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DesignSpace: Virtual Interior Design App

Varsha Dange[1], Sneha Phatangare[2], Sahil Phatangare[3], Ketakee Suryawanshi[4], Shreekar Nyayapathi[5] and Arjun Thakur[6]
[1-6]Vishwakarma Institute of Technology /Information Technology, Pune, India
Email: {varsh.dange1, sneha.phatangare23, sahil.phatangare23, ketakee.suryawanshi232, shreekar.nyayapathi23, arjun.thakur23}@vit.edu

***Abstract*— By providing immersive and useful solutions in a variety of fields, augmented reality, or AR, has completely changed how people interact with both digital and physical environments. The creation of a virtual interior design application with AR Core, Android Studio, Java, and Kotlin is investigated in this study. Through the use of a mobile device's camera, the application allows users to digitally place furniture and décor pieces, including sofas, into real-world settings, allowing them to design and imagine their living spaces. Users can improve the pre-purchase decision-making process by moving their cameras to examine how products fit into their environments by utilizing AR Core's spatial tracking and object placement features.**

The study wraps up with going into user feedback from early testing, the app's shortcomings, and potential future improvements including adding more objects to the library, integrating e-commerce features, and utilizing AI-based recommendations. The purpose of this study is to stimulate creative solutions in home interior design and advance the field of AR-driven applications.

***Index Terms*— Virtual Design App, java, Augmented Reality, Sustainable design, User Interaction, AR Core and E-Commerce.**

I. INTRODUCTION

Experiences that engage and immerse at the edges between digital and real worlds—over these, AR technology has fundamentally revolutionized a good number of industries over the last few years. Some essential domains in which AR has particularly shone include interior design, allowing users to see and experience different furniture and décor configurations within real-world settings. This paper will review the creation and deployment of an augmented reality application for interior design using AR Core, Android Studio, Java, and Kotlin to create a user-friendly platform for visualizing and changing spaces. Some of the challenges in interior design are the proper visualization of how furniture will fit into a space, proportion estimation, and comprehension of aesthetic impact by new additions. Old-fashioned methods, such as visiting showrooms physically and taking manual measurements, can be costly, time-consuming, and limited in outreach.

augmented reality (AR) is a developing technology which seamlessly integrates digital substances into real-life environments, enhancing user interaction and spatial perception. AR overlays computer-generated 3D models, text, and visual elements onto physical surroundings in real time. This technology has found applications across various domains, including interior design, education, healthcare, and architecture [5].

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Unlike traditional methods, AR-based solutions do not require specialized hardware beyond a smartphone or tablet, reducing the barriers to entry for designers and homeowners. AR applications leverage real-time 3D object interaction, allowing users to rotate, zoom, and reposition virtual furniture within their real-world environment, significantly improving spatial perception and decision-making [6].

Problems of this nature can now be solved almost satisfactorily by augmented reality (AR) technology, which allows users to take pictures with the cameras of their mobile devices and superimpose virtual objects onto real-world environments at that precise moment. It is thus made possible for users to experiment with different configurations, styles, and combinations without any outlay or permanent change to the environment.

Our virtual interior design software utilizes the progressive features of motion tracking and environmental considerate, to provide an excellent, smooth, and lifelike visualization experience. Users can choose virtual furniture from a library such as couches and tables and place them in their space while moving their camera around the room. These items will be dynamically adjusted to the real-world environment to keep accurate scale and alignment and to respond to lighting conditions for added realism. This introduction highlights the necessity of innovation in the interior design process and provides the application as a solution to overcome existing barriers. The software includes the benefit of reduced dependence on physical showrooms, remote consultations in interior design, and creative freedom to visualize their desired settings.

The article ends with testing comments pertaining to the app, limitations of its current form, and suggestions for some enhancements for subsequent versions. This study is intended to inspire further developments in technology-oriented solutions for interior design and related fields by taking part in the growing stream of knowledge on AR-based applications.

