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Design and Development of a Cost Effective WebVR Commerce System Prototype

[1]Nurazlin Zainal Azmi*, [2]Thomas Liem Shiaw Hong
[1]Dept. of Information Systems, International Islamic University Malaysia, Kuala Lumpur, Malaysia.
[2]Faculty of Engineering and Computing, First City University College, Petaling Jaya, Malaysia.

*Corresponding author: nurazlinazmi@iium.edu.my
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Abstract— This project focuses on the design and development of a cost-effective WebVR commerce system prototype to enhance the online shopping experience. Despite the rapid growth of E-commerce, platforms face challenges such as limited interactivity, static product presentations, and lengthy purchasing procedures, which often lead customers to abandon online shopping in favor of physical stores. The proposed WebVR system leverages virtual reality to address these issues, providing an immersive and interactive shopping experience. By enabling users to visualize and explore products in a 3D virtual environment, the system bridges the gap between online and in-store shopping. However, virtual reality often requires costly hardware and powerful workstations to process the positioning data. Therefore, this project focuses on utilizing affordable technologies and frameworks to create a seamless and accessible solution, making WebVR a more practical option for a wider audience.

Keywords— Cost effective WebVR, virtual reality, e-commerce.

I. Introduction

Since the development of the first system in 1979 by Michael Aldrich [1], the online shopping platform has grown exponentially from simple texts and images multipage website to utterly complicated networks of online applications, featuring mobile-friendly purchasing, social shopping and much more. Innovation in today's technology has constantly evolved the E-commerce landscape and has worked as a catalyst to move it forward. E-commerce practitioners from all industries need to be ready to step up and embrace innovation as a mean of staying ahead of the game.

Virtual reality (VR) has already existed in the market for decades. It represents a transformative shift in how we interact with digital environments, crossing the boundaries between the physical and virtual worlds, and at the same time offering immersive experiences to the user [2]. Most of the VR equipment in the market are extremely expensive and require specific sets of software installed to bridge the two worlds. For the WebVR to become a norm in everyday use, it is essential to develop a cost-effective system.

A. Problem Statement

E-commerce provides an easy way to sell products to a large customer base. Customers expect to find what they are looking for quickly and easily. While shopping online, customers must imagine and interpret what an item would feel like in their hands or look like in their home. These sensory elements that customers rely on to make their purchasing decisions are often lost during online shopping, which can lead to unsatisfactory purchases.

B. Objective

The main purpose of this project is to develop a cost-effective virtual reality system that allows everyone to explore new ways of accessing daily information and resources through environment simulations using three-dimensional graphics.

This paper is based on a final year project completed in 2017. While the technologies and methods used reflect the standards of that time, the prototype serves as a foundational basis for ongoing work in this area. Recent advancements and current practices have been reviewed and incorporated into the discussion to ensure relevance moving forward.

The general structure of this paper is as follows: The first section provides an introduction. Related works are presented in Section 2. Prototype requirements are listed in Section 3. The development process and methodology, the preliminary results, and the discussions are represented in sections 4 and 5, respectively. Finally, the study's conclusion is presented in Section 6.

II. Related Work

Back in 2010, VR was already considered an alternative to conventional methods, improving product presentation and offering greater flexibility to customers [3]. In recent years,

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more research has been dedicated to studying extended reality within the e-commerce context.

[4] focused their study on levelling the field between large companies, and small businesses and retailers, by giving them a chance to compete equally using VR and AI-driven e-commerce platform. They proposed to develop a VR-powered shopping platform with a recommendation system (RS) and an intelligent agent that allows small businesses to offer their products in a virtual environment.

The immersive feature of VR makes it appealing for integration into the e-commerce field, enhancing the shopping experience, as discussed in the following works. [5] proposed an integration of Augmented Reality (AR) and VR to enhance customer engagement. AR is used for visualizing shortlisted items as well as in-store navigation, whereas VR is utilized for heightening the shopping experience while interacting with objects in a shared simulated environment with family and acquaintances. A similar work is also reported by [6], where the results yielded positive outcomes, including enhanced product visualization, improved customer engagement, reduced product returns, and increased cross-selling and upselling. However, there was also a concern addressed by customers regarding the privacy and security when using AR/VR technology in e-commerce. [7] shared the same outcome, where their proposed model for an AR/VR e-commerce to enhance user experience has seen significant improvements in user engagement, personalization, and product information flexibility.

