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Immersive Interior Design: Exploring Enhanced Visualization Through Augmented Reality Technologies

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***Abstract*—This article explores an augmented reality (AR) application for interior design, leveraging advancements in technology. With the increasing integration of virtual information into construction practices, the conventional method of purchasing furniture in physical stores becomes challenging for individuals with limited time. The traditional furniture products lack interaction with users, comprising static text and images. This study proposes a novel approach to interior design utilizing character-based AR. In this AR environment, users can choose furniture from a diverse range of options and visualize it within their actual surroundings. Furthermore, users have the capability to make real-time adjustments to the virtual furniture on the screen, facilitating interaction with the furniture in a simulated real environment. This innovative method aims to provide users with a clear perspective on furniture placement, streamlining the interior design process and ultimately saving time and effort.**

***Index Terms*—Real-world Integration, 3D Modeling, Augmented Reality**

I. Introduction

In the past, envisioning how a piece of furniture would complement a room, considering factors like size, color, and harmony with the existing decor, required significant contemplation. Augmented Reality (AR), a technology that overlays computer-generated graphics onto the real world, has emerged as a versatile solution across various fields such as engineering and architecture, effectively addressing practical issues. Originally referred to as "mediated reality," wherein a computer enhances one's perception of the real world, AR has progressed to refine the precision of our reality perception. Devices like head-mounted displays (HMDs), contact lenses, eyeglasses, and monitors have seamlessly integrated augmented reality, predominantly catering to professionals. However, the applicability of augmented reality extends beyond professionals, providing practical solutions to everyday challenges for the general population.This research project introduces an innovative interior design system that harnesses the power of augmented reality. Implemented as an android application, this system seamlessly overlays virtual furniture into physical environments. Signs display ideas around the room, e.g. on the floor or walls, enable precise tracking, defining the scale and coordinate system of the space. Users can select virtual furniture on their device's screen and effortlessly integrate it into the physical room, effectively merging the virtual and real worlds. Augmented reality technology empowers users to manipulate the position of selected furniture items, viewing them from various angles, all in real- time. Crucially, this application leverages the ubiquitous mobile camera found in Android devices, ensuring accessibility to a wide user base.One of the most significant challenges in interior design, decision-making, is substantially simplified through this sys- tem. Users can effortlessly experiment with different room lay- outs, aiding in the selection of the ideal furniture arrangement. This new approach eliminates the need to visit furniture stores in person, saving time and effort and making interior design accessible to a wider audience.Despite the existence of comparable systems, it is asserted that this particular system enhances the user interface and de- livers superior performance. Notably, it introduces the concept of tangible augmented reality, enabling interaction with virtual furniture to streamline the exploration and visualization of designs and diversity. This user-friendly application extends the appreciation for realism in interior design to both professionals and hobbyists, making it widely accessible.Augmented reality possesses remarkable capabilities to ad- dress practical challenges, particularly those associated with time and financial constraints. The current focus is on specific issues concerning the budgetary considerations in interior design, given its growing demand in today's world. While hardware-dependent devices like headsets and monitors are typically designed for professional users, Android-based augmented reality applications are emerging as a viable solution. This app is compatible with numerous user-friendly Android devices and smartphones, leveraging the accessibility of various AR tools. Drawing on existing research on AR and its applications, the app facilitates decision-making for users, ultimately leading to time and cost savings—an aspect that serves as a driving force for its development

II. Related Work

The utilization of computer vision in daily life is exemplified through the application of augmented reality (AR) in automatic furniture planning, particularly in the context of social networks. This AR system goes beyond connecting virtual furniture to physical spaces; it also leverages the KINECT depth sensor to estimate space dimensions. Employing a

RANSAC-based method, the system estimates support planes for virtual furniture, providing an intuitive user interface for selection and modification. Additionally, it suggests the most suitable appearance based on the geometry and functionality of the chosen furniture. The system's versatility extends to large or tall furniture, and the composition of virtual furniture and the real environment is transformed into a digital image for future use. [1]

Another approach involves environmental mapping of real-world objects using AR toolkits, assuming virtual objects eliminate background elements. This technique creates multi-dimensional images of real objects by capturing images from various angles, generating alpha faces and textures. It employs image-based real-time rendering technology to capture all aspects of the real environment, including objects, visibility, shadows, floating objects, and color balance. [2]

While augmented reality systems are commonly integrated through head-up displays (HUD), some prefer AR devices such as head-mounted displays (HMD) for a non-invasive, hands-free, widescreen AR experience, capitalizing on the computational capabilities of smart devices. [1] However, the adoption of portable devices introduces challenges related to affordability and user-friendly designs. Unlike mobile phones, which are typically not worn, portable devices require distinct design considerations. Nevertheless, these devices embed built-in intelligence through sensors and video processing, making them suitable for augmented reality and other applications, presenting a departure from earlier hardware-intensive requirements for interior design applications involving 3D objects, which heightened system complexity. [3]

III. Proposed System

The suggested system utilizes augmented reality for interior design, seamlessly blending virtual furniture with the physical environment through a smartphone or Android device operating system. Markers strategically positioned on the floor or walls serve to track items, determine unit measurements, and establish coordinates. Users have the ability to choose virtual furniture from the screen, and the system integrates 3D virtual furniture into the real environment, enabling placement alongside actual furniture. [2] The essential prerequisites for the system include a smartphone with the Android operating system and access to a printer.

