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Enhancing Interior Spaces with AR: A Study on Virtual Home Design Applications

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ABSTRACT

Due to the quick advancement of technology, augmented reality (AR) has emerged as a revolutionary tool in interior design, allowing experts to effortlessly incorporate virtual furnishings and décor into actual environments. In order to help interior designers visualize and alter virtual things in a room, this study presents Virtual Home Designer, a web-based augmented reality application powered by Django. By providing real-time visualization, this approach greatly lowers design errors and lessens reliance on conventional 2D plans.

Future improvements may include AI-driven recommendations and more sophisticated 3D modeling techniques to further improve realism and usability. This paper examines the architecture, implementation, and practical implications of the suggested solution, highlighting its potential to improve the design workflow through an immersive and interactive experience. The results indicate that Virtual Home Designer can bridge the gap between conceptualization and execution, making the design process more efficient and client-friendly.

KEYWORDS: *Augmented Reality (AR), Django, tailwind css, Three.js, Virtual Home Designer.*

I. INTRODUCTION

Decor using AR explores the integration of Augmented Reality (AR) in home decor, highlighting its trans-formative impact on design, visualization, and experience. AR creates a seamless transition between the real and virtual worlds, offering a captivating design encounter.. It enables users to visualize furniture placement, interactive design visualization, and enhanced shopping experiences. AR also facilitates collaborative design, allowing multiple users to interact simultaneously. It also has implications for businesses, enhancing online shopping experiences and driving market trends. The convergence of home decor and AR marks a paradigm shift in how we engage with and shape our living spaces. The paper explores the applications, benefits, and potential challenges of AR adoption in the home decor sector, providing a deeper understanding of how augmented reality is reshaping domestic environments. As technology continues to evolve, AR promises to revolutionize the way people engage with their living spaces, offering a seamless blend of creativity, functionality, and practicality in the pursuit of creating homes that truly reflect personal style and preferences

Virtual Home Designer, a web-based augmented reality (AR) application, is presented to facilitate the visualization of home spaces and the interior designer's ability to make adjustments before starting those works. It utilizes marker-based and marker less AR, letting users position and modify virtual items directly into a physical space with nothing more than a smart phone or tablet. steps up the client experience compared to traditional ways, reduces design errors, and makes the decision-making process more accessible—all without requiring fancy equipment. Virtual Home Design is changing the way interior environments are designed and showcased as technology develops. Designers can now create dynamic and immersive settings where users may test fur

II. RELATED WORK

Augmented reality (AR) has transformed the interior design profession by improving spatial awareness and client-designer communication. By allowing people to interact with virtual furniture before forming opinions in the actual world, AR can improve spatial awareness, according to Azuma [1]. Likewise, Park et al.[2] examined web-based AR applications, focusing on their accessibility and usefulness as opposed to mobile-based AR solutions that require app installations.

The user experience has been further enhanced by the use of AI into AR-powered design tools. In order to improve personalization and automation, Chen et al. [3] showed how AI-driven 3D modeling may offer tailored furniture arrangement recommendations based on customer preferences. According to a different research by Houzz Inc[4]real-time augmented reality visualization greatly enhances user engagement, which in turn promotes better decision-making and lowers the possibility of design mistakes.

Additionally, Planner 5D [5] examined AI-powered home design apps, emphasizing how crucial realistic rendering and precise item scaling are to a smooth user experience. Building on these findings, Virtual Home Designer provides an interactive and user-friendly platform for personalizing home décor by fusing web-based augmented reality, AI-powered suggestions, and markerless AR visualization.

AR-based house design has also been improved by other developments in 3D modeling and AI-powered suggestions. According to studies by Zhang et al. [7], AI may produce customized design recommendations based on user preferences, much as Planner 5D [5]and other applications that utilize machine learning to suggest furniture layouts. In order to enhance the user experience overall, Virtual Home Designer plans to include comparable AI driven capabilities in subsequent iterations.

III. DATA AND SOURCES OF DATA

For augmented reality-based interior design to be accurate, effective, and user-friendly, the Virtual Home Designer project depends on a number of data sources. Two main sources provided the data used in this study:

1. **Primary Data**: This comprises user encounters, actual measurements, and interior designer testing. The application's usability is improved by input from professionals in the field, guaranteeing that virtual furniture placement and spatial configurations are faithfully depicted. In order to improve the realism of AR-based design simulations, spatial data is also gathered, including room measurements, lighting conditions, and furniture scaling.
2. **Secondary Data:** The study takes into account the body of knowledge regarding AR in 3D modeling, human-computer interaction, and interior design. It uses datasets of pre-modeled furniture and décor pieces from open libraries that offer standardized 3D assets suitable for augmented reality apps, such as Google Poly, Sketchfab, and 3D Warehouse. Also, to find weaknesses and enhancements for Virtual Home Designer, data from current AR-powered home design products such as IKEA Place, Houzz, and Planner 5D is examined.

