



# Enhancing E-Commerce Experience through Advanced Augmented Reality Technology

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**Abstract:** This paper presents an innovative Augmented Reality (AR) application poised to transform the furniture shopping experience in e-commerce. Breaking away from traditional AR technologies like Vuforia, 3.js, or YOLO, our application is crafted using Unity and AR Foundation, introducing a novel approach tailored for online furniture visualization. This project differentiates itself by employing custom-made 3D furniture models created in Blender and refined in Unity, ensuring a unique and immersive user interaction. Users can effortlessly visualize and position furniture in their homes with unparalleled precision, courtesy of our application's phone camera integration. A standout feature is our application's user interface, intuitively designed to facilitate seamless interaction with AR elements. We've introduced a custom placement indicator and raycast function, specifically engineered to tackle the common spatial challenges, ensuring accurate furniture placement without recognizing walls as potential planes. This approach addresses critical limitations observed in competing AR e-commerce platforms, where objects erroneously extend beyond physical boundaries. By prioritizing spatial accuracy and user-centric design, our application caters to both immediate consumer needs and the broader movement towards digitalization and sustainability in retail. This initiative not only elevates the shopping experience for customers, enabling better decision-making and reducing return rates but also heralds a new era for online retail, enhancing engagement and fostering loyalty among users.

**Keywords:** Augmented Reality, AR, E-Commerce, Blender, Unity, Furniture, Raycast positioning, AR Foundation, Plane Tracking, Mobile Application

## 1. INTRODUCTION:

In the realm of digital innovation, Augmented Reality (AR) has emerged as a transformative technology, seamlessly merging virtual objects with the real world to enhance user experience and interaction. This paper introduces a groundbreaking AR application, specifically designed for the e-commerce sector, to revolutionize how consumers select and visualize furniture in their home spaces. Our application, developed using Unity and AR Foundation, diverges from traditional methodologies by not relying on commonly used technologies such as Vuforia, 3.js, or YOLO. Instead, it presents a novel approach tailored to deliver a unique and immersive shopping experience.

### 1.1 Overall Workflow

The application's workflow, meticulously designed for a seamless and intuitive experience, is further enriched by the addition of unique, high-quality 3D furniture models created in Blender and refined in Unity, providing users with a diverse and exclusive selection that underscores the application's uniqueness. This customization elevates the user experience beyond the conventional.

Addressing a critical gap observed in competing AR e-commerce applications, our project avoids the common misplacement of objects beyond physical boundaries, like walls. This advancement in spatial accuracy ensures a more realistic and practical visualization of furniture within the user's environment, markedly setting our application apart in the competitive landscape.

The integration of sophisticated AR techniques such as plane tracking and depth analysis further enhances the realism of virtual furniture placement. Coupled with our distinctive placement indicator that employs raycasting for precision, our application offers dynamic item placement with real-time feedback. This allows users to make informed decisions about furniture arrangements, significantly improving the online furniture shopping experience by addressing size and fit challenges within a space.

Our application not only caters to the immediate needs of furniture shoppers but also paves the way for a more interactive and engaging e-commerce landscape, promising enhanced satisfaction and confidence in online furniture purchases.

## **1.2 Augmented Reality**

Augmented Reality (AR) is a technology that overlays digital information—such as images, videos, or 3D models—onto the real world, enhancing one's perception of their surroundings. AR has found applications across various fields, from entertainment and education to healthcare and e-commerce, demonstrating its versatility and impact.[1]

For our e-commerce application, we employ superimpositionbased AR, which allows users to see virtual furniture pieces superimposed over their real-world environment, offering a realistic preview of how the items would look in their space.

