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A Study on Role of AR in Shaping Virtual Furniture Shopping

Nuzhat Shaikh[1], Atharva Gawade[2], Talaksha Chavan[3], Samruddhi Kale[4] and Sharmishtha Satturwar[5]
[1-5]Department Of Computer Engineering, Wadia College of Engineering, Pune, India.
Email: {nfshaikh@mescoepune.org,{atharvagawade2003@gmail.com, talakshachavan28@gmail.com, kalesamruddhi6@gmail.com, sharmishthashailesh@gmail.com}

***Abstract*—Augmented Reality (AR) technology is transforming online furniture shopping, making it easier for users to visualize how items will look in their homes. The proposed work introduces a mobile app that uses AR to allow users to virtually place and arrange furniture in their rooms. By scanning their space, users can see how different furniture pieces would look in real-time, offering a more personalized and interactive shopping experience. The app features a simple and user-friendly interface, providing a catalog of furniture from inbuilt options and third-party platforms. After scanning their room, users can select furniture items from the catalog and use AR to visualize them in their space, helping them understand how well each piece fits and looks.**

Additionally, users can save their favorite designs or layouts to compare later. With integrations from third-party platforms, the app offers a wider range of furniture options. By combining AR technology with an extensive catalog, the proposed work bridges the gap between online shopping and real-world visualization, enabling users to make confident and informed decisions about furnishing their spaces.

***Index Terms*— Augmented Reality, Furniture Visualization, Markerless Tracking, GLTFLoader, Interior Designing, Waterfall Methodology, Android Applications.**

I. INTRODUCTION

The Virtual Furniture Showroom and Shopping App is an application that streams AR furniture shopping. One can conveniently and enjoyably shop for furniture with the aid of the application, which provides a chance to view realistic 3D models in their own room.

Using either their device's camera or scanning a marker, users can place virtual furniture in their space, with the option to use a specific marker or go markerless.

That freedom lets users freely test various furniture arrangements to give them a very personalized shopping experience. Among the app's key features, its capability to let users arrange multiple pieces of furniture and try out different layouts and designs for their own rooms is one of the popular features of the app. The app also Due to the import options of 3D models from other sources, users are now in a position to source furniture from elsewhere besides the app's own catalog, hence acquiring a wide variety of furniture from other online stores. Apart from the AR, the app has a virtual showroom through which the user can see and move around in an interactive space with multiple furniture sets.

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This will enable users to experience different items from Such furniture can be accessed from various angles like in the physical showroom; however, the ease of online shopping with the immersive feel of a showroom visit has brought it all together to support comprehensive shopping experience that users make the best-informed furniture decisions.

