# Augmented Reality Interior Design and Customization

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***Abstract*: This project will employ augmented reality and virtual reality technologies to digitally re-create and analyse the spatial geometry of a four-walled room. It will be possible to input the dimensions of a room, so that it will accurately map the 3D structure of a closed environment. Using the computed available space, users can virtually place objects within a room. The main objective is to mimic real spatial arrangements in a virtual environment and hence enhance applications such as interior design, architecture, and spatial planning. With this technology, users can see furniture layouts, assess decor choices, and conduct ergonomic analyses by observing configurations in a virtual environment before any physical changes occur. This approach not only reduces trial-and-error procedures but also maximizes space usage and increases user interaction. Capturing, processing, and visualizing spatial data, it builds this project with various technologies integrated together as part of AR and VR. Its core technology stack involves using Unity 3D for powerful real-time 3D content creation and scripting the manipulation of 3D objects as well as the spatial interaction using C#. Augmented reality frameworks, for instance, AR Core for Android, provide functionalities for the identification and charting of horizontal surfaces in an environment to facilitate spatial measurement and positioning of objects. Using depth data from AR Core, a spatially accurate model of a room is created to enable precise placement of virtual entities. This project integrates the most advanced AR frameworks for a room layout. This technology marks a great leap forward in spatial computing, interactive, and user-friendly interfaces to engage with digital environments.**

***Keywords*: Augmented Reality, Spatial Geometry, Virtual Environment, AR Core, Depth Data.**

## 1. Introduction

AR technology is an innovation that enhances real images by adding computer-generated images and has its applications in engineering and architecture to tackle practical problems. Many systems of today use AR, such as fashion, video games, and navigation applications are great interactive tools. What one finds fundamentally important about AR functionality, thus, is the ability of the integration of elements pertaining to the digital world into tangibility and reality. And therefore, components are not regarded just as mere data displays that appear as such but in the context of augmentation itself, considered part of this surrounding environment. Through such augmented reality technology, the interior design application has emerged where it is capable of making visual appearances of furniture inside a given real-world environment before anyone purchases any of them. The interior design application, therefore, helps users have a selection of virtual furniture and move them into space by simply dragging the item into a real-world scenario. The application would also demonstrate compatibility with all the currently available Android versions since the mobile camera represents such a significant element. The camera makes live image capture possible inside panoramic context, and using that, users can manoeuvre any chosen furniture and preview from different angles. This application is going to help the user save time as well as efforts for selecting the furniture due to visiting the shop personally. The implementation of this AR technology in the Mobile application is done by employing AR SDK tools. With Augmented Reality (AR) several types of 3D objects are placed in this real world.

## 2. Literature Review

Augmented reality is the next generation of technology that is making it possible for interior designers to think differently, design, and individualize space in ways that were unimagined before. Augmented reality connects the virtual world with the physical world; it allows users instantly to interact with digital models of furnishings and decorations and hence makes an immersive design experience possible that was not achievable by conventional means.

Many research studies have explored the integration of AR into interior design applications. The most prominent advances in such areas are marker-less AR systems, automatic algorithms of furniture arrangement, and environment-aware recommendations. All of these enable virtual objects to be placed and adjusted easily within a physical space. Users can experiment with furniture layouts, colours, and textures without having to alter their spaces physically. An interactive experience improves decision-making, reduces design errors, and boosts purchasing confidence. Research has shown how the immersive visualization capabilities of AR enhance communication between designers and clients, encouraging collaboration and clear expression of design expectations. Despite these advantages, there are still problems. Compatibility with devices, computational requirement, and lack of personalization are some of the major problems in using AR-based design applications. Some systems rely on SLAM and 3D modelling, which are based on advanced technologies requiring much processing power and specific hardware.

Moreover, intuitive and user-friendly interface has been a recurring theme in research because complex interfaces overwhelm users and take away from the design experience. The integration of AI and AR can further show the scope for even more intelligent design options. AI-powered recommendation systems can evaluate user tastes, spatial dimensions, and style trends to provide optimized arrangements and decorative matching suggestions. This approach not only makes designing easier but also enhances personalization that will allow users to realize different kinds of customized interiors in much less effort. Forward looking into the future, however, will be based on further realism for AR's utilization of features like live texturing, and lighting changes and haptic feedback. Further development in cross-platform compatibility and adoption with Web AR could also bring the capability of having many such design tools for a design professional to access without going to the need for new and specialized devices.