## **1.3 Plane Tracking**

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Plane tracking is an AR technology that detects horizontal and vertical surfaces in the user's environment, such as floors, tables, and walls. Using AR Foundation, our application utilizes plane tracking to understand the spatial layout of the physical space. This capability is crucial for placing virtual furniture in the user's environment accurately. It ensures that digital objects are not only positioned on detected surfaces but also adhere to the spatial constraints of the room, enhancing the realism of the AR experience.[7]

## **1.4 Depth Sensing**

Depth sensing involves measuring the distance from the device to objects in the physical world. This technology is vital for creating immersive AR experiences that accurately blend virtual content with the user's environment. In our project, depth sensing allows the application to assess the size and scale of the room and the relative positioning of objects within it. This information is used to adjust the size and orientation of virtual furniture, ensuring it appears natural and correctly scaled within the space. Depth sensing enhances the user's ability to make informed decisions about furniture placement, contributing to a more interactive and satisfying shopping experience.[7]

## **1.5 Raycast**

Raycasting in AR is a technique used to project a ray from the user's device into the AR scene to determine where virtual objects should be placed based on their interaction with the detected planes and surfaces. Our application employs raycasting for its placement indicator feature, which guides users in accurately positioning furniture in their desired location. When the user moves their device around the space, the raycast dynamically updates the placement indicator's position in real-time, allowing for precise placement of virtual furniture. This feature not only improves the ease of use but also significantly enhances the application's interactivity, enabling users to experiment with different

furniture arrangements effortlessly.[7]

Together, these technologies form the backbone of our AR ecommerce application, enabling us to offer an innovative solution that addresses the traditional challenges of online furniture shopping. By leveraging AR Foundation, plane tracking, depth sensing, and raycasting, we provide users with a powerful tool to visualize and interact with furniture in their homes, thereby enhancing decision-making, reducing uncertainty, and improving overall customer satisfaction in online shopping experiences.[7]

## **1.6 Background and Motivation**

The advent of Augmented Reality (AR) technology has revolutionized various sectors, with e-commerce being a prime beneficiary. The motivation behind our project stems from the desire to address existing limitations in online shopping, particularly in the furniture domain. Traditional ecommerce experiences often leave customers uncertain about how products would fit and look in their actual living spaces. Our project aims to bridge this gap by leveraging AR to allow users to visualize furniture in their homes accurately before making a purchase. This initiative is driven by the need for more interactive, immersive, and user-friendly shopping experiences that can reduce return rates, increase customer satisfaction, and enhance decision-making processes. By developing a novel AR application that overcomes the shortcomings of previous implementations, such as reliance on pre-existing models and lack of intuitive user interfaces, our project sets out to redefine the standards of online furniture shopping.

## **1.7 Development Framework**

The development framework for our AR e-commerce application is built on Unity and AR Foundation, offering a cross-platform solution that integrates advanced AR functionalities such as plane tracking, depth sensing, and ray casting. Unity provides the versatile environment necessary for designing and deploying immersive 3D content, while AR Foundation bridges the gap between Unity and platform specific AR capabilities (ARKit for iOS and ARCore for Android), ensuring a wide-reaching application compatibility. This framework is crucial for accurately positioning virtual furniture in real environments, utilizing plane tracking for surface detection, depth sensing for realistic object placement, and raycasting for precise user interactions. Adopting an agile development methodology, we prioritize iterative testing and optimization to enhance user experience across diverse devices, ensuring our application not only meets but exceeds user expectations for an immersive shopping experience.

## **2. RELATED WORKS:**

The evolution of AR in e-commerce began with foundational work [8], utilizing Unity and Vuforia to elevate product visualization and customer purchase intentions, despite limitations such as dependency on existing models and lack of innovative UIs. Study [9] deepened the understanding of AR's psychological effects on consumer perception, indicating a need for context-aware AR applications. A broader technological scope in retail was examined in [10], advocating for more cohesive AR experiences for challenges like furniture shopping.

The potential of immersive visualization and virtual try-ons was further brought to light in studies [11] and [12], revealing the technological barriers to creating realistic and interactive environments. The practical application of AR, particularly in furniture shopping, was demonstrated in [13] and [14], which improved consumer satisfaction but noted the difficulty of seamless virtual object integration. Study [15] built an AR enhanced store showcasing AR's potential to boost engagement and conversion rates, yet pointed out the need for more intuitive interactions.

