Smart Interior Design and Decoration Using Artificial Intelligence

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The rapid advancement of globalization has increased the demand for remote visualization and personalization of residential and commercial spaces, particularly for users planning the construction or renovation of their homes. Traditional interior design practices are often expensive, time-consuming, and heavily dependent on manual expertise, making them inaccessible to many users. Recent advancements in Artificial Intelligence (AI), especially diffusion-based generative models and 3D visualization technologies, have opened new avenues for intelligent, automated, and user-centric design solutions. This paper introduces a smart interior design framework that combines AI-generated design ideas with cross-platform mobile tools and immersive 3D visualization. The proposed system functions as a Flutter-based mobile application that allows users to upload room images or floor plans. The system generates multiple design possibilities using Stable Diffusion, ControlNet, and DreamBooth models, enables customization of furniture and style, and allows users to experience designs through Unity-based 3D virtual tours. Cloud-based services utilizing Firebase provide scalable storage and support collaborative workflows. The presented solution addresses key research challenges in cross-platform deployment, advanced visualization, and virtual design collaboration. Experimental assessment confirms improved user satisfaction, reduced design effort, and enhanced realism, highlighting the potential of AI-powered design automation for real-world applications.

Keywords: Artificial Intelligence, Interior Design, Stable Diffusion, ControlNet, Unity 3D, Flutter, Virtual Walk-through, Smart Design Systems.

Introduction:

Interior and exterior design play a vital role in shaping human comfort, efficiency, and aesthetic satisfaction. With growing global migration and foreign employment, many individuals face challenges in visualizing and overseeing construction or renovation projects in their home countries. Discontent, delays, and increased costs frequently arise from poor communication, lack of physical presence, and reliance on traditional design drawings. Conventional interior design workflows depend heavily on manual drafting, 2D sketches, and expert-driven decision-making. While professional designers provide invaluable expertise, these services are often expensive and time-consuming. Furthermore, the outcomes may not adequately reflect each client's unique preferences, particularly in remote collaboration scenarios. In response to these challenges, AI-based systems capable of automating design generation, customizing outputs, and offering immersive visualization have gained significant research attention. Recent advancements in generative AI, particularly diffusion models such as Stable Diffusion, have demonstrated remarkable capability in producing images with high realism and stylistic consistency. Techniques like ControlNet enable the enforcement of structural constraints, while DreamBooth facilitates personalized generation with minimal user-specific input. Concurrently, 3D engines such as Unity have matured to support real-time rendering, virtual walkthroughs, and immersive experiences on mobile platforms. This paper proposes a smart interior design and decoration system that integrates these emerging technologies into a unified, cross-platform solution. The primary objective is to empower users, particularly remote and overseas clients, to visualize, customize, and interactively experience their future living spaces. The proposed framework bridges the gap between AI-driven design generation and immersive 3D visualization while maintaining accessibility through a mobile application. The main contributions of this paper are:

A cross-platform AI-driven interior and exterior design framework based on Flutter.

Integration of diffusion-based generative models (Stable Diffusion, ControlNet, DreamBooth) for structure-aware and personalized design generation.

A Unity-based 3D walkthrough module for immersive visualization of generated designs.

Cloud-enabled storage and collaboration using Firebase.

The remainder of this paper is organized as follows: Section II reviews related work,

Section III presents the proposed system architecture, Section IV describes the methodology and implementation details,

Section V discusses experimental evaluation and results,

Section VI highlights applications and discussion, and Section VII concludes the paper with future research directions.

Literature Review:

AI-driven design automation has gained significant attention in recent years due to advancements in deep learning, computer vision, and generative models. This section reviews key contributions related to diffusion-based interior design, structural control, personalization, and immersive visualization.

