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# Product Visualization in AR using Unity

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***Abstract*— In the evolving landscape of e-commerce, the in ability to physically examine products prior to purchase remains a major barrier to consumer confidence and satisfaction. This research presents an augmented reality (AR)-based product visualization solution aimed at transforming the traditional online shopping experience. By integrating AR technologies, the proposed application enables users to realistically visualize products, such as furniture, food items, and home decor, in their actual environments, thus enhancing decision-making and reducing uncertainty. The system leverages Unity and the Vuforia engine for robust AR integration, allowing image-based targeting and accurate 3D object placement. The development follows a systematic methodology, including requirement analysis, design prototyping, implementation, rigorous testing, and deployment. The platform further enhances user experience by providing detailed product information, reviews, and customization options. This approach offers an immersive, interactive, and user-friendly shopping experience, empowering customers to make confident and informed purchase decisions in a digitally augmented real world context.***

***Index Terms*— Augmented Reality, Vuforia Engine, 3D Object, E-commerce.**

## I. INTRODUCTION

In recent years, the e-commerce industry has experienced unprecedented growth, offering convenience and accessibility to consumers worldwide. However, a persistent challenge in online shopping remains the inability of customers to phys- ically interact with products before making a purchase. This gap often results in uncertainty, dissatisfaction, and increased product returns. Traditional product images and descriptions frequently fall short of providing the contextual understanding that consumers require to make confident decisions, especially for items like furniture, home decor, stationery, and food, where spatial fit, aesthetics, and realism are crucial.

To bridge this gap, Augmented Reality (AR) technology has emerged as a powerful tool for enhancing user engage- ment and decision-making in digital commerce. AR allowsthe overlay of virtual objects onto the real world through a device's camera, enabling users to visualize products in their actual environments. This immersive approach not only enhances the shopping experience but also supports better- informed decisions by offering a realistic and interactive view of products in context This paper proposes an AR-based product visualization mobile application that empowers customers to place and view 3D models of products in their real-world surroundings. Developed using Unity and the Vuforia engine for robust AR capabilities, and supported by cross-platform technologies such as React Native or Flutter, the application ensures wide accessibility and usability. The system also provides detailed product specifications, reviews, and customization options to further aid the decision-making process.

The subsequent sections of this paper detail the methodol- ogy adopted for the development of the application, the tools and technologies utilized, implementation specifics, testing processes, and the overall impact of integrating AR into the e-commerce experience.

## II. RELATED WORK

In a variety of fields, such as e-commerce, architecture, and data representation, augmented reality (AR) has become a game-changing tool for improving product display. AR enables immersive product experiences in the e-commerce space, allowing customers to view products in their actual environments.

In Chennai, India, Kannaiah and Shanthi [1] investigated how AR affects consumer behavior and found a favorable relationship between AR applications and increased purchase inclinations. Similarly, Daphal et al. [2] presented an Aproduct visualizer aimed at bridging the gap between digital and physical retail, emphasizing the importance of accurate 3D models and user-friendly interfaces in enhancing user engagement.

Numerous studies have also examined the integration of AR into architectural visualization. Thomas et al. [3] suggested using Spatial Augmented Reality (SAR) as a method for visualizing 3D data, highlighting its ability to provide tangible and intuitive interactions with architectural models. Continuing the discussion on comprehensible visualization techniques in AR, Kalkofen et al. [4] focused on the use of interactive visualizations to improve the clarity of spatial relationships between virtual and real-world objects.

Samkari et al. [5] conducted an extensive assessment on the use of AR and VR in product visualization, identifying key challenges such as the need for high-quality 3D models and real-time rendering capabilities. Kan et al. [6] explored the potential of VR-based product presentations in enhancing e-commerce platforms, demonstrating their effectiveness in

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increasing consumer trust and reducing return rates.

Luo and Wu [7] studied the use of VR technology for computer-aided animation material development, showcasing the adaptability of AR/VR technologies in creative domains. Yassien and Abdennadher [8] examined the use of Spatial AR for 3D data visualization, focusing on its capacity to deliver immersive and interactive experiences across multiple industries.

Taken together, these studies highlight the substantial poten- tial of AR in enhancing user engagement and decision-making processes across a wide range of application domains.

## III. METHODOLOGY

### A. AR Object Placement Using Unity and AR Foundation

This project employs Unity's AR Foundation framework to facilitate the placement of 3D virtual objects within a real-world environment, leveraging plane detection and raycasting techniques.

#### *1) Integration with Vuforia Engine*:

We utilized the Vuforia engine to implement Augmented Reality (AR) functionality. The system uses target image recognition to trigger the visualization of 3D models of products. When the user points the camera at a specific target image, the application detects the image and overlays a corresponding 3D model in the real- world environment. This setup enables a seamless transition from viewing a 2D product image to interacting with the product in 3D, allowing users to get a sense of how the product would appear in their own physical space.