Continuing the exploration, [16] and [17] addressed the experiential aspects of AR, gradually refining user engagement, realism, and object placement. The role of AR in influencing purchase decisions and integrating advanced technologies for competitive advantages was highlighted, without delving into the specifics of data processing. The qualitative impact of AR on consumer behaviour in mobile commerce was assessed in [18], emphasizing immersive experiences.

Web application use of AR for user interaction with 3D models was explored in [19], indicating a promise for heightened engagement and satisfaction. Study [20] introduced a web-based AR framework for environment aware interactions, aiming for device-agnostic functionality and improved experiences on mid-range devices. The significant effect of AR on shopping experiences, especially in makeup e-commerce, was found in [21], using PLS-SEM for consumer experience analysis.

Impulse buying behaviours in AR mobile shopping apps were studied in [22], suggesting a significant influence of AR features on such behaviours. Study [23] explored VR in ecommerce, considering the impact of contextualization and gender, concluding that neutral contexts might be more effective. The importance of AR in enhancing shopping experiences was underscored in [24].

The potential of deep learning and the YOLO algorithm for object detection in AR was detailed in [25], showing promise for interactive product visualization, although no application was built from the study. Lastly the factors influencing the adoption of AR apps in shopping environments were examined in [26], highlighting the influence of personality traits on attitudes towards AR shopping.

Our project builds upon the collective insights from these studies, addressing past limitations and introducing our unique AR application for furniture e-commerce. Advanced functionalities like plane tracking, depth analysis, and raycast based positioning are combined with a distinctive asset library of custom-designed furniture pieces. These exclusive assets enhance the uniqueness of the application, providing a rich, personalized shopping experience that sets our application apart in the market for immersive and user-friendly AR shopping experiences.

Mail Automation plays a vital role in this project. The participant's mail IDs are collected in a spreadsheet, and the mail IDs are inputted into the mail automation command. This command sends the particular certificate of that participant to his/her mail ID and also stores a copy of all the documents in a separate folder in PDF format. Robotic Process Automation provides more accessibility for users to automate complex processes using software bots.

### 3. METHODOLOGY:

#### 3.1 Creation of objects in Blender

In the domain of digital asset creation for augmented reality, the procedure of developing furniture objects within Blender assumes a significant role. Commencing with an empty canvas within Blender's versatile 3D workspace, the process involves the conceptualization of the furniture piece's form and function. Each object originates from a basic geometric shape, referred to as a 'primitive,' which undergoes meticulous molding into the desired silhouette of the furniture item through the adept utilization of Blender's robust editing tools.

The manipulation of vertices, edges, and faces of each model is executed through techniques such as extrusion, scaling, and beveling, aiming to refine the shapes into recognizable furniture forms. Particular emphasis is placed on topology to ensure that the models are not only aesthetically pleasing but also optimized for real-time rendering in augmented reality environments.



Fig. 1. Real time Furniture Object created in blender environment

In order to imbue the models with realism, Blender's material and texturing capabilities are utilized, incorporating images and procedural textures to simulate the real-world appearance of various materials, ranging from the texture of wood grain to the reflective properties of metal. Delicate details such as upholstery seams and wood grain directionality are meticulously painted to enhance authenticity.

For models requiring articulation, virtual skeletons are integrated through rigging, while precise UV unwrapping is conducted to ensure alignment of textures. Each model undergoes rigorous testing under diverse lighting conditions within Blender's rendering engine to uphold its structural integrity and visual allure.

Finally, the completed 3D models are exported in a format compatible with Unity, poised for seamless integration into augmented reality applications. This comprehensive process, spanning from conception to exportation, encapsulates a harmonious amalgamation of artistic vision and technical expertise, resulting in a collection of bespoke, high-fidelity 3D furniture models that enhance the user experience within augmented reality shopping platforms.