[8] extended the application into the Metaverse by proposing a virtual commerce that incorporates AR, VR, 3D holographic avatars, and other type of communication. Based on the preliminary testing, it showed that users found it attractive to explore new places in the Metaverse, and the use of 3D avatar influenced them to buy from the stores that use this technology.

Covid-19 was also a reason to incorporate VR into the e-commerce world. Since many consumers were forced to shop online, this led [7] to propose a UX design model for virtual shopping which focuses on psychological stimulation and social shopping, the two aspects that make shopping an entertaining activity.

To make the experience more interesting, [10] proposed a VR-based game called Virtual Bazaar, to support healthier food choices. The game keeps a check on the Calorie requirements set by the user, displays Nutritional Information of products and create awareness for Healthier Products. From the results, it was found that players benefitted from the game by learning how to choose healthier products.

AI has also made its way into the virtual commerce as demonstrated by [11]. Their proposed VR Supermarket included a recommendation system based on the users' purchase history, which in turn makes it a dynamic, adaptive and user-oriented system, improving the overall user experience.

Based on the findings, it is reasonable to predict that VR/AR will become the new normal in the e-commerce industry. This underscores the importance of developing cost-effective systems to ensure that most people can participate in and benefit from this transformative experience.

III. Prototype Requirements

The hardware is a critical component required to ensure the success of this project. Premium VR experiences require head-mounted displays (HMDs) such as the Oculus Rift, HTC Vive, or newer models like the Vive Pro and Meta Quest 3. that are costly on its own and not to mention the cost of a powerful workstation needed to process the positioning data. This approach does not align with our objective of making VR accessible to everyone, including novice users.

The solution needs to be cost-effective while allowing expandability for device upgrades. Smartphones, which most people already own, can serve as displays, paired with affordable viewers like Google Cardboard to create a simple virtual reality setup.

The lenses in the viewers create the 3D effect required, and the gyroscope inside common smartphones translates users' positions into the VR environment. The smartphone itself also provides the processing power for positioning data, and this setup fulfills all the hardware requirements.

IV. Development Process and Methodology

A. *Framework Implementation*

A-Frame, a fully open-source project, is one of the WebVR frameworks that enable VR in web browsers. It provides the convenience of building scenes with just HTML while offering unlimited access to JavaScript, Three.js, and all existing Web APIs. It uses an entity-component-system pattern that promotes composition and extensibility [12]. In modern usage, A-Frame integrates seamlessly with the WebXR ecosystem.

A-Frame, developed by the Mozilla VR team in 2015, enables web developers and designers to create 3D and VR experiences using HTML, without requiring knowledge of WebGL. It offers an easy setup, compatibility with JavaScript libraries, and an extensible entity-component system for reusable components. Unlike Three.js, which requires extensive knowledge of WebGL, or Babylon.js, which focuses on advanced graphics and physics engines, A-Frame stands out for its simplicity, rapid development capabilities, compatibility with existing JavaScript libraries, flexibility, and ease of use. These attributes make it an ideal choice for

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this project, particularly in the context of a time-constrained and resource-limited final year project.

B. VR Viewer Implementation

After selecting the framework, the next step is to display the VR content. To ensure accessibility for everyone, including novice users, using an open-source VR viewer is the most suitable option.

Google Cardboard is one of the best open-source VR viewers, developed as part of Google's 20 percent project – a company policy that allows employees to work on side projects in addition to their regular tasks.

Google Cardboard works by placing a smartphone at an optimal distance from the lenses. Using compatible apps, the lenses create a 3D effect when held up to the users' eyes. As users move their heads, the display output synchronizes with their movements, creating the illusion of moving within a virtual space. This simple setup transforms interactions with a smartphone screen into a seemingly real-world experience.