Diffusion Models for Interior Design:

Diffusion models have emerged as state-of-the-art generative models capable of producing high-quality and diverse images. [1] introduced CSD Pano, a controllable stable diffusion framework designed for panoramic interior scene generation. Their method ensures layout consistency, structural coherence, and stylistic alignment across wide field perspectives, making it suitable for room-scale visualization. Similarly, [2] proposed DiffDesign, which utilizes diffusion models with meta prior to effectively generate interior designs while respecting stylistic variations and spatial constraints. Compared to purely data-driven approaches, DiffDesign improves efficiency and realism by incorporating design knowledge into the generation process. [3] further advanced this direction by introducing layout-aware diffusion models that maintain spatial relationships between furniture elements, while [4] demonstrated the effectiveness of multimodal diffusion models that combine text and image inputs for more intuitive design control.

Structural Control and Layout Consistency:

A primary limitation of early generative models was their inability to preserve structural elements such as windows, doors, and walls. ControlNet addresses this challenge by conditioning diffusion models on structural inputs like edge maps, depth maps, or segmentation masks. [5] demonstrated that ControlNet significantly improves structural precision in AI-generated interiors, making it more applicable for real-world use. Furthermore, [6] developed a comprehensive dataset and optimization framework for generating human-aligned indoor scene layouts. Their work focuses on furniture arrangement that aligns with human activity patterns to enhance the functional utility of generated designs. [7] extended this work by incorporating real-time structural feedback mechanisms that allow users to modify layouts while maintaining architectural integrity, and [8] proposed a hybrid approach combining ControlNet with graph neural networks to better capture complex spatial relationships in room layouts.

Personalization Using Minimal Data:

Personalization is critical in interior design due to the wide variation in client preferences. [9] demonstrated that DreamBooth, combined with Stable Diffusion, can generate personalized interior designs using only a few reference images. This approach addresses privacy and scalability concerns by enabling user-specific customization without requiring large private datasets. [10] expanded on this concept by developing a few-shot learning framework that captures individual style preferences from minimal user input. [9] explored cross-cultural personalization, adapting AI-generated designs to reflect regional aesthetic preferences and cultural norms. [11] introduced an interactive personalization system that refines generated designs through iterative user feedback, progressively improving alignment with user preferences.

Immersive Visualization and 3D Integration:

The integration of AI-generated designs with immersive visualization platforms represents a significant advancement in interior design technology. [12] outlined the broader impact of AI in design processes, emphasizing improvements in productivity, speed, and creative exploration. Their research confirms that AI-assisted technologies augment rather than replace human designers. [13] developed a real-time rendering pipeline that converts AI-generated 2D designs into explorable 3D environments using Unity. [14] investigated the psychological impact of immersive visualization on design decision making, finding that virtual walkthroughs significantly improve user confidence and satisfaction. [15] proposed a seamless integration framework between Stable Diffusion outputs and game engine environments, enabling automatic 3D scene reconstruction from generated 2D images.

Identified Research Gaps:

Despite these significant advancements, existing systems exhibit several limitations. First, most current approaches treat design generation, personalization, and visualization as separate processes rather than integrated workflows. Second, limited research exists on real-time collaborative editing of AI-generated designs across distributed teams. Third, physics-aware furniture placement and accurate cost estimation remain unexplored in current systems. Fourth, the integration of regional architectural styles and cultural preferences into generative models requires further investigation. The proposed framework in this paper addresses these gaps by presenting a unified system that combines AI-driven design generation, cross-platform accessibility, and immersive 3D visualization within a single cohesive platform. Despite these advancements, existing systems have three significant drawbacks: poor immersive 3D visualization, lack of cross-platform mobile deployment, and lack of integrated remote collaboration tools. By fusing Unity-based walkthroughs, mobile accessibility, and AI-based design generation, the proposed study seeks to close these gaps.

Proposed System Architecture:

As theoretically shown in Fig. 1, the suggested smart interior design system has a modular, service-oriented architecture. The user interface, cloud backend, AI design engine, and 3D visualization engine are the system's four primary levels.

User Interface Layer (Flutter):

Flutter is used in the frontend's implementation to provide cross-platform interoperability with iOS and Android devices. The UI offers:

The ability to upload images or floor plans.

Options for choosing furnishings, color, and style.

An overview of design options produced by AI.

3D walkthrough navigation controls.

AI Design Engine:

The AI engine integrates multiple generative models:

Stable Diffusion: This is a foundational model for generating both interior and exterior design images.