Table 1
Literature review table

| Author | Research Objective | Methodology | Key Finding |
|---|---|---|---|
| [1] H. Smith et al. (2021) | to develop an AR-based retail application for virtual furniture placement. | Used ARKit for real-time object placement with a limited catalog of IKEA products. Users can scale and orient virtual furniture. | Enhanced user engagement and decision-making by allowing interactive product visualization. |
| [2 R. Singh and M. Gupta (2021) | To create an interactive AR system for interior design applications. | Used OpenCV and TensorFlow for gesture-based AR interaction with hand tracking and advanced lighting effects. | Provided a more immersive and realistic user experience through gesture-based control. |
| [3] L. Zhang and P. Lee (2022) | to explore AR applications in e-commerce for improving customer interaction. | Developed with Unity 3D, featuring real-time object rendering, color, texture, and size customization. | Increased user engagement and purchase intent through interactive customization. |
| [4] F. Jones and B. Patel (2022) | To analyze the impact of AR on consumer engagement and purchase behavior. | Developed a theoretical framework for AR-driven consumer analytics and personalized product recommendations. | AR personalization increases customer retention and purchase likelihood. |
| [5] K. Tanaka and Y. Sato (2023) | To develop a web-based AR platform for interior customization. | Built using Three.js for browser accessibility, offering basic object resizing, repositioning, and cross-platform support. | Enabled AR interior customization without requiring dedicated AR hardware or apps. |
| [6] D. Lopez and R. Kumar (2023) | To enable real-time AR visualization for interior design. | Cloud-based catalog integration with Vulkan APIs for real-time rendering. Supports rotation, scaling, and extensive customization. | Improved rendering speed and customization flexibility for interior design professionals |

## 3. System Design and Implementation

### *A. System Architecture: Building a Portal to Your Dream Doom*

Imagine wanting to redecorate your living room, but without lifting a single piece of furniture – or even buying anything yet! That's the magic we're aiming to experiment with furniture in your actual space, right before your eyes. The secret is a modular design. Instead of one giant, complicated program, we've broken it down into smaller, more manageable chunks. Think of it like building a fantastic machine, each gear has to turn perfectly to get the job done. This modular approach makes the for with our system architecture. It's all about cleverly merging the real and virtual worlds, letting system easier to understand, develop, and even improve later on.

- The "Eyes" module in the ARCore system actually observes your room. The ARCore system acts as the eyes of the system, realizing spatial awareness, whereby it uses your device's camera in order to map the space-all the while figuring out where the walls are, where the floor is, and how the light behaves. It constantly pours in spatial information, being the curious explorer that maps out the lay of the land.
- *Furniture Factory*: The 3D Asset Management Module - This is the module that creates the virtual furniture. We're not talking about blocky, unrealistic shapes here. We want furniture that looks realistic for any home with real-world scales, nice texture, and realistic design. Blender falls in this category-the open-source 3D modeling software we use. This will truly feel like an elaborate digital sculpting studio. Well, we have to be smart about how we create these models. After all, things will run smoother if we ensure that the AR applications behave accordingly. So, we optimize furniture thoroughly and simplify the designs to keep AR running smoothly.
- *Conductor - Core AR Engine (Unity 3D Takes the Stage)*: This is the brain of the whole operation. Unity3D, the leading game engine, is well put to use in creating interactive AR experiences. It interprets the real-world information coming in from ARCore and puts it together with the beautiful 3D models we created in Blender. It takes care of drawing virtual furniture on the screen, behavior (no floating sofas!) simulation, and user interaction with furniture. Like a stage director combining all peripherals into a perfect seamless execution.
- The Magician - Customization and Interaction Logic. Here is where we put the 'extra' into our application. In Unity, we use C# scripts to define how you can interact with the virtual furniture. While some of those scripts define how, say, you change the color of a chair, for others, flicking your finger will rotate the table. We could even go for some smart features, aligning your furniture with the walls automatically!
- *User Interface (Your Control Panel)*: The interface is your control panel that lets you browse through different kinds of furniture items, pick their colors, and adjust settings. It was designed to be intuitive and user-friendly. Clear visual indications and feedback methods help to guide users through the design process and support their understanding

of the virtual environment, empowering them to make informed decisions for their interior space.