Fig. 1 Google Cardboard DIY Template (Credits: [13])

Google provides an open-source template online for those interested in building their own viewer, as shown in Fig. 1.

C. Scene Design

Designing the scene is the first step in creating a 3D simulated environment using A-Frame. With basic knowledge of HTML and JavaScript, users can construct ready-to-use scenes and design stages using the A-Frame Inspector, as shown in Fig. 2. This visual tool allows for dragging, rotating, and scaling entities with immediate result previews.

After setting up the stage, a 360-degree background is added using a sky primitive, which applies either a color or 360° images as the scene's backdrop. The camera is positioned within the sky-sphere to ensure textures and distortions are rendered accurately from the user's perspective.

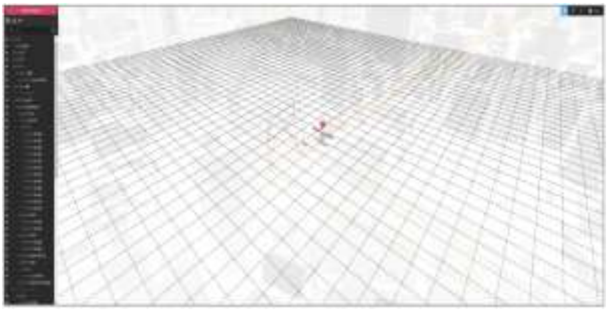

Fig. 2 *Scene Building Process*

To map the background seamlessly, the image used for the sky-sphere must be an equirectangular image, a type of projection that maps the surface of a sphere to a flat image. Fig. 3 shows an example of an equirectangular image.

Fig.3 *Example of Equirectangular Image (Credits: [14])*

In this project, pre-existing equirectangular images from a repository are used, as capturing such images requires a 360-degree camera and specialized software for stitching panoramas to ensure proper alignment and distortion.

D. Splash Screen

A minimalist design splash screen is created, featuring hints and instructions to guide users, as shown in Fig. 4. The hints include navigational instructions for exploring the VR content and explanations of the functions for various buttons.

Fig. 4 *Splash Screen*

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The layout of the splash screen includes an animated logo and a button to start the shopping navigation. Transition animations are added to enhance the browsing experience during the appearance of elements.

E. User Interface Design

Providing proper instructions and guidance on navigation controls is essential for users. The Toggle VR button is included to give users the option to browse the content either in a browser or through a VR viewer. This feature also prepares users before entering the VR mode. If users attempt to enter in portrait VR mode, a friendly guide is displayed to demonstrate the proper way to view the content and redirects them once they have corrected their orientation. Fig. 5 shows the Toggle VR button at the bottom-right corner of the figure.

The WebVR navigation pattern has yet to be standardized, as it is still in its early stages of development. Consequently, there is no standard procedure for performing specific actions. To address this, hints and instructions are provided as a workaround to guide users through the purchasing process.

Fig. 5 *Main Menu with Toggle VR Button*

The VR content is displayed in a 360-degree view, which can occasionally cause users to lose their orientation when switching scenes. To address this, the user interface ensures that users are always oriented toward the content. A Back-to-Content indicator, as shown in Fig. 6, appears when the content region is outside the user's field of view. This indicator serves as a guide to help users return to the correct direction.

Fig. 6 *Back-to-Content Indicator*

The user interface employs a color scheme combining dark grey and fuchsia, which is believed to evoke a sense of excitement and modernity [15], as shown in Fig. 7.

Fig. 7 *UI Colour Theme*

F. Camera and Cursor

A fixed-point interface is implemented to reduce motion sickness and provide easy access to layout controls, although it limits the utilization of space in a 3D environment.

To set up the fixed-point interface, a simple shape cursor or indicator is positioned at the center of the camera view, enabling users to access basic VR controls through clicking and gazing. This interaction is facilitated by a raycaster component that detects click events and captures only the first intersected entity. Fig. 8 shows the camera and cursor setup. When the mouse is clicked, the closest visible entity intersecting the cursor emits a click event. A simple ring geometry is used as the cursor, fixed at the center of the screen and attached as a child of the camera entity to ensure it remains centered regardless of the user's orientation. Events are triggered when the cursor interacts or fuses with an entity.