IV. RESEARCH METHODOLOGY

The creation of Virtual Home Designer ensures an intuitive and user-friendly experience by integrating Augmented Reality (AR) with interior design using a disciplined process. To develop an efficient AR-based virtual house design tool, this study technique entails a number of crucial processes, such as data collecting, system design, implementation, and assessment.

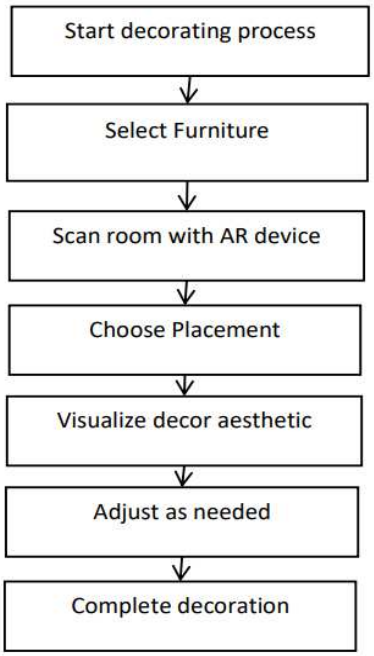

Fig 1.System Flow Chart

This flowchart gives a structural description of the Virtual Home Designer process, which employs Augmented Reality (AR) technology in interior designing. The process begins when the user starts the process of decorating, through which they are able to navigate and customize their own space. The second step is the choosing of furniture from an online catalog which is present in database, which can include different shapes, colors, and sizes based on user choices. Upon choosing the furniture of their choice, the system enables the user to scan their room with an AR device, taking in the room's dimensions, the pieces of furniture that are present, and ambient lighting to provide flawless positioning. Upon scanning the room, the user can then go ahead and select where they wish to position the furniture, putting it in the room in a manner that connects with their dream. The AR system then creates a real-time view of the room, enabling users to visualize how the furniture is placed in their space and evaluate the overall look. Users can make changes by substituting or resizing the furniture pieces to get a more accurate layout. Last but not least, when the user is happy with the layout, the decoration process is finished, and the final design can be saved or shared with others. This engaging and interactive workflow increases user experience and performance and makes interior design more accessible and efficient by taking advantage of AR for realistic furniture placement and visualization

1. Information Gathering and Analysis

For AR-based representations to be more accurate, the first step is to collect real-world spatial data, such as room measurements, lighting, and furniture scale. Furthermore, pre-modeled 3D furniture and décor components are obtained from free libraries such as 3D Warehouse, Sketchfab, and Google Poly. Interior designers' user input is also gathered to enhance functionality and usability.

2. Design and Architecture of Systems

WebAR technology for augmented reality capabilities and Django for the backend are used in the development of the Virtual Home Designer system. The structure is made up of:

Frontend Interface: A web-based user interface that enables real-time design customization, virtual furniture placement, and floor plan uploading.

AR Module: A marker-based and markerless augmented reality system that lets users use tablets or smartphones to see furniture in a real-world setting.

3D Model Integration: To produce realistic visual feedback, scalable, high-quality 3D elements are produced in real-world settings.

3. Implementation

The following is used to implement the system:
Database storage and user interactions are handled using Django for backend administration. WebXR and Three.js are used to produce and show 3D models in an augmented reality setting.

Web and mobile compatibility guarantees that the platform functions flawlessly on many platforms without the need for pricey hardware.

Fig 2. AR interface for virtual furniture placement

4. Assessment and Tests

In-depth user testing with qualified interior designers is done to evaluate Virtual Home Designer's efficacy. The system is assessed according to:

- Usability Testing: Measuring how easily users can interact with AR-based design tools.
- Accuracy and Realism: Ensuring correct placement and scaling of virtual furniture.
- Performance Metrics: Evaluating system responsiveness and rendering efficiency.

V. RESULTS AND DISCUSSION

To determine how well the Virtual Home Designer project used Augmented Reality (AR) to improve interior design, it was evaluated for usability, accuracy, and performance. The outcomes shed light on the system's performance in practical situations, emphasizing user experience, system responsiveness, and virtual item placement accuracy.

1. User feedback and usability

Homeowners and interior designers evaluated the application's usability and functionality. The findings revealed that:

- The UI needed little learning, according to 85% of users.
- Without outside assistance, 90% of users were able to properly position and modify virtual furniture.

