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Enhancing Interior Design through Augmented Reality: Implementing 3D Furniture Based on Android

Jahanur Biswas[1]
Lecturer, Dept. of CSE, Dhaka International University, Bangladesh

Ushing Marma[2]
Student, Dept. of CSE, Dhaka International University, Bangladesh

Md. Muksit Ul Islam[3]
Lecturer, Dept. of CSE, Dhaka International University, Bangladesh

Antu Chowdhury[4]
Lecturer, Dept. of CSE, Dhaka International University, Bangladesh

Md. Tahzib-Ul-Islam[5]
Assoc. Professor, Dept. of CSE, Dhaka International University, Bangladesh

ABSTRACT

The primary objective of this application is to enhance interior design by including augmented reality (AR) technology so that consumers may visualize furniture in their actual environment before they buy it. Using realistic, scalable 3D representations of furniture products inside an interior space, the application intends to be user-friendly and intuitive, thus improving consumer decision-making and satisfaction using Android platforms. This application creates 3D furniture models in real-time within a user's environment, leveraging the broad accessibility and compatibility with ARCore of the Android operating system. Emphasizing iterative testing and improvement, the development process applies an agile methodology. Users of the program can choose furniture from a large digital inventory, view objects in augmented reality, and change their size and orientation to suit their real space. The program uses ARCore for spatial and environmental awareness and Unity3D for graphic rendering. With great accuracy and stability, the applied application effectively showed its potential to show a large spectrum of 3D furniture models inside different indoor surroundings. With reported increases in satisfaction and a dropin return rates, user testing demonstrated notable gains in users' capacity to make wise furniture selections. The program guarantees that augmented reality offers genuine benefits to consumers and stores, thereby greatly improving the interior design process. The tool helps to lower purchase anxiety and increase customer confidence by providing a reasonable picture of how possible furniture purchases would look and fit within a user's real area. Future projects will concentrate on growing the furniture inventory, enhancing user interface design, and including cutting-edge technologies, including interior design advice based on machine learning algorithms to customize the user experience better.

Keyword: *Augmented Reality, AR Core, Unity 3D, Cutting-edge technologies, Blender 3D.*

INTRODUCTION

In the field of augmented reality, the study report [1, 2] states that a real experience depends on perfectly incorporating virtual aspects into the physical surroundings. Through smartphone apps, augmented reality becomes a tool for interior designers, opening up new opportunities for both consumers and designers. Creating a system model for house interior layout software, therefore, closes the gap between virtual and real environments. Using such a tool, customers may virtually test several interior fittings to guarantee the ideal fit and size before buying. This invention might change the shopping experience [3].

Such a solution would mitigate typical judgment errors, while simultaneously conserving time and finances for both retailers and shoppers. Augmented reality empowers customers to make well-informed choices by offering a preview of products aligned with their desired look and aesthetic,fostering confidence in their purchases. Developing AR with a 3D model for interior design necessitates careful consideration of features tailored to the capabilities of the target device, culminating in a dynamic 3D prototype. The effectiveness and ease of use of this AR solution hinge on fostering collaboration between designers and consumers, ensuring a seamless and mutually beneficial experience [4]. Projection-based augmented reality [5] provides users with digital information within a fixed setting. While target objects and users retain mobility within the environment, the scope of AR interactions is confined to the fields of view captured by both the stationary projector and the accompanying tracking camera. Another challenge in home furnishing design involves guaranteeing that the chosen interior fits precisely within the dimensions of the target room, where users may experiment with various spatial arrangements. Achieving real-time alignment of virtual objects within the designated 3D space of the real world, while accounting for physical constraints such as position, rotation, and scaling, necessitates the integration of dynamic monitoring functions.

The rest of the parts are designed in various sections. The literature review shows the analysis of different types of research that are formed related to our topics. Furthermore, our main proposed methodology is described in the research methods section. The outcome analysis describes the overall outcomes of our project. Finally, a short description of our project and future work is expressed in the conclusion section.

LITERATURE REVIEW

Interior design through augmented reality is an amazing topic in the recent era. Everyone wants to decorate his apartment as per his desire. But only a few works are done in this section and here we analyze some research for finding some limitations.