II. Literature Review

AR has made huge strides as a much-loved technology over the last few years to revolutionize such industries as gaming, healthcare, retail, and interior design. AR implementing itself also provides people with unique and important opportunities to engage with surroundings by placing virtual features on their real environments. Hence, the review provides insight into current studies and applications of AR-based design in this area while pointing toward opportunities and gaps that would be filled by our application.

- A projection-based AR system using a pan-tilt projector-camera setup for interior design prototyping. It constructs 3D spatial maps and allows users to interact with the environment using gesture-based spatial user interfaces. The system enhances realism by projecting digital information onto real-world objects and spaces, making it useful for DIY interior designers and architects. However, its reliance on specialized hardware like projectors and RGB-D cameras limits portability, and occlusion issues can arise in large spaces. Despite these challenges, usability studies show that DesignAR enhances collaboration and provides an immersive experience for interior planning [1].
- A cost-effective mobile AR application that supports both marker-based and markerless AR. It enables 3D furniture placement over 2D architectural drawings and offers real-time furniture arrangement and visualization. Unlike projection-based AR, Interno is accessible on smartphones and tablets, eliminating the need for expensive equipment. However, tracking accuracy depends on smartphone hardware, which can lead to variable performance across devices. The system also lacks advanced automation for furniture placement, requiring manual user adjustments. Despite these limitations, it provides a practical and budget-friendly AR solution for interior designers seeking enhanced visualization [2].
- A web-based AR system that utilizes Three.js and WebXR API to allow users to place, scale, rotate, and manipulate 3D furniture models directly in a browser. The system is particularly useful for e-commerce applications, allowing customers to visualize furniture in their spaces before purchase. However, WebAR faces performance limitations on mobile browsers, and tracking accuracy is lower than ARCore-based applications. Despite these drawbacks, WebAR provides an easy-to-use and widely compatible solution for virtual interior design and online furniture shopping [3].
- A mobile AR application designed to simplify interior design by overlaying virtual 3D furniture onto real-world environments using marker-based tracking. Developed with Vuforia and Unity and guided by the ADDIE methodology, the system enables users to select, position, and manipulate virtual furniture in real time via their smartphone cameras. The findings demonstrate that AR significantly enhances decision-making, creativity, and cost efficiency in interior design. Although reliance on marker-based tracking may impose some limitations compared to markerless techniques, the application offers an accessible and interactive platform for modern interior design [4]

III. METHODOLOGY

A. Technologies and Tools for Development

The methodology for creating the virtual interior design application covers the entire process, from choosing the development environment to putting AR features and user interface design into practice. This section describes the methodical approach taken in the app's design, development, and testing. AndroidStudio With its coding, debugging, and user interface design capabilities, was the main Integrated Development Environment (IDE) for creating apps. It was the perfect platform for developing scalable and reliable apps because it supported both Java and Kotlin. Java was used to implement the application's main logic, while Kotlin was used to streamline development, manage asynchronous operations, and improve app performance.

B. Features of the Application

Placement of objects in real time is done with the help of a preset library of virtual furniture components, which is available for users to choose from. The camera can be used to place objects in real-world settings, even when the camera moves, objects are placed steadily thanks to AR Core's motion tracking. AR Core's surface detection capability is used by the app to identify flat objects like floors and tables, ensuring accurate alignment with the physical world by allowing virtual objects to snap to identified surfaces. To improve realism, AR Core's light estimation modifies virtual objects' shadows and brightness to match surrounding lighting. Scaling and Manipulation of Objects is achieved through simple motions like pinching, dragging, and rotation of virtual objects.

C. Architecture of the System

The architecture of the system includes various components working together to deliver an immersive AR experience. O n the client side, real-time footage of the outside world is captured by the camera input. The AR engine uses AR Core to create AR overlays after processing the camera input. The user interface (UI) offers interactive menus for manipulating and choosing objects. The system also includes a library of objects, which consists of a collection of locally saved or cloud-accessible 3D models of furnishings and décor pieces. These models have realistic textures and an appropriate polygon count, making them ideal for AR rendering. The rendering engine uses AR Core's rendering framework to render 3D items on the recognized surfaces, ensuring the seamless incorporation of virtual and real-world elements.