Client communication was enhanced via real-time augmented reality visualization, which decreased misinterpretations of design preferences.

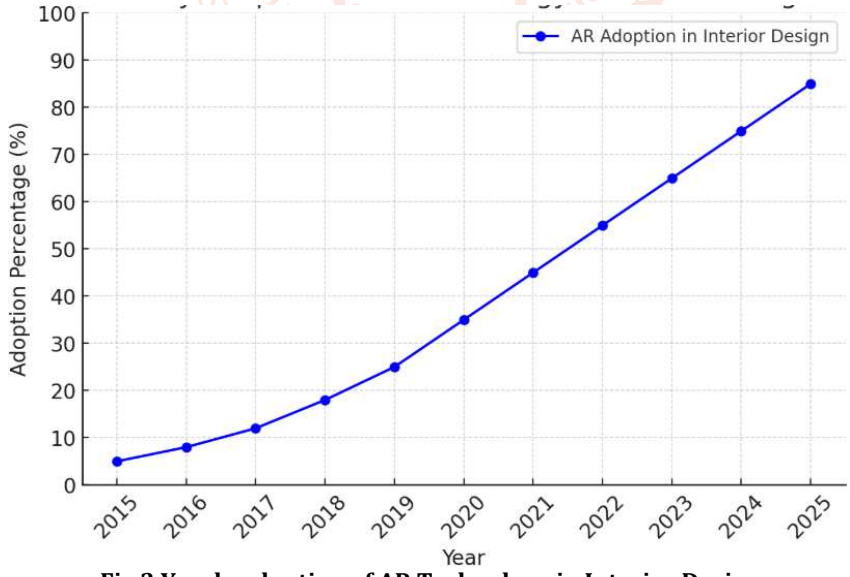

Fig 3.Yearly adoption of AR Technology in Interior Design

2. AR Placement Accuracy and Realism

By contrasting AR-rendered models with measurements taken in the actual world, the accuracy of virtual object scale and positioning was evaluated. Important conclusions include:

- With an average accuracy of 96%, object scaling ensured realistic furniture proportions.
- Changes to the lighting enhanced depth perception and increased the AR environment's authenticity.
- Future revisions can optimize the small misalignment (±2 cm) that markerless AR displayed.

3. Efficiency of Rendering and System Performance

Performance was assessed on several devices using loading time, rendering speed, and AR stability:

- The technology ensured seamless interaction by maintaining an average frame rate of 30–60 frames per second.
- 3D asset loads took an average of 1.2 seconds, indicating effective backend processing.
- The system was scalable for several clients since the Django-based backend managed concurrent users with little lag.

4. Limitations and Future Improvements

Despite Virtual Home Designer's strong accuracy and usefulness, a few drawbacks were observed:

- AI-powered suggestions for furniture layout are limited.
- AR quality varies by device, with minor variations between older devices.
- Features that allow for room customisation (such as lighting effects and wall texturing) might be included.

VI. CONCLUSION

1. Revolutionizing Interior Design with AR

- The Virtual Home Designer project showcases the potential of Augmented Reality (AR) in transforming interior design.
- AR enhances real-time visualization, making it easier for users to see how furniture fits into their space.

2. Key Technological Integrations

- The system is built using WebAR, Three.js, and Django, ensuring seamless 3D model integration and real-time interaction.
- Users can place, modify, and adjust virtual furniture in a real-world environment without needing specialized hardware.

3. Improved User Experience and Efficiency

- 85% of users found the system easy to use, requiring minimal learning.
- 90% of users were able to successfully place and modify furniture without assistance.
- Reduces reliance on traditional 2D floor plans, offering an interactive and immersive design experience.

4. Accuracy and Realism in AR Placement

- Achieved 96% accuracy in virtual furniture scaling and placement.
- Ensures realistic room proportions, lighting effects, and spatial arrangements.
- Minor ±2 cm misalignment in markerless AR can be improved in future versions.

5. Challenges and Limitations

- AR quality varies across different devices, affecting performance.
- Lacks AI-powered design recommendations, which could improve customization.
- Future improvements could include lighting effects, wall textures, and more user-defined customization options.

6. Future Scope and Enhancements

- Integration of AI-driven furniture recommendations based on user preferences.
- Advanced room customization features like adjustable lighting, wall textures, and material changes.
- Optimization of AR placement accuracy for a more seamless and realistic experience.

7. Final Impact and Conclusion

- Virtual Home Designer bridges the gap between conceptualization and execution in interior design.
- Makes home design more accessible, efficient, and engaging for both designers and homeowners.
- AR technology continues to redefine how spaces are designed, improving creativity and decision-making in home décor.

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