A new tool in advertising, augmented reality (AR) integrates computer-generated data with the physical world to provide interactive, real-time experiences, as J. Stoyanova et al. [1] investigated. This study aims to create a prototype AR-based purchasing platform, especially for shoes to evaluate its effect on consumer psychology. To gauge consumer involvement and purchase intention, the study contrasts AR with conventional shopping applications comprising marker-based and stationary models. Especially in emotional response, memory, and involvement, the study seeks to investigate AR's possibilities in improving customer experiences. Acquired knowledge will guide future advertising campaigns and help to clarify AR's impact on consumer behavior. According to Z. Rashid et al. [2], technology is driving retail change; online purchasing is becoming more and more important because of its characteristics. This paper investigates combining Augmented Reality (AR) and Radio Frequency Identification (RFID) technologies to merge online shopping capability with physical retail. Through RFID-based smart shelves and AR interfaces on portable devices, the proposed system connects actual store merchandise to their digital equivalents. Users can interact with actual objects as they would online, therefore improving involvement. Initial studies show that the technology provides a flawless purchasing experience, therefore bridging the gap between online and offline retail. Focusing on improving cooperation between designers and consumers by J. Hui[4]this study looked at how Augmented Reality (AR) technology might be used in interior design. It emphasizes how AR is used to produce 3D interior models with real-time interaction, hence increasing client involvement in the creative design process. AR ensures a harmonious balance between structure and function and enhances the customization of design projects by combining actual and virtual aspects. The study concludes that AR will be extremely important for interior design going forward because it will enable more effective designer-client cooperation. This work developed a real-time plane recognition approach for D. Kim et al. [5] projection-based Augmented Reality (AR) systems in unfamiliar surroundings. Unlike other RANSAC techniques that require specific areas, this one automatically detects several planes using a limited sampling strategy. It ranks planes based on variables such as size, color, and position, and it selects projection areas taking into account occlusions. Without user configuration, the suggested approach greatly increases speed and accuracy, making it suitable for many AR applications, including gaming and immersive environments. Filling a void in research usually emphasizing technological advancement, J. G. Lee et al. [6] investigated the effect of augmented re-

ality (AR) on architectural design assessment from an end-user perspective. 76 participants assessed the systems using visual quality, perceived acceptability, and user experience using AR, VR, and 2D screen displays. With increasing user acceptability and good experiences, the results imply AR is more successful in visualizing design components; technology constraints still exist. The paper emphasizes AR's possibility to improve architectural user-involved design cooperation. L. Brunschwig et al. [7] showed how augmented reality (AR) combined with domain-specific languages (DSLs) produced mobile modeling environments. AR combined with DSLs opens fresh possibilities for domain-specific modeling in sectors such as interior design, Industry 4.0, and tourism. Based on Software Language Engineering ideas, the study suggests a design approach with prototype tool support and emphasizes the main difficulties for further projects. The paper by A. I. M. Elfeky et al. [8] looked at how augmented reality (AR) technology might help tertiary students acquire fashion design abilities. With 54 students split into two groups, the study made use of a questionnaire evaluating creative, utilitarian, and aesthetic elements. When compared to conventional techniques, results showed that AR-enhanced teaching greatly improved students' fashion products in all examined categories, underscoring AR's possible advantages in educational technology. Through computer-generated imagery, C. Dsouza et al. [9] introduced Augmented Reality (AR), which merges real and virtual worlds characterized into marker-based, markerless, projection-based, and superimposition-based types. With an Android application projecting virtual furniture into real-world situations to help users visualize and make decisions about home interior design, this article especially investigates markerless AR. The paper presents a fresh method for using AR in interior design so that users may interact with 3D virtual furniture via a flexible, dynamic interface.

Based on the above study, we have decided to build a project that enhances interior design through augmented reality. We desire to implement a 3D environment for designing our furniture.

METHODOLOGY

This work aims to leverage augmented reality (AR) technology's potential to transform the interior design process. The study specifically aims to create an Android application that allows users to view 3D furniture models inside their real living areas. This program offers a realistic, immersive visualization experience to help customers make more informed furniture purchase selections. The initiative aims to improve customer happiness, reduce the possibility of returns due to mismatches in expectations, and simplify the design and decoration process by incorporating AR into the interior design process. The ultimate goal is to create a tool that not only improves the user experience but also pushes the limits of technology in daily decision-making related to home décor and decoration. Targeting as the primary user group for this program those interested in home decoration and interior design. The research of professional interior designers was also included to gain insights from a technical and aesthetic perspective. This research was recruited via professional networks and forums dedicated to interior design and architecture. Augmented reality is a cutting-edge technology that is gaining traction in various fields, including interior design. By mentioning AR, the interest of an audience looking for modern solutions in spatial visualization. By mentioning Android, the research directly appeals to users of Android devices, which forms a large segment of the mobile user base globally.