#### 3.2 Methodological approach in unity

The methodology involves the utilization of several key scripts and features within the AR framework to enable the projection and integration of virtual objects onto the physical

environment captured by the device's camera.

- 1) **AR Session Origin:** This component initiates the AR experience and manages essential scripts such as the AR plane manager, AR anchor manager, AR raycast manager, and anchor creator. These scripts facilitate the projection of virtual objects, particularly buildings, onto the physical environment captured by the Android device's camera. The AR camera integrated into the AR session origin script captures the real-world environment for overlaying virtual elements.
- 2) **Device Tracking:** This feature enables the identification of the actual device's position in real space, allowing for accurate projection of virtual objects, such as buildings, in front of the device's camera.
- 3) **Environmental Probe:** By utilizing an environmental probe, the application evaluates the surrounding conditions specific to the device's physical position. This aids in accurately placing virtual objects within the environment. In the project context, environmental probes were employed to detect planes for projecting items onto an empty plot.
- 4) **AR Foundation Features:** The AR application utilizes features provided by AR Foundation to comprehend the surrounding environment. This includes identifying and engaging with surfaces like floors and walls, essential for authentic building projections. Additionally, the application adjusts virtual illumination to match the real-world setting, enhancing the immersive experience.
- 5) **AR Camera Parameters:** Parameters such as depth perception, background rendering, and field of view of the AR camera are crucial for creating realistic AR effects. These parameters control the visible area, depth perception, and seamless integration of virtual items with the real-world background on the device's screen.
- 6) **AR Plane Manager Script:** This script is essential for detecting surfaces, particularly on the ground, and arranging imported furniture within the environment. It enables adjustments to the field of view, depth perception, and background rendering, enhancing the quality of the AR application.

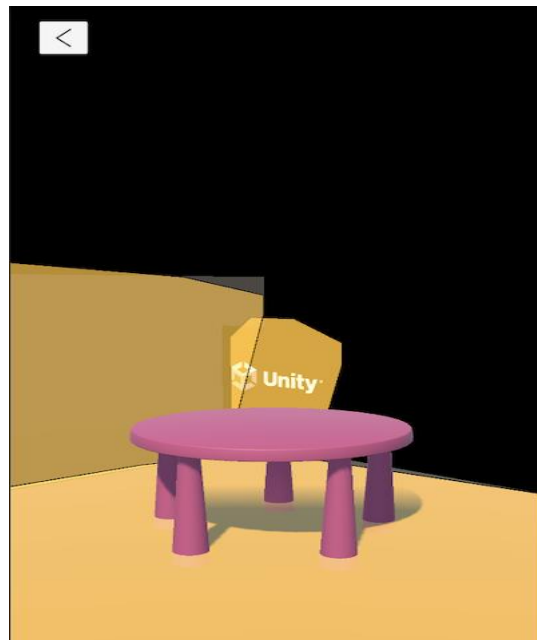


Fig. 2. Objects created in blender is successfully rendered in unity and modelled.

