images. Temporary chaos neural networks (TCNN) are then used for global feature matching and trace initialization. Future studies may concentrate on investigating real-time augmented reality systems and lowering the computing cost of SIFT component retrieval [9].

By superimposing virtual 3D information over a 2D printed surface, augmented reality (AR) offers the potential to improve educational theories, such as a textbook diagram, allowing students to interact with and visualize the content in real time. However, the setup and display of AR can be complex due to various encryption, decryption, and marker requirements. A portable browser-based platform that utilizes scan-able QR codes on mobile phones offers a low-cost and convenient solution. Users can simply scan the QR code with their internet-enabled smartphone, which redirects them to a public website that generates the AR experience directly on their browser. This approach eliminates the need to install specific apps. The system allows users to upload pictures and specify actions related to them, such as displaying a 3D model or playing a movie. The setup is completed by printing an AR card with a QR code and black border, which users can point their smartphones at to view the augmented content. This strategy may be used in reporting, e-commerce, real estate, education, gambling, and other industries [10].

According to Superdata Research, sales of these technologies are forecasted to be 21 times higher in 2020 than in 2016. The COVID-19 pandemic has intensified this tendency, which has increased internet buying and a need for more immersive online experiences. Research has shown that the use of AR in e-commerce can lead to higher conversion rates. According to Shopify, the conversion rate for sales with AR content was 94% higher than for products without AR. Deloitte also points out that immersive experiences from AR and VR may be just as good as or better than those from conventional retail stores and online buying. According to the literature, there is currently a lack of comprehensive knowledge of the use of VR/AR in e-commerce. Extended reality (XR), which covers VR, AR, and MR, has been the subject of systematic literature reviews. While there is a growing corpus of research on the usage of XR in many industries, more empirical studies on the usefulness of XR in e-commerce are still needed [11].

In their work, Ramanujam and Srinivasa suggest a concept for an augmented reality browser that presents online pages devoid of impeding the user's view of things. When using the suggested APIs, the browser offers personalized layouts for websites when viewed through AR headsets. This method allows programmers to design unique web page layouts, which could eventually lead to the standardization of CSS and JavaScript for AR. The study emphasizes the possibility of programming the web-client side while maintaining end-user privacy and security, concentrating on straightforward objects like QR codes. [12].

III. Application Of AR/VR in E-Commerce

A. *Product visualization:*

- Product visualization using AR and VR allows customers to see how a product will look in their environment before they make a purchase. This can be particularly useful for items such as furniture, home decor, and appliances, where customers want to see how the product will fit and look in their own space.
- This can also be useful for products like cars, motorcycles, and other vehicles, by allowing customers to see a virtual representation of the vehicle in different colors or with different options, before making a purchase.
- Retailers can also create AR and VR web experiences that customers can access through a computer or mobile device. Customers can use the device's camera to scan the space and place virtual products in it. Retailers can also use 3D product models that shoppers can rotate and view from all angles to better understand how products will look in person.

B. *In-store experience:*

- Retailers can use AR and VR to demonstrate how a product works, such as showing customers how to assemble furniture or how to use a new appliance.
- Retailers can create virtual store tours using VR technology to allow customers to explore the store and products in a more immersive way.
- Retailers can use VR technology to create virtual store tours, allowing shoppers to more immersively explore stores and products. Retailers can create virtual advertisements that allow shoppers to interact with products in a virtual environment.

C. *Live streaming and events:*

- Retailers can create virtual showrooms using AR technology that customers can explore during live-

streaming events. This can allow customers to see products more interactively and engagingly.

- Retailers could create VR advertisements that let viewers engage with items in a virtual setting while watching a live video. Retailers can use AR to create interactive quizzes and surveys during live streams to increase customer engagement and engagement. Retailers can create virtual reality games that customers can play during live streams to receive discounts or giveaways.
- Overall, the use of AR technology in live broadcasts and events can provide a more engaging interactive experience for customers and increase sales. Retailers can use these technologies to create more immersive, interactive shopping experiences for their customers and help them make better buying decisions.

D. Interactive product tutorials:

- AR and VR can be used to create interactive tutorials and demonstrations, which can help customers learn more about a product and make more informed purchasing decisions.
- VR can be used to create interactive tutorials that customers can experience in a fully immersive environment, allowing them to learn about a product in a more engaging way. This can be especially useful for products like software, mobile apps, and video games.
- AR can be used to overlay step-by-step instructions on top of a real-world product, making it easier for customers to understand how to use it. This can be especially useful for products like toys, gadgets, and appliances.

E. Virtual interior design:

- Virtual reality (VR) may be used to develop interior design experiences that let buyers see how furniture and other accessories will appear in their own homes before buying.
- Virtual interior design with AR and VR technology might improve the online furniture and home décor purchasing experience by enabling buyers to see how products will appear in their own space before buying. This technology can also be used by interior designers to create virtual walkthroughs of design plans for clients. E-commerce businesses can integrate this technology on their website or mobile app to give customers an interactive and immersive shopping experience.
- The use of technology to provide visual representations of interior spaces is known as virtual interior design. This may be accomplished using 3D modeling, virtual reality (VR), augmented reality (AR), and computer-aided design (CAD) tools. Virtual interior design allows designers to create and present design plans and concept boards to clients and allows clients to visualize and interact with their potential new space before any physical work is done. Virtual interior design can also be used for virtual staging, which can be helpful for real estate listings, and for pre-construction visualization.