Tools and Technologies

There are two primary tools and technologies have been employed to develop and implement the AR application: Unity 3D and Blender 3D. Here is a breakdown of how each technology contributes to the research:

Unity 3D: Unity 3D is used as the main development platform for creating the augmented reality application. It is particularly chosen for its robust support for AR development, ease of use, and compatibility with Android devices.

Within Unity 3D, ARCore (Google's AR development platform) is integrated to handle real-time 3D rendering, environmental understanding, and user interaction. Unity3D facilitates the seamless integration of 3D models and AR capabilities, ensuring that furniture items can be realistically placed and manipulated within a user's environment. As an illustration, I've included below a depiction of the Unity 3D and ARCore setup facilitated by XR Plugin Management. The XR Plugin Management is shown in Figure 1.

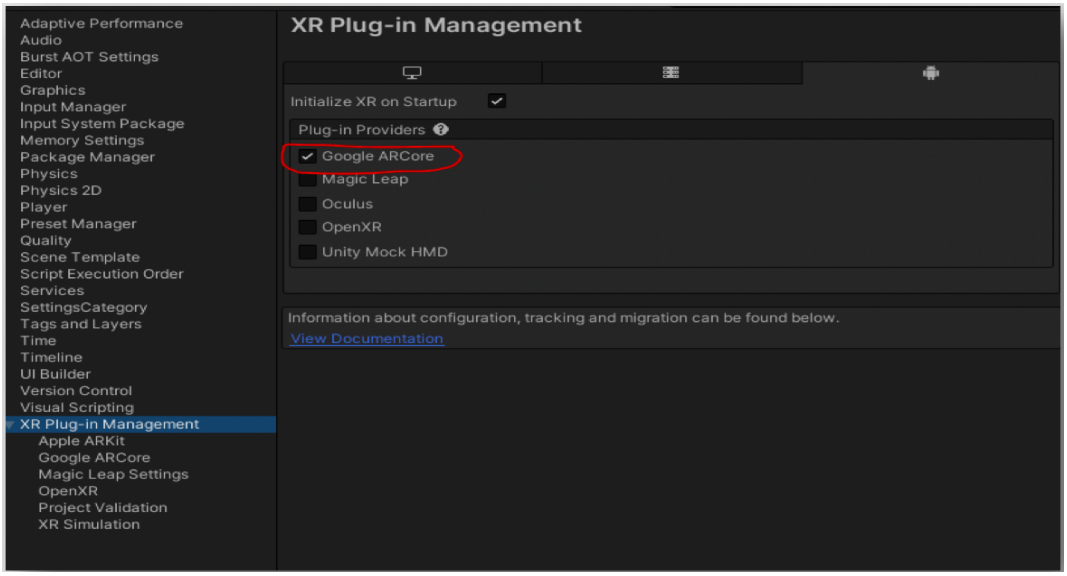

Figure 1: XR Plugin Management.

Blender 3D: Blender 3D is utilized for the creation and editing of 3D furniture models. It serves as the primary tool for designing, texturing, and preparing 3D assets that are later imported into Unity3D.

The 3D model (chair) is shown in Figure 2. The drag-and-drop model is a tremendous way to transmit data within an application. This model permits users to transmit data items between applications on various platforms, as shown in Figure 3.Blender3D supports a wide range of modeling techniques and provides detailed control over aspects such as mesh modeling, UV mapping, and material application. This allows for the creation of highly detailed and realistic furniture models tailored for AR visualization. As an illustration, I've included below a depiction of the chair model.

Data Collection and Testing:To utilize the project efficiently, we had to collect different types of data.

- 3D Model Data: The 3D furniture models created in Blender3D are exported to Unity3D, where they are optimized for mobile viewing and interaction. Each model's scale, textures, and materials are adjusted to ensure they look realistic when viewed through the AR application on an Android device.