II. Literature Review

Augmented Reality (AR)[1] has had a major impact on many industries, especially online shopping, by enhancing customer experiences with immersive visual tools. Augmented Reality (AR) is widely used in furniture shopping, enabling customers to see and interact with 3D models of furniture in their own homes. Studies in this field have highlighted the benefits of AR technology, not only in terms of user experience but also for its cost effectiveness. This review summarizes research on AR-enabled furniture platforms and identifies areas for improvement, setting the stage for creating a Virtual Furniture Showroom and Shopping app. This study[2] demonstrates how AR simplifies furniture selection by allowing users to visualize 3D models in real-time, enabling them to see how multiple pieces of furniture would look together in an empty room. This interactive approach helps customers explore different layouts and make informed decisions. Using tools like Unity and Visual Studio, the application offers an intuitive interface, overcoming the limitation of earlier AR systems that allowed visualization of only one item at a time. By supporting multiple items within a single space, this new application provides a more comprehensive and engaging user experience. Marker less AR[3] enables users to place virtual furniture in real-world spaces without needing physical markers like QR codes, using environmental tracking algorithms and tools like GLTFLoader in Three.js. This technology allows customers to arrange multiple 3D models simultaneously, helping them visualize how different pieces will fit and look within their space, making purchase decisions easier. By creating virtual versions of rooms, users can experiment with furniture placement without physical effort or commitment. Additionally, web-based AR enhances accessibility by allowing interaction directly through a browser, eliminating the need for app downloads and reducing storage constraints, making AR more user-friendly and widely adoptable. Another challenge [4] in online furniture shopping is deciding if a furniture item will fit well in a space or match the room's decor. AR helps solve this by letting customers place virtual models of furniture in their own spaces, helping them confirm the fit, style, and color of the furniture before they make a purchase. A study using Google AR services and Android Studio created an AR-based tool that lets users interact with and customize furniture models in real-time. This tool improves the shopping experience by allowing users to experiment with various layouts from the comfort of their homes, making the decision process quicker and easier. A key focus[5] in AR research is comparing marker-based and markerless methods. Marker-based AR relies on physical markers like QR codes to place virtual objects, while markerless AR uses natural features, such as surfaces and spatial recognition, offering a more seamless experience. This makes markerless AR particularly valuable in furniture shopping, where users can visualize items in their homes without additional setup. Realistic 3D models are crucial for enhancing the AR experience, requiring accurate shapes, textures, and formats to blend with real-world environments. These detailed models help customers make confident decisions by providing a clear sense of how furniture will look and fit in their space. The use[6] of AR in e-commerce has promising implications for the future, particularly in the furniture industry. By letting customers visualize how a product will look in their space before they buy it, AR reduces one of the biggest problems in online shopping: uncertainty about fit and appearance. This immersive shopping experience leads to fewer returns and greater customer satisfaction, as it provides a more interactive and realistic view of products. AR[7] has significantly advanced furniture visualization, evolving from single-item placement to web-based solutions that support arranging multiple items simultaneously. The proposed Virtual Furniture Showroom and Shopping app addresses these issues with a real-time AR solution that simplifies choosing, arranging, and purchasing furniture. The hybrid app design leverages Virtual Reality Modeling Language (VRML) and Active-X technologies to reduce server load and network bandwidth while allowing seamless content updates. By combining efficient product searches with immersive 3D navigation, the app appeals to shoppers seeking both practicality and engaging online experiences. Augmented Reality (AR)[8] apps enhance shopping by placing virtual products in real environments, offering engaging and personalized experiences. This study explored how spatial presence, perceived personalization, and intrusiveness make AR apps persuasive, comparing AR to non-AR apps through experiments. Findings revealed that for first-time users, perceived usefulness drives purchase intentions, emphasizing practicality in initial interactions Augmented Reality (AR)[9] enhances e-commerce by allowing users to visualize virtual products, like furniture, in their real environment, making it easier to decide before buying. This study compared AR shopping with traditional web-based shopping, focusing on six factors: interactivity, information, enjoyment, novelty, vividness, and

intrusiveness. Results show AR offers a highly engaging and visually rich experience, boosting customer involvement and purchase decisions. However, for widespread adoption, companies must address usability challenges like reducing intrusiveness and improving interface design for smoother, more intuitive interactions. By overcoming these barriers, AR can merge the convenience of online shopping with the clarity of in-store experiences, transforming e-commerce.