#### *2) Plane Detection:*

The system initializes by detecting horizontal planes in the user's environment. This is achieved using the ARPlaneManager component, which identifies flat surfaces such as tables or floors. Upon detection, these planes are visualized in the AR scene, providing users with feedback on where virtual objects can be placed.

#### *3) Raycasting for object placement:*

When a user taps on the screen, the application performs a raycast from the touch point into the AR scene using the ARRaycastManager. If the ray intersects with a detected plane, the system calculates the exact position and orientation (pose) where the virtual object should be instantiated. This ensures that the object aligns accurately with the physical surface.

#### *4) Object instantiation and management:*

Upon a successful raycast hit, the selected 3D object is instantiated at the determined pose. The system allows users to switch between different virtual objects (e.g., cube, table, sphere) through a user interface. To maintain a clean AR scene, once an object is placed, the application disables further plane detection and hides existing plane visualizations, focusing the user's attention on the placed object.

#### *5) User Interface integration:*

The application integrates a desktop-based user interface that displays the live camera feed. Alongside this feed, buttons representing different 3D objects are provided. When a user selects an object, it becomes the active model for placement. This interface ensures an intuitive user experience, allowing seamless interaction between the real and virtual environments

### B. System Architecture

The structure of our developed Augmented Reality (AR) object visualization system reflects the modular, event-driven, and reactive nature of the components designed to interact with users. The system architecture includes a level of abstraction based on a layered model where the individual layers pass information in a pipeline fashion.

The User Interface (UI) Layer allows the user to interact with the system by clicking UI buttons for different 3D objects and placements. At the same time, the Event System acts as a controller to decide whether the user is interacting with the UI or the camera feed. This ensures the AR object placement logic only occurs during physical interactions.

The ARRaycastManager checks for valid touches and collaborates with the ARPlaneManager to determine if the touch intersects any real-world surfaces. On a successful hit, the selected 3D object is instantiated and AR planes are disabled to lock the scene. Rendering is handled by the XROrigin, anchoring the object consistently in the real-world view. This modular approach promotes scalability and future enhancements such as multi-object placement and persistent scenes.

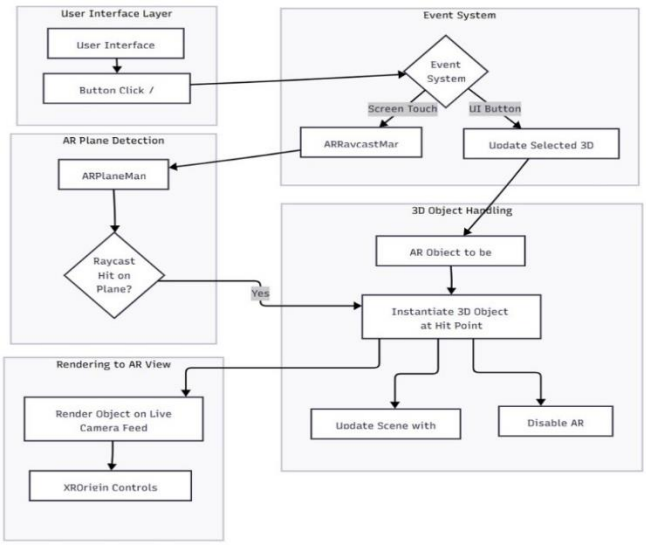


**Fig. 1.** System Architecture of AR Object Placement Using Unity

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### C. Flow Diagram

The system follows a structured data flow for interaction and rendering in the AR/VR environment. The process begins with user inputs, which guide object selection, camera input capture, and rendering of 3D models. These models are integrated into the display pipeline, optimized for performance, and overlaid within the camera feed using spatial anchors.

The AR/VR integration ensures that virtual objects align with real-world surroundings, allowing for animated visualization, object adjustment, and interaction. Features such as collision detection and data storage further enhance user interaction and experience persistence.