F. Training and Education:

- Training and education are crucial aspects of the e-commerce sector, and AR/VR/MR technologies play an important role in enhancing the effectiveness and efficiency of training programs. Here are some ways AR/VR/MR can be utilized for training and education in the e-commerce industry.
- AR/VR/MR can provide virtual product training for employees in the e-commerce industry. Employees can use AR/VR/MR to interact with 3D product models and understand product features, functionalities, and usage instructions in a more immersive and engaging way. This can help them gain a deeper understanding of products and improve their product knowledge, which is crucial for providing accurate information to customers.
- AR/VR/MR can be used to train employees on various e-commerce processes and procedures, such as order fulfillment, inventory management, and shipping logistics. Employees can participate in virtual simulations that replicate these processes, allowing them to practice and master the steps involved in a realistic virtual environment.

IV. Available AR and VR Products in the Current Market in the E-commerce Segment

Numerous AR and VR products available in the market are specifically designed for the e-commerce segment. These products offer a range of functionalities and features aimed at enhancing the online shopping experience for customers, improving product visualization, and driving higher engagement and conversion rates.

Several AR try-on apps are available in the market that allows customers to virtually try on products such as clothing, eyewear, makeup, and accessories. These apps use AR technology to overlay virtual images of the products onto the real-time camera feed of the users, allowing them to see how the products would look on them before buying the products.

Some e-commerce websites and platforms offer 360-degree product visualizations using VR or AR technology. These visualizations allow customers to view products from all angles, zoom in and out, and interact with the products in a more detailed and realistic manner, providing a better understanding of the product's features and quality.

This section compares and contrasts the many AR/VR items now on the market, which are quickly revolutionizing the forthcoming technologies in the e-commerce industry. (TABLE I).

TABLE I.

S.No.	*AR/VR Product Name*	*Product Description*	*Product Image*
1.	**IKEA Place**	Customers can envision how furniture will appear in their homes with IKEA's augmented reality app before purchasing a product.	
2.	**Wayfair**	Wayfair's AR app offers customers to see how furniture would look in their space before purchasing a product.	
3.	**Sephora Virtual Artist**	The Sephora app allows customers to try on makeup virtually before making a purchase.	
4.	**Lowe's Holoroom**	Lowe's Home Improvement's VR app allows customers to design their kitchen and see how it would look in a virtual reality setting.	
5.	**Amazon's AR view**	Amazon's AR feature allows customers to view products in a digital overlay on the physical world, making it easy to visualize how an item would look in the space.	
6.	**Zara's virtual fitting room**	Zara's AR app allows customers to virtually try on clothes before making a purchase.	
7.	**Virtual reality showrooms**	Many e-commerce companies are using VR technology to create virtual showrooms for their products, allowing customers to explore and interact with them in a virtual environment.	
8.	**L'Oréal Makeup Genius**	L'Oréal's AR app allows customers to try on makeup virtually while making a purchase.	

V. Issues for Implementation of AR, VR in the E-Commerce Industry

- **High development costs:** Companies may need to spend a lot of money on pricey hardware and software to sustain AR and VR technologies, which may be expensive to develop.
- **Limited customer base**: Not all customers have the hardware or software necessary to use AR and VR technology, which can limit the potential customer base for companies that implement it.
- **Lack of standardization:** There is currently a lack of standardization in the AR and VR industry, which can make it difficult for companies to ensure that their technology is compatible with the hardware and software used by their customers.
- **Technical challenges**: AR and VR technology can be complex, and companies may need to invest in specialized staff or hire outside contractors to ensure that the technology is implemented correctly.
- **Data privacy and security:** Because AR and VR technology depend on the gathering and use of personal data, there may be worries about data privacy and security. As a result, businesses must take extra precautions to secure consumers' data.
- **Limited scalability:** Companies need to consider the scalability of their AR and VR technology and ensure that it can handle many users and transactions.
- **Limited support:** AR and VR technology is still a new field and support from the vendors is limited. Companies may have difficulty finding experts who can help them troubleshoot problems or provide ongoing support for their technology.
- **Mobility/miniaturization issues:** Either Mobility is a major issue or very few VR products limit free to use. Movement due to the large number of cords attached to the HMD (Head Display), and other wearable devices and the development of these VR products Compact, lightweight, compact, and convenient form to give users Wireless or cordless and ease of use.

VI. Conclusion and Future Scope

In conclusion, by offering customers fresh and engaging purchasing experiences, augmented reality and virtual reality have the potential to completely transform the e-commerce sector. These technologies may be used to build virtual showrooms, provide customers with the option to virtually try on clothing and cosmetics, enable them to picture objects in their homes, and many other things. However, there are implementation issues that companies need to consider such as high development costs, limited customer base, lack of standardization, technical challenges, data privacy and security, and limited scalability. Despite these challenges, many companies are finding that the benefits of AR and VR technology and e-commerce outweigh the costs and challenges of implementation. As technology continues to advance, the use of these technologies in e-commerce will likely become more widespread and sophisticated.

The future of AR and VR in e-commerce is promising, with many opportunities for growth and innovation. As technology continues to improve, and more people become familiar with it, we can anticipate more businesses using AR and VR in their online storefronts. AR and VR have a bright future in e-commerce, with many opportunities for growth and innovation. As technology continues to improve, and more people become familiar with it, we can expect to see more companies adopting AR and VR in e-commerce operations. Overall, the usage of AR and VR in e-commerce has a bright future since it will continue to change how consumers purchase and engage with goods and services.

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