### 3.3 Detailed System Architecture

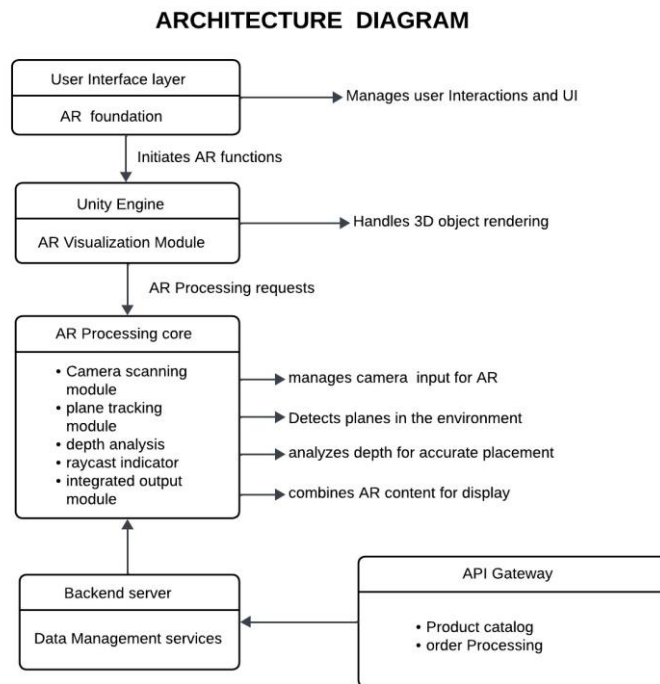


Fig. 3. Detailed System Architecture Diagram

The Figure. 3. provides a structured representation of the architecture behind our e-commerce shopping application running on a mobile device:

- 1) **User Interface Layer:** This is where users interact with the app, choosing furniture and making decisions based on the AR visualization. It's designed for ease of use, facilitating an intuitive shopping experience.
- 2) **AR Foundation:** This layer in Unity initializes the augmented reality features, providing a consistent set of AR functionalities such as spatial recognition and object anchoring, tailored for furniture visualization in a home setting.
- 3) **Unity Engine:** Acts as the powerhouse for the application, rendering 3D models of furniture with precision and handling the interactive visualization module necessary for a realistic AR experience.
- 4) **AR Processing Core:** Comprises multiple modules like:
  - a) **Camera Scanning Module:** Captures the user's environment to superimpose digital furniture models.
  - b) **Plane Tracking Module:** Identifies suitable surfaces within the environment to place virtual furniture accurately.
  - c) **Depth Analysis:** Ensures the furniture model's size and placement are true to scale and appear natural within the space.
  - d) **Raycast Indicator:** Allows for precise positioning of the furniture through user interaction, enhancing the shopping experience.
- 5) **Backend Server and Data Management Services:** Manages the application's data, such as user accounts, furniture catalogue, and user interactions, ensuring the system

runs smoothly and efficiently.

6) API Gateway: Facilitates communication between the app and backend services, handling product selection, order processing, and other e-commerce transactions. This architecture supports the seamless operation of an AR ecommerce application, ensuring users can visualize and interact with furniture products in a realistic and engaging manner.

#### 4. RESULTS AND DISCUSSION:

Our journey in developing this AR application for furniture ecommerce was driven by a desire to enhance the online shopping experience through innovative technology. We focused on creating a user-friendly interface and incorporating custom furniture assets, enabling customers to visualize and place furniture in their homes with unprecedented ease.

##### 4.1 Survey

After developing the AR application, we conducted testing with participants to evaluate its usability. We conducted a survey using Google Forms to see if the integration of Augmented Reality in e-commerce boosts consumer interest in buying. The survey we conducted included 5 questions rated on a 4-point Likert scale (Regenbrecht & Schubert, 2021). Table 1 displays the question in use.

Table. 1. Questionnaire Question

<i>Questions</i>	<i>Likert Scale</i>
Q1. I find the products displayed in our AR application to be as realistic as in the real world.	(1: Strongly Disagree – 4: Strongly Agree)
Q2. I find the navigation and controls in our AR application intuitive and user-friendly.	
Q3. AR technology affects my decision to buy products in e-commerce positively.	
Q4. I believe that using AR technology increases my confidence in making purchasing decisions.	
Q5. I would recommend our AR application to others for visualizing products in their living space.	