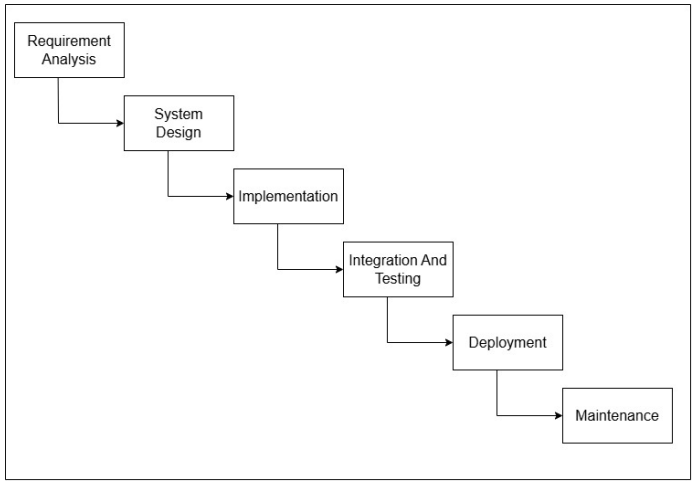

Fig. 1. WaterFall Model

The Waterfall model[1] was applied in the development of a Virtual Furniture Showroom and Shopping app, designed to improve the user experience of buying furniture through Augmented Reality (AR). The Waterfall model follows a structured, step-by-step process where each phase depends on the completion of the previous one. It starts with Requirement Gathering, where the team identifies the user needs for AR visualization, API integration, and database management. Then, in the System Design phase, decisions are made about how the AR rendering, model management, and user preferences will be handled. The Implementation phase involves coding the app's features, such as the AR engine, 3D model viewer, and API manager. The Integration and Testing phase ensures that all components work well together, focusing on user interactions, model accuracy, and API integration. Once deployed, the system moves into the Maintenance phase, where it will be updated and supported over time. By using the Waterfall model, the development process is clear and organized, ensuring the app is reliable and of high quality. Online shopping[10] has changed the way people buy things, thanks to the rapid growth of Internet technology. In Taiwan, for example, the National Development Council found that more people are shopping online. Recently, augmented reality (AR) has been introduced to online shopping websites, adding a new feature for customers. This study looked at a popular Taiwanese online shopping website that included an AR feature, allowing customers to virtually try on headwear. To compare its effectiveness, the same website without the AR feature was also tested. Thirty participants, with ten in each of the three age groups (20-29, 30-39, and 40-49), all with prior online shopping experience, took part in the study. Each participant first practiced using both the AR system and the regular website, and then completed four randomly assigned scenarios. Objective measurements like task completion time and mouse performance were recorded, and after each scenario, participants answered questions using the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ). The results showed that participants preferred using the website with the AR feature. The AR system also reduced the number of mouse clicks, improved mouse speed, and lowered the frequency of paging, suggesting that AR can make shopping decisions faster and more efficient for customers. E-retailers[11] are leveraging augmented reality (AR) to enhance shopping experiences and drive purchases, with features like novelty, wow-factor, and inspiration boosting hedonic motivations and purchase intentions. However, excessive wow-factor and distraction can hinder engagement, highlighting the need for balanced AR design. In mobile AR environments, attributes such as perceived augmentation, simulated physical control, and response time positively impact brand equity by strengthening cognitive, emotional, and sensory brand associations, with consumer innovativeness playing a moderating role. These insights emphasize the potential of AR to transform e-commerce when carefully optimized for user engagement and brand impact. Augmented reality (AR)[12] enhances shopping decisions by reducing cognitive load, an often-overlooked factor in consumer behaviour. Using the stimulus-organism-response model and cognitive load theory, this study examined how AR influences perceived similarity among products, choice-related confusion, and repurchase cognitive dissonance, ultimately