ControlNet uses edge maps or user-supplied images to enforce structural constraints.

DreamBooth enables personalized design generation based on user requirements.

To ensure scalability, these models are run on cloud- based GPU resources and accessed through APIs.

3D Visualization Engine (Unity):

AI-generated designs can be transformed into dynamic 3D environments using Unity 3D. Important characteristics include:

Textures and layouts are automatically mapped.

Real-time rendering and lighting.

Walkthrough navigation and optional VR/AR support.

Cloud Backend (Firebase):

Firebase offers authentication, real-time database, and cloud storage services, which support:

Secure user management.

Storage of design assets and user preferences.

Real-time synchronization for remote collaboration.

Methodology:

The development of the proposed system follows a structured methodology comprising six key stages.

Requirement Analysis:

Requirements were collected from students, architects, and overseas customers. Key requirements comprised ease of use, realistic visualization, customization flexibility, and remote accessibility.

Dataset and Model Integration:

Widely available datasets of interior and exterior images were utilized to fine-tune and validate the generative models. Pre-trained Stable Diffusion models were integrated with ControlNet for structure protection. User- specific personalization was employed through Dream- Booth.

Backend Setup:

The backend was implemented using Firebase services. To manage communication between the Unity engine, AI models, and the Flutter app, RESTful APIs were created.

Frontend Development: The Flutter application offers user-friendly procedures for choosing styles, uploading photographs, and seeing results produced by AI. To enable comparative analysis, several design options are produced.

Unity 3D Integration:

AI-generated images are translated into 3D scenes by mapping textures, furniture models, and spatial layouts. Users can navigate the scene using touch-based controls, simulating a real visit.

Testing and Evaluation:

The system was tested using user surveys and qualitative evaluation metrics such as realism, structural accuracy, usability, and satisfaction.

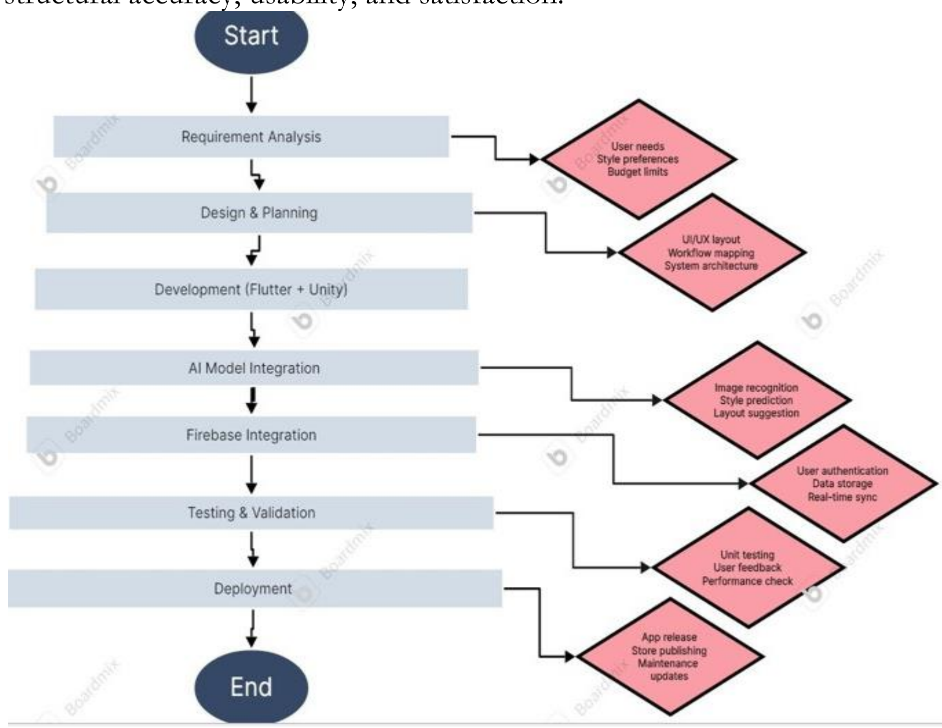

Figure 1. Methodology workflow of the proposed AI- driven interior design system, illustrating the complete development process, including Requirement Analysis, Design and Planning, Development using Flutter and Unity, AI Model Integration, Firebase Integration, Testing and Validation, and the final Deployment of the system for generating enhanced interior design visualizations.