Anticipated to address diverse user needs, this application is designed to offer numerous enhancements and optimizations, with a focus on refining the user interface. Through the incorporation of tangible augmented reality, users gain the ability to engage with furniture in real-time, making on-the- fly adjustments to color, style, or finish within their physical space. This interactive feature facilitates a dynamic and exploratory approach to design, democratizing the use of AR technology for interior design by catering to both professionals and enthusiasts.

A. Marker Detection

In this system, the identification of furniture is contingent upon markers, which are images or symbols recognized from video images through technologies like image processing, pattern recognition, and computer vision. Markers are pivotal for precise measurement and camera detection adjustments, constituting what is known as marker-based tracking. The marker detection process encompasses the identification of outliers in the image and the extraction of corner positions. Identity verification is a prevalent method employed to make decisions during this process. The system relies on data derived from activity checks to compute the pose. [4]

Fig. 1. AR Marker

B. Tracking Moudule

The tracking module comprises two key components. [3] Initially, the system captures characters, predicting their placement in the room to identify available space. At this stage, users can utilize the interface to drag and drop virtual furniture models into position. Subsequently, the tool readies the selected furniture model based on specified tasks. Finally, the envisioned furniture placement is overlaid onto the real space. Fig. 2 depicts the functionality of the tracking module. The AR lens offers real-time feedback through photography, measuring each image's space and character identification. Coordinates are established and transmitted to the AR camera, then to the image processing module, where objects associated with the symbols are assigned.

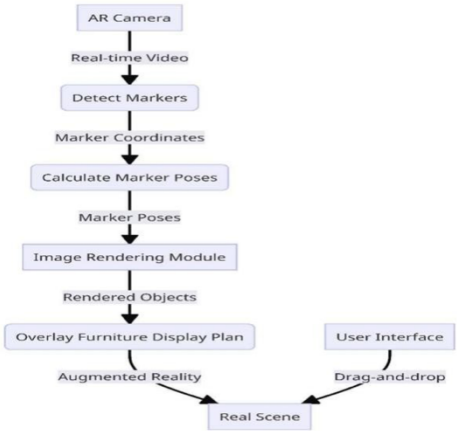

Fig. 2. Tracking Module

IV. Application Workflow

The application operates through the following steps:

- **Capture of Real-World Video:** The system is activated by capturing video of the real-world environment using the device's camera.
- **Feature Detection:** In each frame of the video, the application diligently searches for specific features or predefined markers in the image.
- **Camera Position Estimation:** Upon detecting different features or markers, the system calculates the accurate position of the camera relative to the marker. This information is crucial for maintaining spatial relationships.
- **Computer Model Creation:** After determining the camera's position, the system utilizes a combination of symbols as reference points to create a computer model.
- **Furniture Overlay:** The 3D furniture model is inserted into the world video stream and associated with specific tags. This connection ensures that the virtual furniture aligns with the real space.
- **Real-Time Display:** The final layout seamlessly integrates virtual furniture into the real scene and presents it to the user via the device's camera input. Users can view virtual objects overlaid on top of the real environment, allowing for interaction and real-time updates.

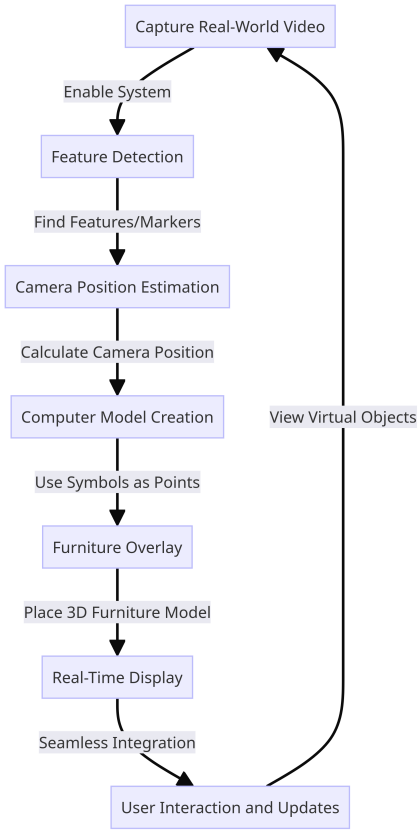

Fig. 3. Application Workflow

The system captures real-world video, detects features or symbols for spatial analysis, and calculates the exact location of the camera using symbols for accurate positioning. Using this information, computer models are created, and 3D furniture models are placed on real-world images based on the symbols. The screen combines virtual furniture with reality, presenting it to the user in real-time through the camera. Users can interact with and customize virtual objects to enhance their designs in a virtual reality environment.

V. System Architecture

The system's architecture comprises two fundamental modules: the Data Module and the Display Module.