D. Workflow for Implementation

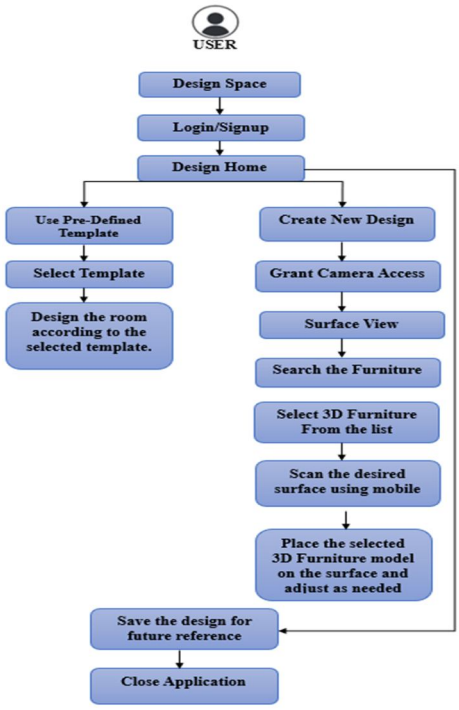

Figure 1. Workflow of the app

Establishing the project, where the AR Core SDK was set up and Android Studio was installed. The minimal operating system versions and supported devices for the application were specified. In the second phase, AR Core was integrated by enabling motion tracking and environmental awareness within the AR Core session, and the plane-finding API was used to implement surface detection. The third step involved the integration of 3D models, where 3D models of furniture in AR Core-compatible formats were either created or obtained, and interactive controls were added to allow users to choose and work with these models. Finally, the user interface was designed using the XML layout tools in Android Studio to create an intuitive experience, including menus for navigation controls, personalization choices, and item selection.

IV. Technical Architecture

The virtual home design app's technical architecture is made to take use of AR Core's sophisticated augmented reality capabilities and smoothly incorporate them with the Android Studio development environment. The architecture guarantees realistic depiction of virtual objects, seamless user interactions, and effective processing of AR data. The technical architecture of the system is broken down in detail below.

A. Essential Elements

The essential elements of the system include several key components that work together to deliver an effective AR experience. The AR Core engine provides motion tracking, which ensures that virtual objects stay rooted in the real world by continuously monitoring the device's orientation and position. It also enables environmental understanding by using plane identification methods to detect flat surfaces like tables and floors. Additionally, light estimation dynamically adjusts the brightness and shadows of virtual objects for realistic rendering based on ambient light analysis. The rendering engine uses AR Core’s Sceneform SDK to render 3D models in augmented reality and manages the alignment, scaling, and positioning of virtual objects on identified surfaces in real time. The layer of object interaction includes gesture-based controls that allow users to intuitively move, rotate, and resize virtual objects using multi-touch gestures such as drag-to-move and pinch-to-zoom.

B. Workflow of the System

The workflow for the system begins with AR Core processing input by receiving real-time data from the device's camera to detect planes. It then sets the scene by creating a 3D environment based on the observed area, allowing users to place objects on the highlighted surfaces. Finally, objects selected from the library are positioned on the detected planes, scaled and aligned according to the surroundings and plane orientation.

C. Architecture Layers

The architecture layers of the system are divided into several functional components. The layer of devices uses the camera to capture real-world input and processes user input through touch gestures. The AR Core layer handles core processing tasks such as motion tracking, plane detection, and light estimation. The application logic layer manages gesture recognition, user interface interactions, and object libraries. The rendering layer integrates virtual objects into the AR scene, adding lighting and shading effects. Finally, the presentation layer displays the complete augmented reality experience to the user.

V. Proposed System

The proposed system provides a seamless workflow for the users interacting with the application. Initially, user accesses the application interface to begin the design process. The system then presents user with options for either template selection or customization, allowing users to choose between standard templates which offers predefined layouts which they can use directly for their interior design or customize the room according to their personal choice. Once user select between the given options the application then prompts user with a request for camera access to enable the real time environment scanning. AR Core then processes the camera input to detect flat surfaces within the user’s environment, which are later used as anchors for the object placement. The system provides variety of virtual 3D models to choose from and once the user selects the model of their choice, they can place it on the detected surface. Users can interact with and position these models using touch-based gestures, ensuring accurate placement and scaling relative to the real-world space.