impacting purchase intentions and willingness to pay. Conducted in an online cosmetics store context, the research combined focus groups and an experimental study to validate findings. Results revealed that AR minimizes confusion and dissonance, improving decision-making and boosting purchase intentions. This highlights AR's value in e-commerce, especially for retailers with extensive product ranges, by enhancing customer experiences and increasing sales. This study[13] aims to understand the impact of augmented reality (AR) technology on consumers' purchase behaviors. As AR becomes more widespread and accessible for marketers, many retailers are launching AR-based apps to promote their products. Despite the rise of these applications, there is still limited knowledge about how they influence consumers' purchasing intentions and the underlying mechanisms that drive these intentions. This research examines how AR app stimuli affect users' cognitive and emotional responses, ultimately influencing their intent to purchase. Based on a sample of 394 responses from U.S. consumers, the study identifies how specific features of AR apps activate cognitive and affective responses, which then lead to purchase-related behaviors. Additionally, it considers the role of habituation, comparing first-time users with experienced users. Findings indicate that, as users become accustomed to using AR apps for shopping, they begin to prioritize different app elements based on their experience level. This study[14] utilized two separate online questionnaires, distributed across various digital platforms such as Telegram, Zoom, and email. This distribution method was carefully chosen to accommodate the COVID-19 pandemic context. Both groups of participants, who had prior exposure to AR technology, were given the task of virtually selecting an armchair for their homes. The study specifically targeted university students, given that it took place in a developing country where familiarity with AR technology is generally lower than in developed countries. By choosing university students, they ensured a participant group both capable of quickly adapting to AR and able to understand its benefits and applications. During these sessions, they emphasized how AR can transform the shopping experience by allowing users to visualize products in their own environments. Two supervisors of this project were also present in these video conferences, further enhancing the credibility and guidance provided to participants. The link to the first video conference was sent to approximately 280 students via their academic email addresses, ensuring that all participants in the study were university students. This approach aimed to achieve a well-informed and AR-literate sample, critical for generating meaningful insights into AR's impact on purchase-related behaviors. This video conference[15] was organized for the control group, with 244 participants actively joining. During the session, they provided the questionnaire link either directly through Zoom or by sharing it via communication channels like email and Telegram. Ultimately, 204 participants completed the questionnaire. The control group primarily consisted of individuals with experience in web-based online shopping. For this exercise, their task involved an imaginative shopping scenario where they selected an armchair using the IKEA store website. To ensure data validity and accuracy, they collected responses from this initial set of questionnaires before proceeding with a second video conference for the experimental group. For this second session, they sent the conference link to a different set of approximately 280 students via their academic email addresses. This second video conference focused on the experimental group, with 233 participants actively attending. In the end, 206 participants completed the questionnaire. This experimental group was given specific instructions to download and install the IKEA Place app on their smartphones, available on both the App Store for iOS devices and the Play Store for Android devices, to enhance their experience with AR in the shopping task. This study helped in analyzing different responses of the individuals which led to successful research of the usage of AR in the furniture shopping, it also helped in showing the ability of AR to work on different devices and platforms. Augmented Reality (AR)[16] has transformed how we interact with the real world, allowing virtual objects to blend seamlessly with real surfaces. By combining fields like computer vision, virtual reality, and human- computer interaction, AR has found applications in gaming, entertainment, navigation, and more. In library management, AR can revolutionize book tracking by guiding users directly to a book's location. Unlike traditional systems that relied on fixed computers and manual searches, AR automates the process, using features like marker-based tracking for context awareness and book spine-based tracking for faster results. Borrowers can navigate through the library, locate books efficiently, and access augmented information about them. This modern approach makes library systems faster, user-friendly, and far more effective than traditional methods. Microsoft HoloLens[17] has revolutionized the way users interact with digital content, enabling them to view and manipulate holograms as if they were real objects. This project focuses on using HoloLens in education to make learning more interactive and engaging for computer engineering students. By creating applications that simplify complex topics like engineering graphics, scheduling algorithms, and data structures, the project aims to improve understanding through immersive visualizations. Using features like gesture control, voice recognition, and gaze tracking, the proposed work offers a modern and effective way to grasp challenging concepts, enhancing both learning outcomes and student interest. Construction documentation[18] has progressed from traditional drafting to advanced 3D modeling,

streamlining planning and decision-making. While 3D models offer detailed visualizations, they often lack tools for group collaboration and fail to provide customers with a complete understanding of room layouts or features. Interactive software addresses this by allowing customers to explore projects through virtual walkthroughs on their devices, offering a realistic view of layouts and aiding interior planning. This system, supported by a backend server, collaboration tools, and an interior planning module, enhances customer engagement by delivering a comprehensive and immersive experience of the infrastructure. For interior design[19], the system requires seamless communication between hardware and software components. Cameras, sensors, and software APIs work together to accurately display virtual 3D objects. Google's AR-Core platform enables phones to sense and understand their environment by tracking the phone's position and identifying key points, such as flat surfaces, while adjusting for lighting. This allows AR-Core to place virtual objects in the real world in a way that blends naturally. The process involves capturing the environment with the camera, selecting and adjusting objects from a menu, and using AR-Core tools to anchor, scale, and rotates them.