The system employs a Fuse-Based Cursor, also known as a gaze-based cursor. Instead of clicking or tapping, the cursor triggers a click when users gaze at an entity for a predetermined amount of time, resembling a laser extended from the user's head into the scene. If the user stares at an entity long enough, the cursor initiates a click on the respective entity. Figure 9 illustrates the Fuse-Based Cursor, with the left side showing the cursor idle and the right side showing it fusing with a menu button.

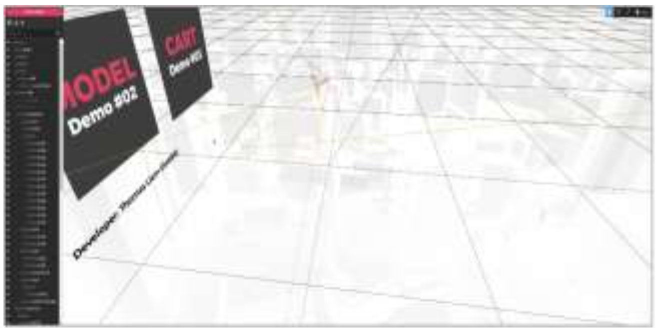

Fig. 8 *Camera and Cursor*

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Fig. 9 *Fuse-Based Cursor*

The advantage of using fuse-based interaction for VR is that it does not require additional input devices other than the headset, making it ideal for Google Cardboard applications. However, the main drawback of the fuse-based cursor is that it requires users to turn their heads frequently, which can be physically demanding.

To enhance user experience, visual and audio feedback are incorporated to make the system more responsive and user-friendly. Whenever the cursor intersects with an entity, it emits an event that triggers the animation system, playing an animation along with an audio clip. This feedback provides users with a clear indication of the cursor's fusion with the entity.

G. Object Modelling

A-Frame supports assets imported from software like Blender, Maya, or 3DMax in formats such as OBJ and DAE. For this project, a COLLADA (.DAE) model is used, with the Collada model component loading the 3D assets.

Due to the complexity of 3D modeling, suitable object models were selected from a model repository to save time. These pre-existing sample models are compatible with the prototype. Once the 3D models are added to the scene, they are animated, allowing users to view the products in 360 degrees. Users can freely zoom in and rotate the objects as they change their view, as shown in Fig. 10.

The 360-degree product visualization adds significant value to the purchasing process by bridging the gap between imagination and reality. It allows customers to accurately visualize products, leading to more confident and satisfying purchase decisions.

Fig. 10 *Information Panel*

H. Payment Gateway

At the time of developing this prototype, PayPal was the only feasible option for integrating a payment gateway into VR websites. Foreign payment gateways were less favorable due to the lack of multi-currency support, making PayPal the preferred choice as it could be easily integrated into websites written in any programming language. Fig. 11 shows the payment gateway implemented in VR mode.

It is worth noting that avoiding foreign gateways is less critical nowadays. Payment gateway solutions for VR websites have evolved, with APIs specifically designed for VR, such as Stripe, Meta Pay, and the Web Payment API.

Fig. 11 *Payment Gateway*

I. System Procedure

When the system starts, users are presented with a splash screen. At this stage, all graphical assets are preloaded to ensure a seamless experience without delays before starting the session.

From the splash screen, users are redirected to the main menu, where three tile buttons are displayed, each corresponding to a different demo function. Users can select a tile button by gazing at it.

Selecting the product demo option transports users to the product demo scene, where three product models are available for preview. Gazing at a product model zooms in on the selected product and displays its information panel. The panel contains details such as the product description, price, availability, reviews, and ratings. If users are satisfied with the product, they can add it to their cart by selecting the 'Add to Cart' button.

Selecting the model demo option displays a rotating model, allowing users to visualize the product being worn for a better viewing experience. An information panel is also provided, displaying details about the product and the merchant. If satisfied, users can proceed by adding the product to their cart.