After object placement, a room preview is generated, offering users a visual representation of the designed space within the actual environment. The system also provides an option to save the final layout, enabling users to revisit their design later. This architecture effectively integrates template-driven customization, real-time AR object placement, and interactive preview capabilities to deliver a comprehensive interior design experience.

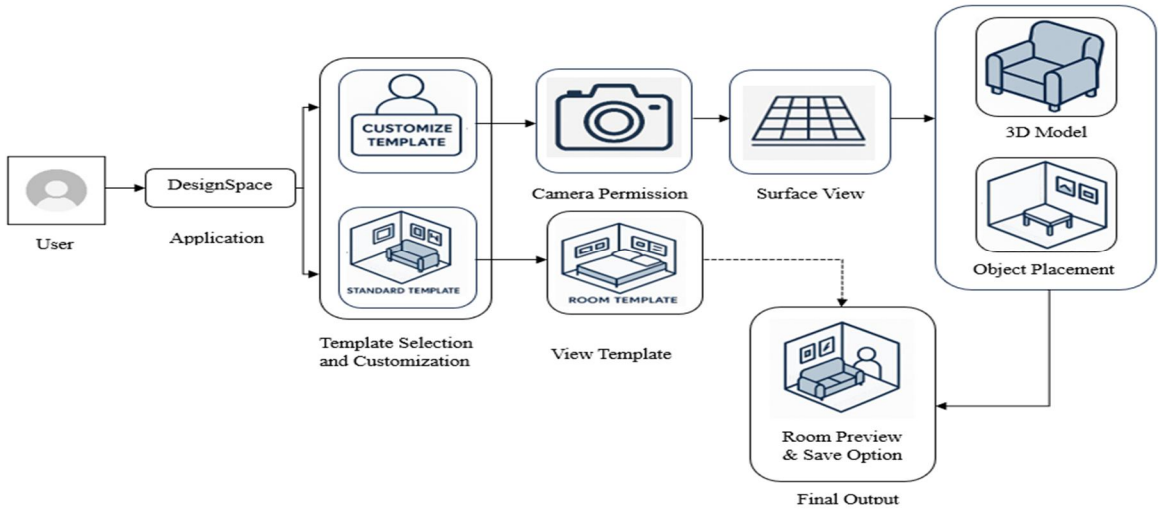

Figure 2. Proposed System Diagram

VI. GRAPH AND TABLE

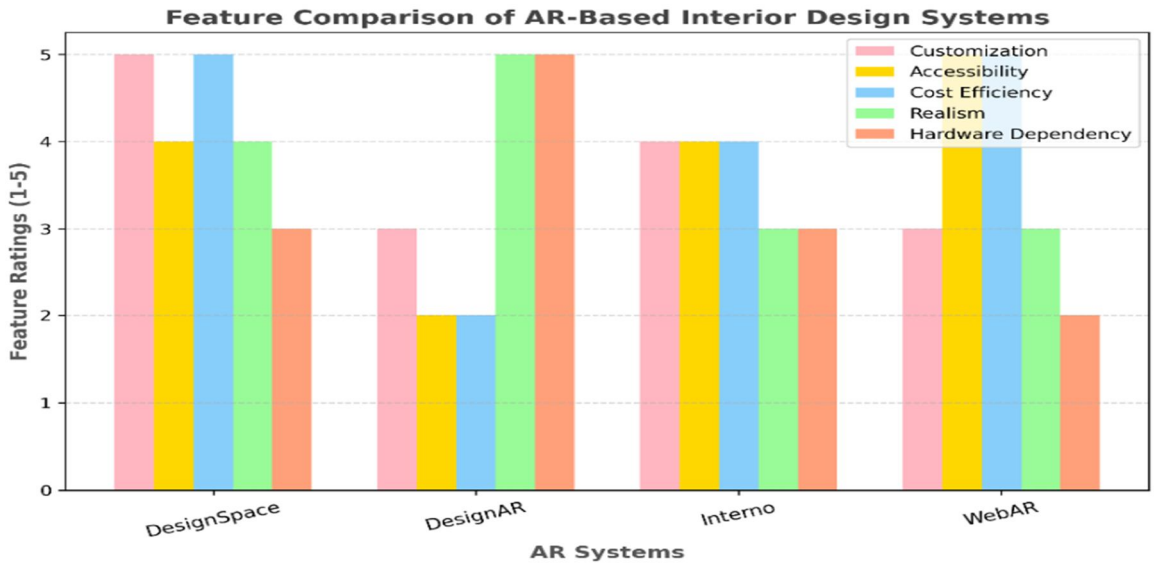

Figure 3. Comparative analysis of the app

TABLE I. FEATURE COMPARISON

Feature	Design Space	DesignAR	Interno	Markerless WebAR
Technology Used	ARCore	Projection-based AR	Marker & Markerless AR	WebAR
Platform	Android	Projector setup required	Android, iOS	Web browser
Hardware Requirements	Smartphone with ARCore support	Projector, RGB-D Camera	Smartphone or Tablet	Any device with web browser
User Interaction	Drag-Drop, Scale, Rotate7	Gesture-based, Projection UI	Manual Placement	Touch-based manipulation
Accessibility	Widely Accessible	Accessible	Widely accessible	Most accessible
Use Case	Home interior design with full control	Large-scale, immersive design prototyping	Architectural visualization	E-commerce & online furniture shopping