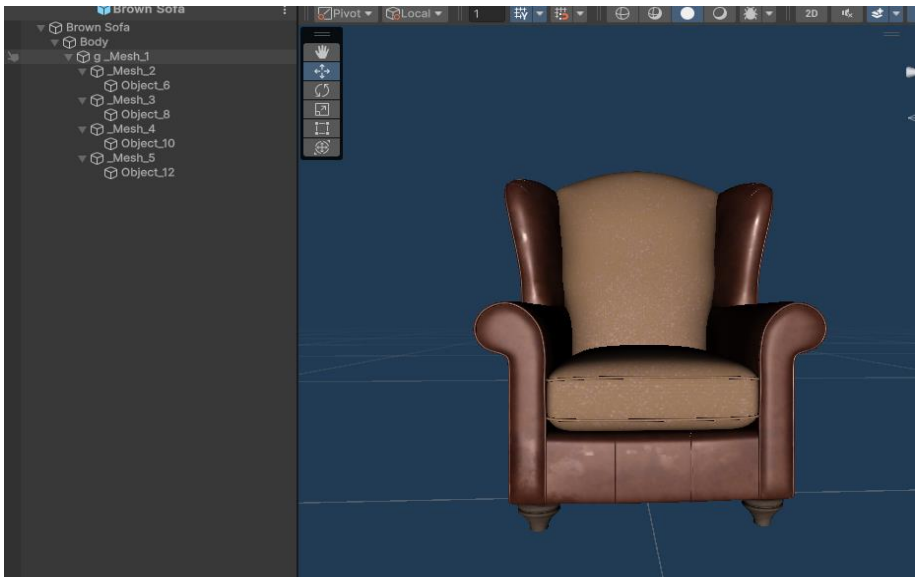

Figure 2: 3D model of chair.

Figure 3:Drag and Drop Model.

- User Interaction Data: Unity 3D collects data on user interactions with the AR environment, such as placement accuracy, user adjustments to furniture models, and overall usability feedback. This data is crucial for iterative improvements to the application interface and functionality.

  The combination of Unity 3D and Blender 3D provides a comprehensive suite of tools that supports all aspects of AR application development, from 3D modeling to deployment on Android platforms. This technological approach ensures the research meets its aim of enhancing interior design through innovative augmented reality solutions.

Proposed Procedure

The interior design system, developed using the AR Foundation Framework SDK and Unity platform for Android/iOS devices, seamlessly integrates augmented reality techniques to realistically showcase virtual models within the user's real environment. Additionally, it provides functionality to capture and display measurements of augmented components, enabling users to interactively design their living spaces. Moreover, the system facilitates real-time photo integration into the AR scene, enhancing the user's ability to visualize and customize their home decor.

Framework of the Proposed System: The Framework of the Proposed System is shown in Figure 4. In this system, commencing with the real-world environment, the system activates the AR camera, seamlessly integrating virtual elements into the live feed. Utilizing advanced tracking technology, it accurately maps and tracks the ground plane, ensuring a stable foundation for augmentation. Users are presented with a user-friendly interface to select furniture items from a comprehensive catalog. Upon selection, the chosen furniture is rendered as AR objects within the scene, perfectly aligned with the tracked ground plane. Through the seamless integration of virtual and real-world elements, users can experience an immersive environment where virtual furniture seamlessly coexists with their physical surroundings. This fusion enables users to visualize and interact with their desired furniture placements in realtime. Within the AR model display, users have complete control over the virtual furniture. They can effortlessly manipulate objects by intuitively moving, scaling, and rotating them in any direction, simply by touching the screen. In summary, the system offers a captivating and interactive experience, empowering users to effortlessly design and customize their living spaces through the seamless integration of virtual furniture into their real-world environment.