- ER Diagram - Mapping Out Our Data Landscape: An ER Diagram is sort of like a blueprint for our data; thus, it guides you in defining the different entities within our system (say, furniture items, users, room dimensions), their attributes (for instance, the color, size, and material of various pieces of furniture; username, preferences for users, etc.), and how they associate with each other. For example, a user can "own" many furniture items, while an item of furniture relates with one category.

### *B. Technology Stack: Our Toolbox for Blending Worlds*

Let's peek inside our toolbox and see what specific technologies we're using to build this AR experience.

#### *1) ARCore: Giving Our App Eyes and a Sense of Space*

*About ARCore: Unifying Our App with Eyes and a Sense of Space*

- *Motion Tracking*: Think of it as the app being aware of its location at all times in a room. As you move your phone or tablet, the virtual furniture doesn't budge; it's as if it really were there.
- *Environmental Understanding*: ARCore manages to wrap its digital arms around the detection of varied surfaces within a given environment, such as a floor, walls, and tables since this is essential to place the furniture realistically.
- *Light Estimation*: ARCore can go further and know what room one has in terms of illumination. It allows the virtual furniture to look more lifelike by modifying its brightness and shadows to fit in with the real-world lighting.
- *Augmented Faces*: Another feature of ARCore is the identification and tracking of human faces in the surrounding environment allowing for face-based interactions with others, such as virtual try-on and animations.
- *Cloud Anchors*: Cloud Anchors enable the multiple users to surround the same virtual objects while sharing a single physical space, which makes possible the experiences of collaboration using augmented reality.
- *Persistent Anchors*: Even when the app is restarted or the device is moved, virtual objects will stay in place over time, guaranteeing that the built environment is developed together over a long span of time.

#### *2) Blender: For Building Digital Future*

- *Detailed Modeling*: We can generate highly detailed and realistic furniture models, correctly replicating shapes, textures, and materials used in actual objects.
- *Customization Options*: Simply put, we can make differently staged versions of the furniture type for users to use in customizing the visual and tactile feel of virtual furniture.
- *For AR Optimization*: We furnish model optimization in accordance with the AR functions. This entails lowering polygon counts, creating optimized textures, and exporting the models in a format amenable to being used by Unity.

#### *3) Unity 3D: The Stage Where It All Comes to Life*

- Many AR projects have utilized AR Foundation, the base for developing AR applications, to give developers a way to write code for both Android and iOS devices using a common interface.
- Unity allows not just programmers but many other people to use visual scripting to create gameplay ideas in a node-like manner.
- The Unity Asset Store possesses thousands of ready-made assets, plugins, and tools that can help with reducing the development time and improving the AR application's functionalities.

#### *4) C#: the Magic That Makes It Happen*

- *AR Interactions*: C# scripts handle all the interactions with virtual furniture, moving it, rotating, scaling, and customizing it.
- *User Interface*: the C# scripts are also responsible for user interface, enabling a fluid way for the users to browse through furniture, select colours, and make any necessary adjustments.

### *C. Furniture Customization Module: Unleash your Inner Designer*

We want you to feel like you're in control. That's why we've created a robust furniture customization module.

- *A Rainbow of Colours*: Pick from a wide array of colours.
- *Touch and Feel*: Change the texture and material of the furniture.
- *See It Live*: All changes happen in real-time.
  Shape It Your Way: Advanced settings let you tweak the shape and size.

### *D. DFD: Visualizing the Flow of Information*

On the contrary, DFD delineates the information flow across our system. It shows the processes involved (like browsing furniture, customizing a piece, placing it into the AR environment), external entities (like user and SketchFab API), and data stores (like shopping cart). By placing this flow into a format, we might be able to identify where bottlenecks are occurring, optimize processes, and ensure data is being processed as efficiently as possible within the app. That is, a DFD indicates how a user request for a specific model of furniture initiates data flow from the SketchFab API into our app and then from there to the AR rendering engine.