V. RESULTS

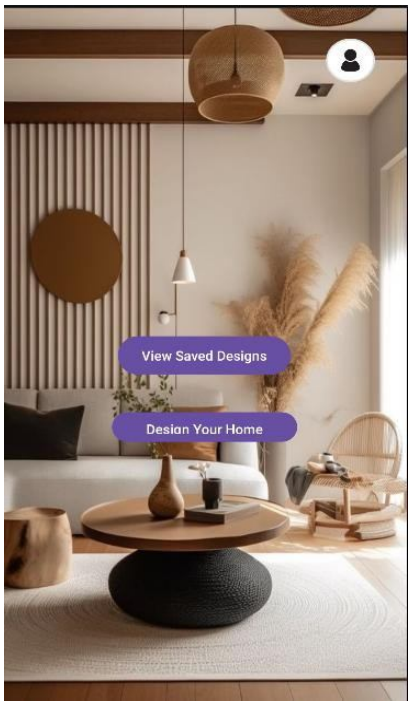

Figure 4. Home page of the app

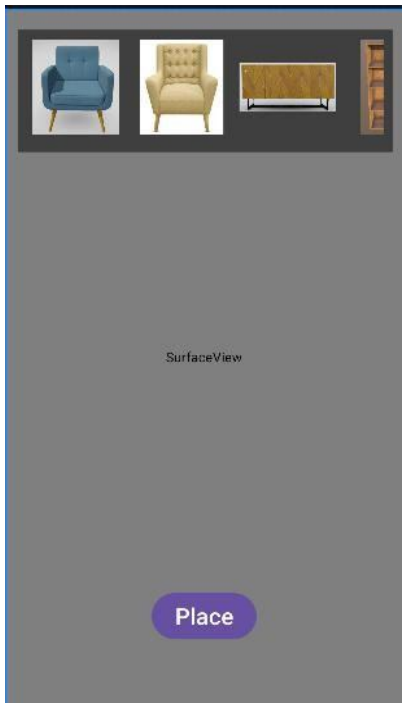

Figure 5. Surface view for object placement

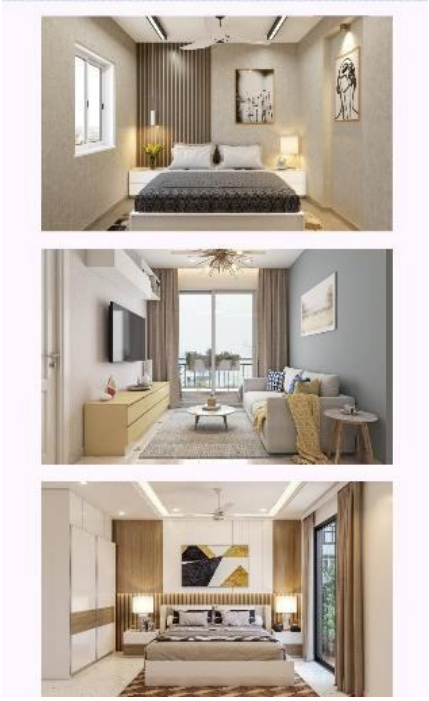

Figure 6. Templates for room design

VIII. CHALLENGES AND LIMITATIONS

A number of technical, user experience, and adoption-related issues and constraints that impact the virtual interior design app's operation and user pleasure were discovered during its development and deployment. Assuring the stability of virtual items positioned within the environment was a major technical problem. Though

sophisticated, AR Core's motion tracking periodically jittered when the camera moved quickly, which made the virtual objects unstable. Another difficulty was portraying these things realistically, particularly in settings with intricate or quickly shifting lighting conditions. Some of these problems were resolved by AR Core's light estimate capability, although light and shadow irregularities remained, detracting from the overall realism. Additionally, there were issues with surface detection accuracy, especially when dealing with textured or uneven surfaces like carpets or patterned flooring. Low-end devices also had performance issues. Since AR Core relies on advanced technology, devices with low-grade CPUs or GPUs were slow and rendered at a lower quality. In addition, the file size of the app increased because of the use of high-quality 3D models and textures, which may deter users with limited storage. Another challenge was creating accurate and user-friendly movements for manipulating objects since overly sensitive controls resulted in unintended variation of size, rotation, and position of the object. From the standpoint of user experience, the app's UI and interaction features presented a learning curve for new users. Sometimes people thought the multi-touch gestures for moving, rotating, and resizing things were complicated and counterintuitive. The app's attractiveness for users looking for a more customized experience was further limited by the lack of comprehensive customization tools for the virtual objects, such as the ability to alter their colors, textures, or proportions. Furthermore, interacting with virtual items became less immersive due to the lack of haptic input, making the experience less captivating.