##### 4.2 Survey Results

Table. 2. Survey Results

Most Answer Chosen		
Questions		Frequency
Q1	3	45
Q2	4	41
Q3	3	32
Q4	3	34
Q5	4	47

The questionnaire focuses on the efficacy of our augmented reality (AR) application and its level of user engagement. The findings derived from the examination of 55 persons are as follows:

Table 2 displays the survey results. The first question concerns the realism of the object displayed on their smartphones. Among the 55 participants, 45 selected the value 3, indicating the high precision of the objects utilized in the program. The second aspect pertains to the degree of user engagement with the program. The majority of users selected the value 4, indicating that the application's user interface was effectively designed to satisfy the users. The third question challenges the user's decision-making process in relation to the employment of augmented reality (AR) technology. Among a group of 55 individuals, 32 individuals selected choice 3, while the remaining 20 individuals chose option 4, and 2 individuals chose option 2. This demonstrates that individuals are unfamiliar with augmented reality (AR) technology, hence need a period of time to establish confidence in the technology. The fourth question explores the level of faith that consumers have in AR technology. Out of the total participants, 34 individuals selected choice 3, however only a small number chose the remaining options. This indicates that there is a need to create further applications utilizing Augmented Reality (AR) Technology in order to establish confidence among users and enhance their understanding. The last inquiry pertains to endorsing our application to others. A total of 47 individuals opted for option 4, citing the superior quality of our application. According to this survey, our application is considered more trustworthy by individuals, despite their unfamiliarity with the technology.

### **4.3 Application Overview**

- 1) **Highly Detailed and Realistic Models:** Each piece of furniture was meticulously modelled to ensure a high level of detail and realism. This precision allows users to visualize how the furniture will look in their actual spaces, considering textures, colours, and dimensions.
- 2) **Optimized for Performance:** Despite their detail, the models are optimized for mobile performance. This means they have a balanced polygon count and are textured in a way that looks great but doesn't overburden the user's device. This optimization ensures smooth, real-time AR visualization on a wide range of smartphones and tablets.
- 3) **Diverse Furniture Catalogue:** The assets include a wide range of furniture types and styles, from sofas and chairs to tables and cabinets. This diversity ensures that users can explore various options and find pieces that match their space and aesthetic preferences.
- 4) **Interactive Elements:** Some furniture models include interactive elements, such as drawers that can open or adjustable parts. This interactivity enhances the user experience, providing a more immersive and realistic AR shopping experience.
- 5) **Unity Integration:** The 3D models are imported into Unity, a powerful game engine that supports AR development. Unity serves as the platform for developing the application's interface, AR functionalities, and integrating the assets into the AR environment.
- 6) **AR Technology Utilization:** Using ARCore (for Android) or ARKit (for iOS) technologies, the application detects the ground plane in the user's environment through the device's camera. This is accomplished by plane tracking and raycasting techniques, which identify flat surfaces and enable the placement of virtual objects—furniture, in this case—onto these surfaces.
- 7) **Interaction and UI Simplicity:** Users interact with the application via a simple and intuitive UI. They can select furniture from a catalogue, place it in their room, and

adjust its position by dragging or rotating with finger gestures. This process does not require repeated ground plane detection, allowing for fluid and rapid changes to the furniture arrangement.

- 8) User Experience and Efficiency: The application significantly enhances the shopping experience by enabling users to visualize how furniture fits in their actual space, aiding in decision-making.