A. Data Module

This module contains the basic data required for the application to run and includes the following components:

- **Markers:** Functional tokens are elements used in the global environment and play a vital role in social decision-making.
- **3D Objects:** This model contains comprehensive information about 3D furniture objects. Users can select and control these objects to create their virtual environments.

B. Display Module

The display module is responsible for processing virtual reality and consists of several sub modules:

- **Camera:** The camera component captures video where the body is located, forming the basis of the AR experience.
- **Marker Detection:** In this variation, the system identifies characters in the video to ensure accurate tracking and positioning.
- **Object Rendering:** The object processing sub-module transforms 3D objects into real-world scenes.
- **Object Tracking:** To ensure virtual objects stay in sync with their respective characters, these objects constantly track the character's location.
- **Object Transformation:** This transformation allows users to interact with virtual furniture in real-time to perform tasks such as movement, rotation, and style change. These changes are instantly reflected in visual augmented reality, providing a design experience.

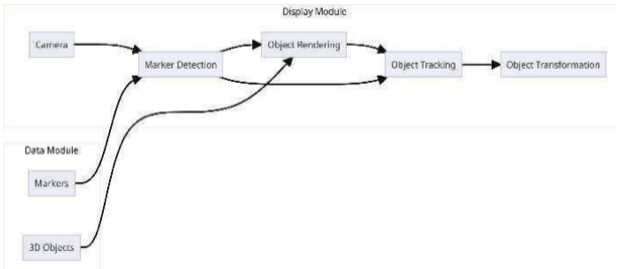

Fig. 4. System Architecture

VI. Implementation

The implementation of the system involves the following steps:

- **Marker Preparation:** Initially, the user downloads from or API and prints. The sign size will vary depending on the size of the room and the nature of the items to be placed.
- **Application Launch:** The user launches the augmented reality application and positions the printout in the desired location of the room. Each symbol is associated with a virtual object and stored in the application.
- **Furniture Arrangement:** Virtual objects are displayed above the icons, and users can observe them in real- time. The application presents a selection of furniture to the user. If there are items in the collection that the user does not want included in the scene, they can easily slide the image around to remove them.
- **Manual Object Manipulation:** Initially, virtual objects are placed over the signatures. Users have the option to manage these items manually. By dragging an object, its position in space can be changed according to the user's preferences.
- **Rotation Capability:** Users can rotate objects, and the rotation plane is displayed in real-time, making it easier for users to understand and control.
- **Variations in Objects:** Different elements can be used for the same symbol. For example, if the user wants to explore various sofa or bed designs, they can enable the three-touch interface. This allows users to switch between different chairs or changing beds and preview how each will fit into the expanded environment.

VII. Outcome of Comparison

Papers	Techniques	Method
Advancements in Augmented Reality for Interior Design	Marker-based AR for Interior Design	Real-time design experience, User-friendly, Flexible furniture arrangement
Exploring Virtual Furniture Placement through Augmented Reality	Virtual Furniture Placement through AR	3D furniture arrangement, Easy user interaction, Realistic visualization
Augmented Reality Catalogues for Interior Design Elements	AR Catalogues for Interior Design Elements	Object recognition, Seamless furniture integration, User-customizable layouts
Enhancing User Experience in AR-based Home Decor Applications	User Experience Enhancement in AR Home Decor Apps	Intuitive interfaces, Personalized recommendations, Enhanced user engagement
A Framework for Markerless Augmented Reality in Interior Design	Markerless AR Framework in Interior Design	Spatial tracking, Natural object interaction, Reduced setup complexity

TABLE I
Paper Comparison

VIII. Outcome of Application

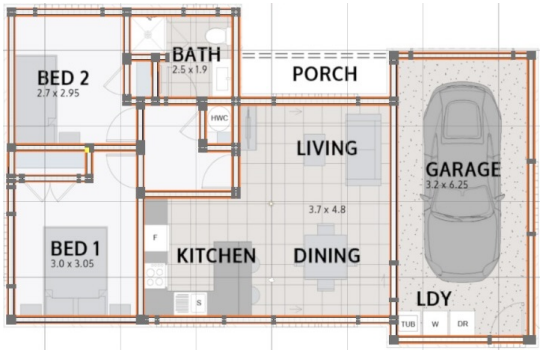

Fig. 5. Architecture of House

Fig. 6. Rendering Different Furniture

Fig. 7. AR Interior Design Application

Fig. 8. Real-time Overlaying Objects

IX. Conclusion

This work presents an augmented reality (AR) application for interior design that offers a new and intuitive approach to designing and placing furniture. Users can enjoy a dynamic, interactive, and personalized design experience by utilizing marker-based tracking to seamlessly integrate virtual furniture into real-world environments via common Android devices.

The study demonstrates the effectiveness of the method in accurately constructing drawing-related virtual furniture to meet the needs of users with varying skill levels. Future work will focus on improving search algorithms, expanding customization options, including AI-driven design recommendations, and addressing scalability issues to enhance this AR technology's ability to transform the interior design process and meet customer needs.

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