During development, there were additional issues with broader adoption. Users with outdated smartphones or devices lacking the necessary hardware capabilities are not able to use the app because it is only compatible with Android devices that support AR Core. The app's market reach is further restricted by the fact that iOS users cannot access it. Although the main functions of the program are offline, using the cloud-based 3D model library necessitates an active internet connection, which may restrict its usefulness in places with inadequate connectivity. Its usefulness as a complete interior design solution was further reduced by the absence of direct e-commerce integration, which prevented users from buying the furnishings they saw straight from the app.

Finally, the available AR technology lacked functionality to augment the app completely. Ambient light is a massive influencer when it comes to how well features of AR perform, and places with less brightness are not great for object rendering and surface detection. The limitation of AR Core to sense the depth further bounds the app to manage complex setups with non-level or overlapping surfaces. Moreover, the augmented scenes lack authenticity because virtual objects cannot really interact with real-world objects because complete occlusion is not supported. Another problem was scalability since AR Core's dependency on flat surface recognition made it hard to deal with larger areas or outdoor settings.

IX. Conclusion

Using augmented reality (AR) technology, the virtual interior design app transforms how users see and arrange their living areas. The software bridges the gap between creativity and actual application by allowing users to envision and put virtual furniture and decorations in their real-world. Without making any financial or material commitments, the app provides a dynamic and interactive platform for designers, homeowners, and retail shoppers to experiment with aesthetics and space layouts. In the future, enhancing the graphics engine with advance AR features can improve visual realism. Expanding to iOS via ARKit would widen its accessibility, and integrating e-commerce functionality could allow users to directly purchase furniture from within the app, would further enhance usability across a broader audience.

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