III. Research Gap

Many people struggle with buying furniture online because they can't easily picture how it will look or fit in their homes. This can lead to hesitation, doubts, and even returns after they've made a purchase. Customers often feel uncertain if the size, color, or style of the furniture will work with their existing space and decor. Without a realistic way to visualize the furniture in their own homes, they might decide not to buy at all, or they may end up disappointed when the item arrives and doesn't meet their expectations. Traditional online shopping methods are mostly limited to photos and measurements, which don't provide an immersive experience. This limitation can leave customers feeling disconnected and uninformed, affecting their confidence in their buying decisions. For retailers, this can mean lost sales opportunities and higher return rates, which can impact their business. This work is designed to solve these challenges by giving customers a more interactive experience when shopping for furniture. It aims to bring online shopping closer to real-life visualization, so customers can see how items would actually look and fit in their homes. By helping customers feel more engaged and confident in their choices, this approach has the potential to reduce uncertainty, improve satisfaction, and support retailers in making more successful sales.

IV. Problem Statement

The proposed work presents an innovative solution for enhancing the furniture shopping experience through an Android Based Application based on Augmented Reality which renders 3d models. It will offer marker based as well as marker-less rendering of the 3d models. It will also have a functionality of combining 3d models from external websites to give the end user a option of exploring various furniture items that he has to buy. The work also proposes the function of liked items management so the user can view multiple items at the same time and arrange them.

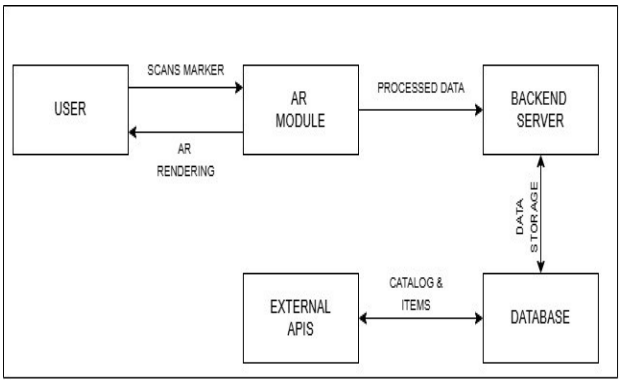

Fig. 2. Block Diagram

V. Methodology

A. User Device

The User Device is the main tool used by the user, such as a smartphone or tablet. It allows users to scan their rooms using the camera and browse through furniture options. The device shows furniture in augmented reality,

letting users see how it would look in their space. Users can also save their favorite furniture arrangements for later. All the data captured by the device, like room dimensions and furniture selections, is sent to the AR Module for further processing.

B. AR Module

The AR Module is responsible for creating the augmented reality experience. It processes the scanned data from the User Device and displays virtual furniture in real time. This makes it possible to see how the selected furniture fits and looks in the room. The AR Module ensures the placement is accurate and realistic. After processing, it sends this information to the Backend Server for further use, like saving designs or fetching additional details.

C. Backend Server

The Backend Server is like the app's control center, man- aging all the data and communication between different parts of the system. It takes the processed data from the AR Module, interacts with the Database to save or retrieve user data, and connects with External APIs to get more furniture options. The server ensures everything runs smoothly, like fetching saved designs or providing users with updated catalog options.

D. Database

The Database stores all the important data for the app, including user profiles, saved designs, and furniture de- tails. When users want to access their saved room layouts or specific furniture information, the database quickly provides it. This ensures that the app operates efficiently and gives users the information they need without delays.

E. External APIs

The External APIs help the app connect with third- party platforms like IKEA or Amazon to access a wider range of furniture options. These APIs bring in additional furniture models and details, which are processed by the Backend Server and displayed in the app. This allows users to explore more choices beyond the app's inbuilt catalog.

VI. CONCLUSION

The Virtual Furniture Showroom and Shopping app will revolutionize furniture shopping. Users can see furniture items in their real environments through marker-based and markerless augmented reality. This app therefore closes the gap between online shopping and real-world experiences. Thus, users can try out furniture to look for it and arrange it in their homes and offices before buying. Highly reduces the chances of purchasing furniture that would not fit or suit their space. Integration with other e-commerce websites increases the amount of furniture to select from hence, a wide collection of models by different brands will be accessible on one platform. The app is highly interactive and immersive. However, it also operates with limitations like device compatibility. The app has widespread use among all types of industries, from retail and real estate to event planning and interior design education.

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