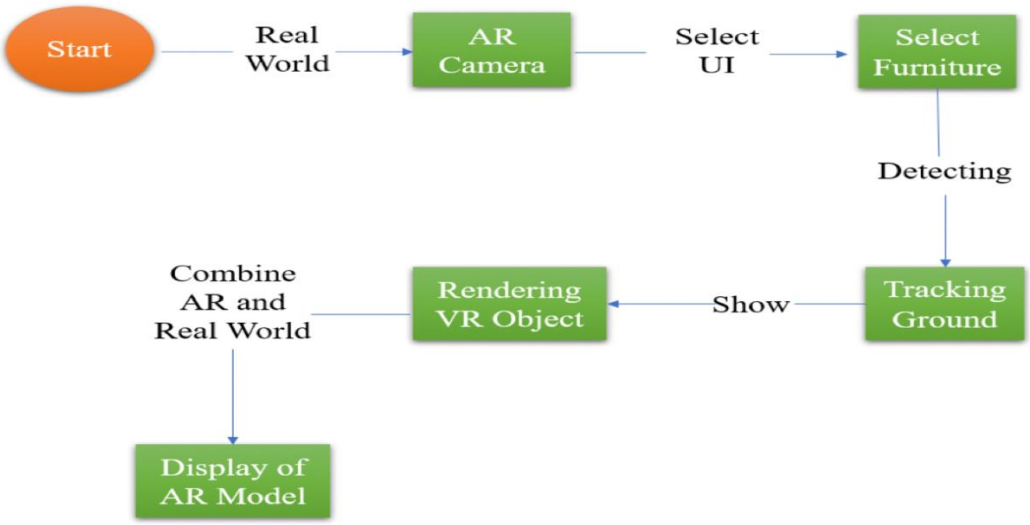

Figure 4: Framework of the Proposed System.

Exploration and Design of Tracking Components: The Tracking Components are shown in Figure 5. The tracking mode serves as the cornerstone of the entire AR scene, pivotal in enabling seamless interaction within the display module. In this Augmented Reality system, we aim to provide users with a streamlined experience, requiring only mobile interaction without any additional auxiliary operations. This ensures users can immerse themselves in virtual interior augmented reality within any unfamiliar indoor setting effortlessly.

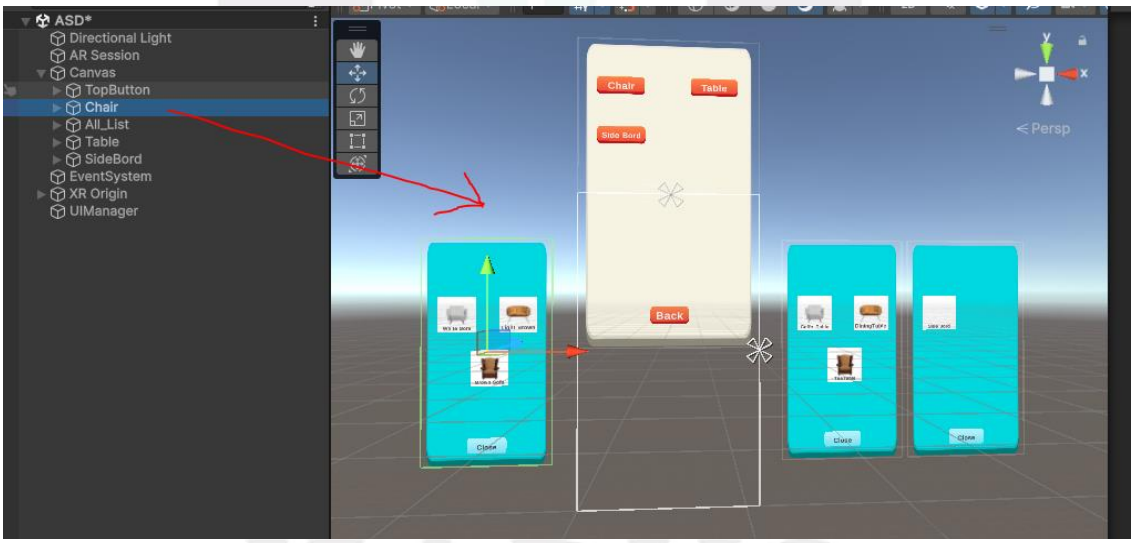

Figure 5: Tracking Components.

Leveraging the AR Foundation framework SDK, the system initiates the augmented reality camera, seamlessly integrating 3D models into the real-world environment while accurately tracking the ground plane surface and can move, scale, and rotate the furniture models by the selected UI element. Users can seamlessly integrate virtual elements into their surroundings, creating a tangible and immersive experience.

Interactive Display Module: This user-centric application offers an immersive experience of the real world, empowering users to seamlessly position 3D components according to their preferences. Users can also access measurements of the displayed components within the AR camera interface, allowing them to zoom in and out to customize room settings. Additionally, users can view all components simultaneously, providing a comprehensive real-world design experience through this application.