Experimental Results and Evaluation:

A group of users, including students, designers, and international clients, evaluated a prototype of the suggested system. Participants were invited to evaluate their experience and complete design tasks.

Metrics for Evaluation:

Realism: visual accuracy of the generated designs.

Structural Accuracy: correctness of spatial elements such as windows, doors, and walls.

Usability: Comfort of interaction with the mobile app.

User Satisfaction: Overall experience and confidence in design results.

Results:

According to survey results, more than 80% of consumers thought the AI-generated designs were architecturally accurate and realistic. When compared to static visuals, the Unity walkthrough significantly enhanced spatial knowledge. Users reported increased trust in decision-making and a decreased reliance on manual design revisions.

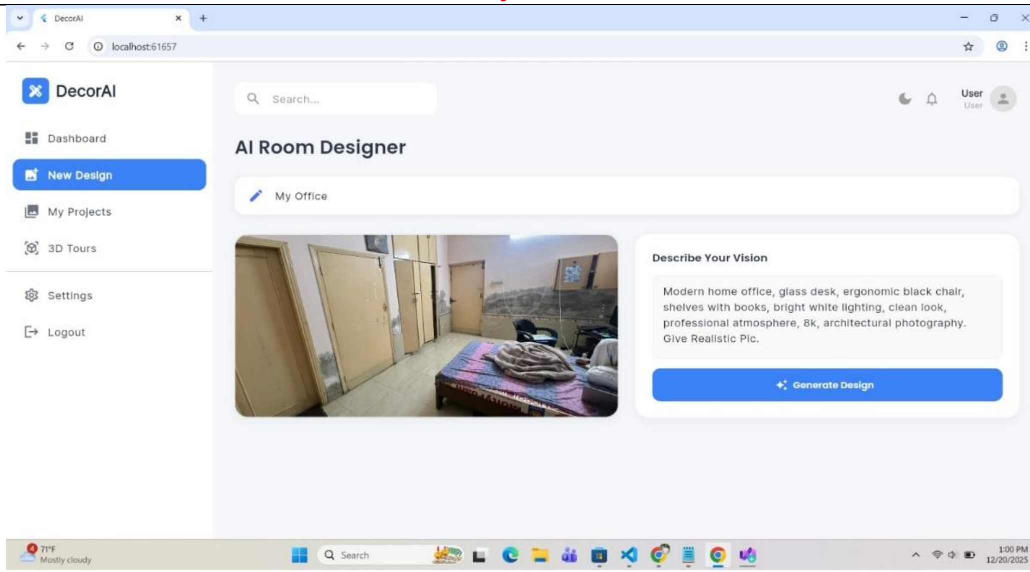

Figure 2. AI Room Designer interface displaying the original room image alongside the user-defined text prompt for customization