Using Augmented Reality (AR) has produced favorable results in enhancing the user experience and facilitating decision making in space customization for interior design. Technologies which let users place furniture in actual-world scenarios through virtual environments that are enhanced by real-time rendering technologies such as Unity 3D and real-time Vulkan APIs, giving realistic and smooth interactions have proved to enhance the virtual user interaction with real

environments, thereby enhancing the purchasing probabilities. Such advancements allow the users to work with the objects and manipulate them in natural ways, leading to more confident decisions regarding the fitting of furniture and other designs in real-world setups. This technology lets users manipulate and interact with objects, allowing fine-tuning, so they can be more confident about how furniture and other designs will fit into space.

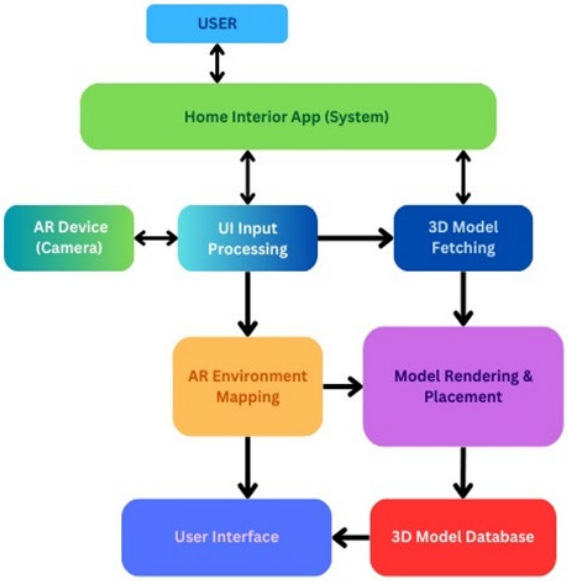


Fig.1. Work flow of project

By adopting ARKit/ARCore with precision measurement of real-world spaces, virtual objects were hardly placed into a space. This helped the user understand whether one piece of furniture indeed fits workable in their room without moving things. Further, this guide is a discussion on how AI comes as one of the very influential agents of change in the interior design world.

Cloud platforms did considerably better for cooperative design, allowing for concurrent users to join together in the same virtual environment in real time. This is particularly useful in group design projects where everyone can give feedback and make changes in real-time. The AR platforms enable access through mobile devices and web browsers.

While AR has opened possibilities for collaborative workflows and dynamic visualization in interior design, designers and developers continue to face an uphill task in getting the technology right for real-world application. One persistent obstacle is actually scaling AR solutions to work uniformly across the entire spectrum of devices-including premium VR set-ups to budget smartphones-without compromising on the actual rendering quality or responsiveness. In such a case, even achieving smooth frame rate on comparatively less powerful devices will resort to dynamic resolution scaling-perhaps, not rewarding any visual fidelity in the process. Cross-platform compatibility complicates development further, given the array of hardware specifications and input methods that require the accompanying specifications to be tailored under resource-intensive conditions. Here fig.2 and fig.3 represent the previous and our work on this project.

## 4. Conclusion

To summarize, AR application in interior design has contributed to a paradigm shift in the way of visualizing, customizing, and interacting with the spaces by our millennial generation. The combination of real-time rendering technology, accurate spatial measurement data, and personalized AI has deepened user engagement, optimized decision-making, and improved design personalization in the augmented reality world. Cloud/In-the-Cloud Summary of Changes to the 3D Game Transformation Cloud-based platforms are having a transformative effect on 3D game design. Challenges such as device compatibility issues and the inability to replace tactile experiences, AR continues to evolve and development augmenting reality applications enables the interior designing field.

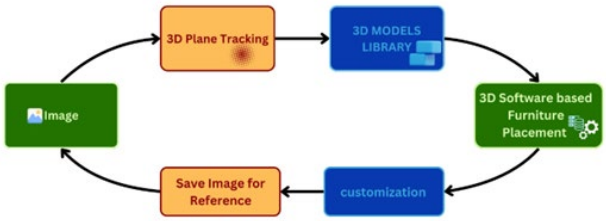


Fig.2. Previous work on this project

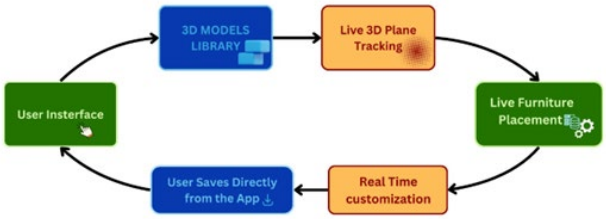


Fig.3. Our work on this project

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