Creation and Crafting

This system operates through four distinct modules. They are-

1. **Live Streaming:** The primary advantage of live streaming is its time-saving nature, enabling users to swiftly navigate and manipulate objects in a 360-degree view. Upon opening the application, the camera initiates automatically, allowing users to position it according to their desired location for placing selected components.
2. **Object Detection:** The system quickly recognizes and locates the selected object after the camera is positioned and a component is picked. Users can then move, rotate, and resize the object in any way they want. Using ground-plan detection, the camera precisely positions the chosen object where it belongs.
3. **Dimensional Analysis:**The algorithm finds and positions the selected object based on camera placement and component choice in the application UI. Before placement, users input the length and width of the chosen object. The technology then shows the tracking ground area, facilitating an effective interior room layout.
4. **Integration of Virtual and Real-world Objects:**Users can view all objects together once they have positioned them in their proper places, thereby mimicking a living room. Users can swap objects as needed, therefore creating a completely equipped area that improves spatial vision.

User Scenario Diagram

Starting the augmented reality (AR) environment, the user opens the program on their gadget. The user selects a furniture component from the available options within the application using the user interface (UI). Tracking the ground plane, the AR system finds appropriate surfaces for the chosen furniture component in the user's actual surroundings. Using simple touch controls or gestures, the user positions and sets the chosen furniture component at its intended spot within the AR scene. The selected furniture piece is created as a 3D model that is effortlessly merged into the user's actual environment via the AR display. Touch gestures or on-screen controls let the user interact with the installed furniture component, changing its position, size, and orientation to suit their tastes. Having effectively put, altered, and viewed the chosen furniture component inside their actual surroundings, the user finishes their interaction with the application. Now seen in Figure 6 are user scenario diagrams.

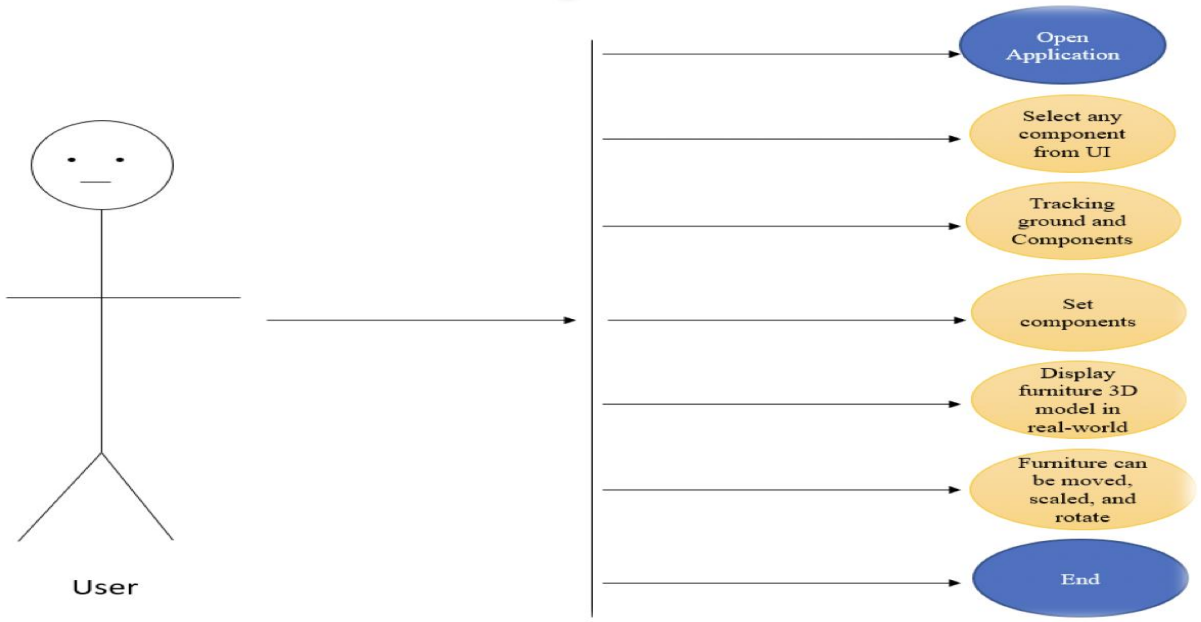

Figure 6: User Scenario Diagrams.