After adding items to the cart, users are redirected to the payment gateway. Since the payment gateway is accessible in VR mode, users do not need to remove their VR viewer to fill out the payment information form. The gateway displays the details of the selected product, enabling users to verify them before proceeding to checkout.

Once verified, users are redirected to PayPal for the checkout process. The purchasing process is considered complete once the payment is successfully made in PayPal and the transaction is processed without issues.

V. Preliminary Usability Testing

For the preliminary testing phase, the focus was placed on gathering qualitative feedback through a survey conducted with a selected group of participants who had experience with online shopping. The primary goal at this stage was to assess the system's usability, interface design, and overall user experience. Quantitative data, such as task completion times or success rates, was not collected during this phase as the objective was to identify areas for improvement rather than measure performance metrics.

From the preliminary testing, most participants agreed that the system features a user-friendly interface. They found that the hints and instructions available in every scene had effectively guided them through the purchasing process. Additionally, the clean and minimalist design, utilizing the selected color scheme, was well-received.

Participants reported minimal motion sickness during the process and found the experience interesting and engaging. Many noted that they had never tried online shopping in VR mode before and expressed interest in using the system again if it were officially launched.

Despite the positive feedback, some participants pointed out some limitations found with this prototype. A notable issue was the inability to control the rotation of 3D models during the preview. Users had to wait for the object to rotate to their desired position instead of freely adjusting it. Another limitation was the incomplete cart system, which allowed only one item to be added at a time. This was due to the lack of native support for such functionality in A-Frame, requiring the use of third-party JavaScript libraries.

Additionally, the system experienced disorientation errors when accessed on smartphones with smaller screens, impacting the overall user experience.

TABLE I
Feedback Summary

Positive Feedback	**Negative Feedback**
User-friendly interface	No control over 3D models
Motion sick minimized	Incomplete cart system
New and interesting experiences	Poor space management
Products visualized through 3D models	Limited compatibility

Table 1 provides the summary of the feedback from participants during this closed testing session.

According to [16], challenges include designing for various devices, addressing motion sickness and discomfort, and ensuring privacy and security. [17] further highlights issues like latency, power consumption, hardware stability, usability, and portability. While privacy and security are not the primary focus at this stage, this project encountered device compatibility and navigation issues during development. Creating an immersive WebVR environment that matches real-world experiences remains challenging, with latency being a critical factor that reduces user satisfaction and heightens motion sickness.

To address this issue while making the system accessible to everyday users, certain compromises are suggested. High-performance hardware typically required for seamless VR interactions could be substituted with simplified, predefined object viewing configurations, which would mitigate the impact of latency while maintaining usability. Similarly, adopting a minimalist user interface could reduce computational demands, addressing latency concerns and enhancing the user experience. These proposed trade-offs highlight the balance required to develop cost-effective WebVR systems.

VI. Conclusions

VR online shopping offers a unique and engaging experience. However, making it a common shopping experience for everyone requires time, resources, and collaborative effort.

Based on the feedback received, several improvements can be implemented for this prototype:

- Proper database implementation: A robust database is essential efficient data management. Integrating a database with third-party JavaScript libraries can enhance the cart system's functionality. Additionally, with the rise of AI, data collection can facilitate statistical analysis and insights into users' preferences and shopping patterns. This, in turn, can enable personalized recommendations for current and future purchases.
- Improved device compatibility: Display disorientation was reported during testing. For VR online shopping to appeal to a wider audience, compatibility with a broader range of devices, including tablets and smartphones with smaller screens, must be improved.
- Integration with AR: Augmented Reality (AR) can be incorporated to visualize virtual objects in the real world. Displaying objects in real-world dimensions could provide users with a better understanding of spatial usage, aiding in more informed purchasing decisions.

Although this prototype was initially developed in 2017, it remains relevant for continued research and development. Moving forward, recent technological advancements, particularly in privacy and security, will be incorporated to further extend and refine the original work presented here.

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foundation for this paper. His contributions provided a strong basis for extending the concept and adapting it to align with current technological advancements.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

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