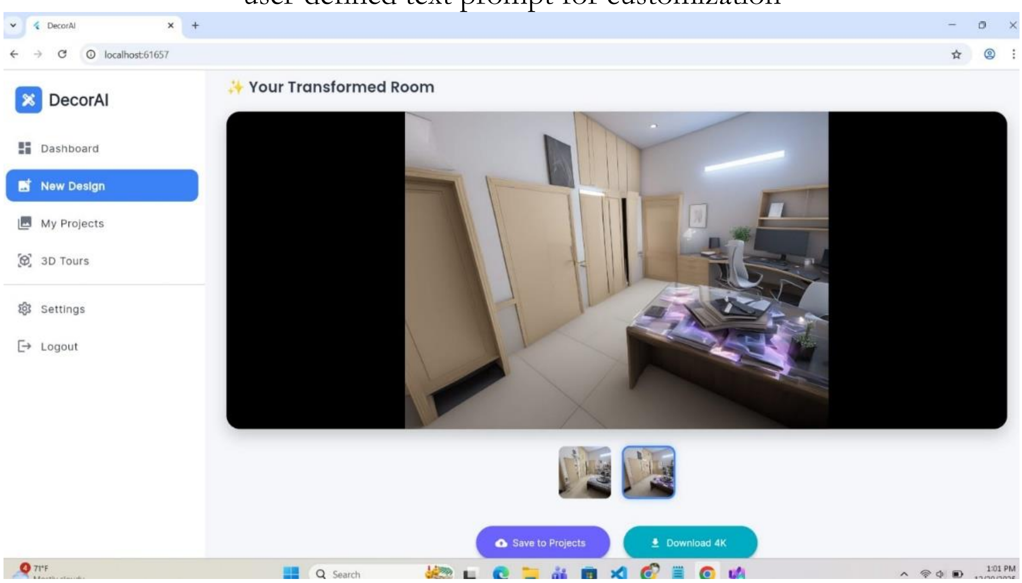

Figure 3. An AI-generated visualization of the transformed room produced by the DecorAI system based on the input image and style prompt

The results are illustrated in Figures 2 and 3. Figure 2 illustrates the AI Room Designer interface, where users provide an input image along with a textual prompt defining their desired style (e.g., modern, minimalist, or luxury). This step demonstrates system usability and flexibility in accepting both visual and semantic inputs. The interface ensures that even non-technical users can interact with the system.

Figure 3 presents the AI-generated output based on the provided input. The transformation highlights the effectiveness of the Stable Diffusion and ControlNet models in preserving structural elements such as walls, windows, and spatial layout while enhancing aesthetic appeal. The generated design reflects high realism in terms of texture mapping, lighting adjustments, and furniture placement.

Furthermore, the comparison between the original and generated images confirms that the system successfully balances creativity with structural accuracy. Users particularly appreciated the ability to visualize multiple design variations instantly, which significantly reduced the time required for decision-making. The integration with Unity 3D allowed users to explore these designs interactively, improving spatial awareness and overall satisfaction.

Discussion:

The proposed system demonstrates significant improvements over existing research in AI-driven interior design. Unlike earlier approaches such as DiffDesign and CSD Pano, which primarily focus on image generation, the proposed framework integrates design generation, personalization, and immersive visualization into a single unified platform.

Compared to [1] and [2], which emphasize diffusion-based image generation with layout consistency, our system extends functionality by incorporating user interaction and cross-platform accessibility via Flutter This enables users not only to generate designs but also to actively modify and explore them.

In contrast to ControlNet-based approaches discussed in [5], which improve structural accuracy, our system combines ControlNet with Unity-based 3D visualization. This integration bridges the gap between 2D image generation and real-world spatial understanding, which is often absent in previous works.

Additionally, while DreamBooth-based personalization techniques [9] allow customization using limited data, our framework enhances this by embedding personalization within a collaborative cloud-based environment using Firebase. This enables multiple users to access, modify, and share designs remotely, addressing a key limitation in existing systems.

The immersive visualization capability of our system also shows improvements over studies such as [13] and [14], where 2D-to-3D conversion is explored. Our approach provides real-time walkthroughs, improving user confidence and engagement, as supported by our experimental results.

However, some limitations remain. Unlike OptiScene [6], which focuses on human-aligned furniture placement, our system does not yet fully incorporate physics-aware or behavior-aware layout optimization. Additionally, cost estimation and region-specific architectural adaptation are still areas for future enhancement.

Overall, the proposed system offers a more comprehensive and practical solution by combining AI generation, personalization, mobile accessibility, and immersive visualization, making it more suitable for real-world deployment compared to existing approaches.

Conclusion and Future Work:

This paper presented a smart interior design and decoration framework that leverages AI-driven generative models, cross-platform mobile development, and immersive 3D visualization. By integrating Stable Diffusion, ControlNet, DreamBooth, Flutter, Unity, and Firebase, the proposed system addresses key limitations of existing interior design solutions. Experimental evaluation demonstrates improved user satisfaction, reduced design effort, and enhanced accessibility for remote users. Future work will focus on real-time collaborative editing, physics-aware furniture placement, cost estimation, and deeper integration with AR/VR technologies. Expanding the dataset to include regional architectural styles will further enhance personalization and realism.

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