RESULT ANALYSIS

The system renders and shows the object as a 3D model using the AR interior design interface, making it perfectly integrated into the user's surroundings. This immersive experience allows users to see the object inside their area in realtime, improving their awareness of its appearance and size. The overall procedure of the project outcomes is shown in Figure 7.

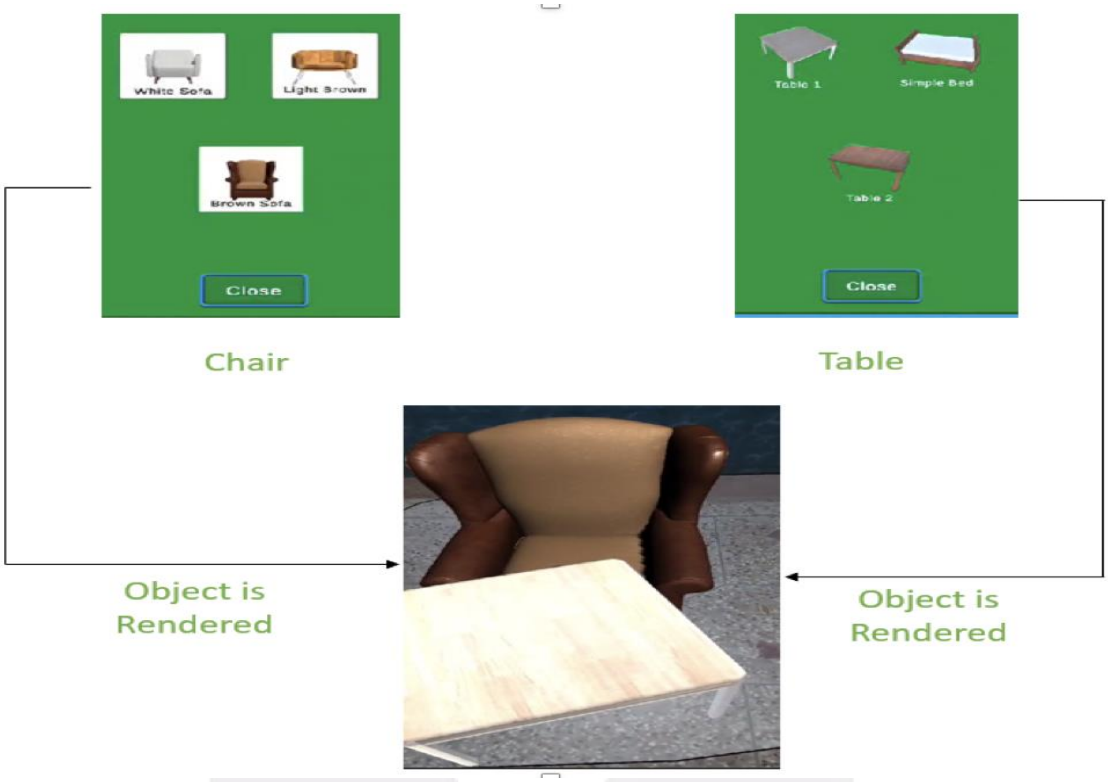

Figure 7: Outcome Analysis.

CONCLUSION

With interior design applications, augmented reality (AR) technology is transforming the real estate sector. According to polls, interior designers who use AR's benefits to improve efficiency and simplify their jobs are on the rise. This creative strategy provides immersive experiences that go beyond conventional approaches, providing the easiest way for home tours. AR technologies provide users with insights into several design aspects and their spatial configurations, helping to manage the excessive information flow. Moreover, this program presents consumers with a different viewpoint by highlighting important room elements, therefore enabling easy vision of their future area. Understanding their possible room layouts helps users make wise judgments before committing to any design solution. This program is a great tool for interior designers showing concepts ahead of time, allowing them to quickly make changes before any work starts and helping to enable cooperative conversations with clients. In the end, this integration of AR technologies is changing the scene of interior design and encouraging more customer satisfaction, efficiency, and innovation.

Promising achievements in improving user experience in virtual interior design have been shown from the present implementation of our interactive 3D modeling application for furniture decoration, which combines augmented reality (AR), Unity3D, and Blender3D. Still, there are various directions for the next studies and development to raise the scalability, usability, and performance of the system by enhancing realism and lighting effects using advanced rendering techniques, incorporating AI tools, real-time collaboration features, integration of other smart home devices, and also by increasing AR accuracy and stability by taking user feedback and personalization.

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