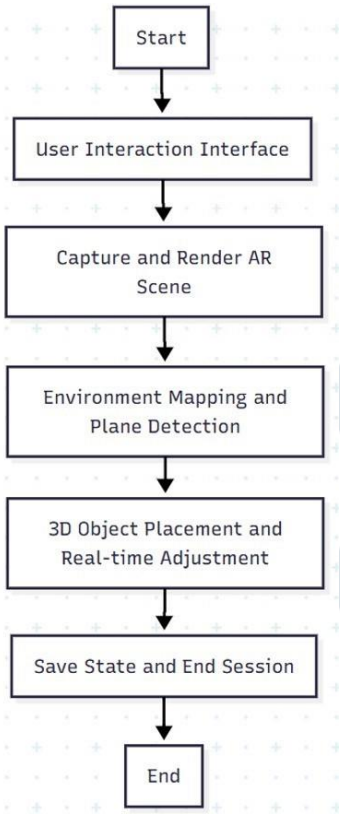


**Fig. 2.** Flow Diagram of AR/VR Visualization and Interaction Pipeline

## IV. PROPOSED SYSTEM

The proposed framework leverages increased reality (AR) to empower clients to put 3D models into real-world situations utilizing portable gadgets. It coordinates real-time plane discovery, touch-based client input, and energetic rendering to encourage precise and instinctive protest arrangement. The design ensures measured operation through five essential com- ponents: client interface interaction, occasion taking care of, AR plane discovery by means of raycasting, 3D question instantiation, and live rendering. This framework underpins differing AR applications, such as instructive apparatuses, plan visualization, and intelligently reenactments.

### A. System Overview

The proposed framework empowers intuitively situation of 3D objects in an expanded reality (AR) environment utilizing AR plane location and touch-based input. The engineering comprises five key components:

- **Client Interface Layer:** Captures client input through buttons or screen touches.
- **Occasion Framework:** Handles interaction occasions and courses them to the fitting modules.
- **AR Plane Discovery Module:** Performs raycasting to identify real-world surfaces for question situation.
- **3D Question Taking Care of Module:** Oversees choice and instantiation of 3D objects at substantial hit focuses.
- **Rendering Module:** Renders 3D objects onto the live camera bolster utilizing AR controls.

This secluded structure encourages consistent client interaction and guarantees precise spatial arrangement of virtual

***Key Features***

- **AR Visualization:** Users can place and view 3D models of products in their real environment using smartphone cameras.
- **Product Details:** Each item includes complete specifications, user ratings, and reviews.
- **Customization:** Users can modify product attributes such as size, color, or orientation.
- **Cross-platform Support:** The app is accessible on both Android and iOS through a mobile interface.
- **Real-Time Interaction:** The Unity-Vuforia pipeline enables interactive manipulation of the 3D models based on user gestures.

### B. Workflow

1) **Product Selection:** The user selects a category and views available items.
2) **AR Activation:** The app uses the Vuforia engine to recognize target images and display the corresponding 3D model.
3) **Interaction and Customization:** Users interact with the model (rotate, resize) and change its attributes.

## V. RESULT AND DISCUSSION

The AR Product Visualization system was developed and evaluated to determine its capability to enhance product understanding during online shopping. The application enables Android users to scan target images using their device's camera and visualize corresponding 3D models in real-world settings. Testing results and user feedback revealed several insights.

### A. Functional Results

- **Effective Product Visualization:** The system successfully renders 3D models of products such as furniture, stationery, and decorative items on recognized image targets using Unity and the Vuforia engine.

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- **Interactive Experience:** Users are able to rotate, zoom, and move 3D models in real time, providing an engaging and realistic interaction with the products.
- **Smooth AR Performance:** On most Android devices, the app delivered fluid AR experiences with minimal latency and stable model rendering.

### B. Discussion

The combination of Unity and Vuforia proved effective for delivering high-quality AR-based product visualization. The ability to see and manipulate virtual products in a real setting significantly addresses the visualization gap that often causes hesitation in e-commerce purchases.

While performance was generally consistent across various devices, the application performed best in environments with ample lighting and a flat surface for accurate detection.

User feedback emphasized the value of the AR experience in improving product understanding. However, several users sug- gested potential enhancements, including improved material realism, dynamic shadow rendering, and the ability to place multiple models simultaneously within the scene.

**Fig. 3.** AR-based 3D furniture visualization in real-world environment

## VI. CONCLUSION

This project successfully demonstrates the potential of Augmented Reality (AR) to enhance the online shopping experience through real-time, interactive product visualization. By integrating Unity with the Vuforia engine, the developed system allows users to scan predefined target images and view 3D models of products in their actual environment using an Android mobile device. This immersive approach addresses a key limitation in traditional e-commerce—customers' inability to accurately judge product fit, appearance, and context.

The system showed high accuracy in target detection and delivered smooth AR interactions. User feedback confirmed that the solution increases confidence in purchase decisions and makes the shopping experience more engaging and informative. With a user-friendly interface and stable AR performance, the application represents a promising advancement in merging physical and digital retail spaces.

## VII. FUTURE WORK

Future improvements can include the integration of marker- less AR, allowing for product visualization without predefined targets, and enhanced realism with features like dynamic lighting, shadow casting, and occlusion effects. Expanding the product database with customizable options such as size, color, and texture will provide a more personalized experi- ence. Additionally, incorporating gesture recognition and voice commands will further enhance interactivity, while connecting the system to e-commerce platform will facilitate seamless purchase transitions. Analytics tools can also be integrated to track user preferences and improve business insights.

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