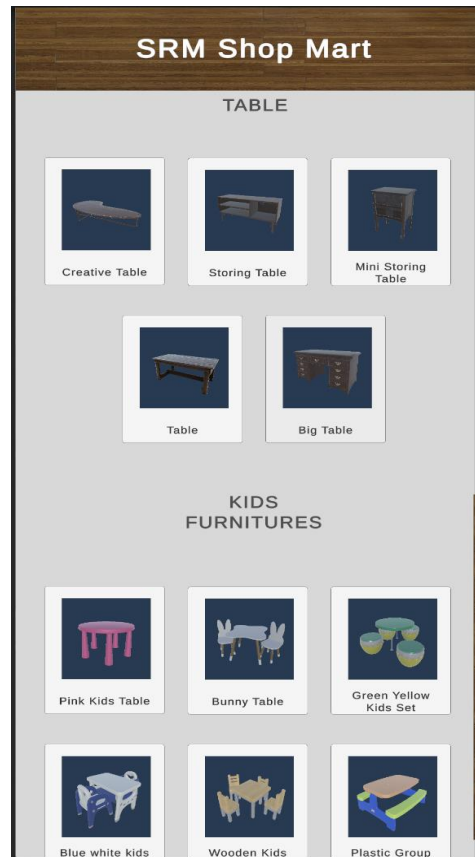


Fig. 4. A look at the Application's Interface

The focus on ground plane detection, excluding wall detection, streamlines the app's functionality, making it more reliable and precise in placing objects where most furniture would logically be situated.

The ease of moving and swapping furniture pieces without reinitiating the AR setup process is highlighted as a key advantage, offering a user-friendly experience that surpasses current AR-based e-commerce solutions.

However, the development process was not without its challenges; occasional bugs led to rare app crashes, primarily due to compatibility issues with certain Android device specifications and software versions. Currently, our application runs exclusively on Android, reflecting our initial developmental and resource priorities. Yet, recognizing the potential for broader market reach and the diverse needs of our user base, we are actively planning to expand our offerings. Development is underway for both an iOS version and a web application, aiming to make our innovative AR shopping experience accessible to a wider audience. This expansion not only reflects our commitment to improving the e-commerce landscape but also marks an exciting step forward in our project's evolution.



Fig. 5. Shows the working of the application on real time world

## 5. CONCLUSION AND FUTURE WORKS:

In conclusion, our project successfully developed an augmented reality (AR) e-commerce application that revolutionizes the online furniture shopping experience. Through meticulous conceptualization, design, and implementation, we created an immersive and intuitive platform that allows users to visualize and interact with virtual furniture objects in their physical environments. Leveraging the power of Blender for 3D asset creation and Unity for AR application development, we achieved exceptional results in terms of realism, usability, and performance. The integration of essential AR features such as plane tracking, depth analysis, and ray casting enhanced the realism and usability of the AR experience, providing users with a seamless shopping experience. The creation of a user-friendly and visually appealing user interface further facilitated navigation and interaction within the application, contributing to overall user satisfaction. Thorough testing, optimization, and post-launch maintenance ensured the stability, performance, and relevance of the AR e-commerce application in the ever-evolving landscape of e-commerce. The project's success demonstrates the immense potential of AR technology in transforming the way users shop for furniture online, offering a compelling alternative to traditional e-commerce platforms.

Furthermore, we aspire to elevate the application's interactivity, delving into advanced features like gesture-based controls, voice commands, and collaborative shopping experiences. This heightened level of interaction empowers users, fostering a deeper sense of engagement and personalization as they navigate the AR environment. Personalization is key on our roadmap, with plans to harness machine learning algorithms for analysing user behaviour and preferences. By leveraging insights gleaned from past interactions, the application can curate personalized product recommendations, delivering a bespoke shopping journey tailored to each user's tastes.

Social integration represents another frontier for enhancement, allowing users to seamlessly share their virtual furniture arrangements with friends and family on social media platforms. This social sharing functionality not only fosters a sense of community but also serves as a powerful marketing tool, amplifying the application's reach through user-generated content.

Moreover, the integration of AR wearables presents an intriguing opportunity to enhance accessibility and immersion. By extending support to devices like smart glasses or headsets, we offer users a hands-free AR experience, further blurring the lines between the virtual and physical worlds. Augmented reality analytics hold promise for refining the application's performance and user experience. By harnessing data on user engagement, session duration, and conversion rates, we gain valuable insights into user behaviour, enabling us to fine-tune our strategies and offerings to better serve our audience. In essence, the journey of our AR e-commerce application is one of continual evolution and innovation. Through a steadfast commitment to enhancing user experience, personalization, and accessibility, we aim to redefine the landscape of online furniture shopping, delivering an unparalleled blend of convenience, immersion, and delight to our users.

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