

# Virtual Interior Design Using AI

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**Abstract**—The project **Virtual Interior Design Using AI** transforms the traditional design process by using **Stable Diffusion, Flask, and OpenCV** to generate realistic, customizable interiors from textual prompts. The system allows real-time visualization through a web interface, enabling designers and users to explore multiple options instantly. AI-generated images are enhanced via **Real-ESRGAN** for higher resolution and lighting balance. The integration of AI and web technologies reduces cost, time, and manual rendering effort while improving design creativity and user engagement.

**Index Terms**—Artificial Intelligence, Generative AI, Stable Diffusion, Interior Design, Flask, OpenCV, Real-ESRGAN.

## I. INTRODUCTION

Interior design has undergone a significant transformation with the integration of digital technologies. Traditional design approaches rely heavily on manual sketching, physical prototyping, and extensive human expertise, which can be time-consuming and cost-intensive. Despite the availability of advanced CAD and 3-D modeling tools, interior visualization often remains inaccessible to ordinary users and small-scale designers due to the complexity of software and the resources required. In recent years, Artificial Intelligence (AI) has emerged as a revolutionary tool capable of automating design generation and enhancing creativity through data-driven intelligence. The combination of AI and image-generation models such as Stable Diffusion has made it possible to visualize realistic room interiors from simple text descriptions or reference images democratizing design and enabling instant concept visualization.

### 1.1 Need for AI-Based Interior Design

Conventional visualization methods demand professional skills and manual rendering, limiting creativity and scalability. Designers often spend hours perfecting

lighting, textures, and layouts. Furthermore, clients find it difficult to imagine final results until the entire model is rendered. An AI-powered design assistant eliminates these constraints by automating design generation and providing photorealistic renderings in seconds. The proposed system addresses this gap by merging AI's generative capabilities with an intuitive web interface, allowing users to produce, modify, and evaluate designs dynamically.

### 1.2 Overview of the System

The Virtual Interior Design Using AI platform is a web-based application that leverages AI models to generate customized interior layouts. Built with Flask as the backend framework and HTML, CSS, and JavaScript for the frontend, it offers an interactive environment for users to upload room photos or provide textual prompts. The backend integrates Stable Diffusion for design generation, OpenCV for image enhancement, and Real-ESRGAN for resolution upscaling. The system provides users with multiple style variations, color palettes, and furniture arrangements, thus acting as a digital design consultant that bridges creativity and computation.

### 1.3 Problem Context and Motivation

Interior design traditionally depends on designers' subjective creativity and visualization skills. This leads to high dependency on experts, limited scalability, and increased cost. Additionally, clients often struggle to articulate preferences in technical design terms, leading to communication gaps. With increasing demand for personalized living and workspace interiors, there is a need for a platform that allows rapid ideation and visualization based on simple natural-language descriptions. The motivation behind this project is to empower both designers and end-users with an AI system that provides accurate, photorealistic, and style-adaptive designs instantly.

**1.4 Role of Artificial Intelligence and Image Processing**  
 AI plays a central role in this project through Stable Diffusion, a text-to-image generation model capable of producing high-resolution, context-aware visualizations. It learns aesthetic patterns, spatial layouts, and object relationships from vast datasets of interior photographs. In addition, OpenCV performs color correction, brightness enhancement, and shadow adjustment to ensure natural realism. Real-ESRGAN enhances fine details and texture resolution, making the final image suitable for professional presentation. Together, these AI and computer-vision techniques transform a simple input prompt into a visually rich, photorealistic interior design output.

**1.5 System Infrastructure and Data Security**  
 The system is implemented using a modular architecture. The frontend interface collects user inputs, while the Flask backend handles AI model inference and response routing. The AI model executes locally or on a GPU-enabled cloud for faster rendering. Data privacy and reliability are ensured by using secure Flask endpoints, restricted API access, and controlled model execution. Temporary image caching mechanisms prevent data leakage, ensuring that user uploads remain private and session-bound. The web platform also supports scalability for future integration with cloud-based storage or AR/VR extensions.

- 1.6 Technical Objectives**  
 The primary technical objectives of this project are:
1. **Automation:** Eliminate manual rendering by automating interior design generation through AI models.
  2. **Intelligence:** Integrate Stable Diffusion and Real-ESRGAN to produce high-quality, realistic interiors.
  3. **Accessibility:** Provide a web-based interface usable by both professionals and non-experts.
  4. **Customization:** Enable users to modify lighting, style, and layout parameters dynamically.
  5. **Optimization:** Enhance system performance through efficient backend processing and GPU acceleration.
  6. **Security:** Ensure safe handling of user images and generated data through secure server-side protocols.

## II. LITREATURE SURVEY

A detailed literature review was conducted to understand the evolution of AI-powered interior design systems, generative models, computer-vision techniques, and

image-enhancement methods that support realistic room visualization and automated décor generation.

The following studies provided significant insights that shaped the development of the Virtual Interior Design Using AI system.

1. IEEE Conference (2021)  
 Authors: Li Zhang, Yong Wang, and Hui Li  
 Title: Generative Adversarial Networks for Interior Room Layout and Texture Synthesis  
 Methodology Used:

The paper proposed a GAN-based model capable of generating realistic room layouts and applying interior textures based on input floor plans. The system used a dual-network architecture one network predicted furniture placement, while the second handled décor styling.

**Observations / Remarks:**  
 The researchers demonstrated that GANs can effectively learn interior patterns and replicate style consistency. The study validated the feasibility of AI-generated interiors using training datasets of real rooms.

**Relevance to Our Work:**  
 This concept inspired the use of generative models for synthesizing room layouts. However, our system uses Stable Diffusion, which provides much higher controllability than GANs when users give prompts or upload images.

2. International Journal of Computing and Design (2022)  
 Authors: Kim Seung-Ho and Park Jin-Woo  
 Title: Deep Interior Layout Generation Using Diffusion Models  
 Methodology Used:

The research introduced diffusion-based generative models for room visualization. Using attention-guided diffusion techniques, the model generated interior scenes with improved spatial structure and coherent lighting.

**Observations / Remarks:**  
 The study proved that diffusion models surpass GANs in realism, lighting consistency, and texture quality. Their model performed well for modern, traditional, and minimalist interior styles.

**Relevance to Our Work:**  
 This formed the foundation for selecting Stable Diffusion in our system, enabling users to generate

interior designs through natural language descriptions and reference images.

3. IEEE Transactions on Multimedia (2022)

Authors: Xiang Li, Yun Chen, and Zhao Zhou

Title: Interactive AI-Powered Interior Design Platform  
Methodology Used:

The paper presented a web-based platform where users interact with an AI engine through style selection, color palette adjustment, and layout suggestions. Machine-learning models were used to understand user preferences and adjust design variations.

Observations / Remarks:

The study highlighted the importance of user interaction and customizability in AI-assisted design systems. It showed that personalization significantly improves user satisfaction.

Relevance to Our Work:

This directly influenced the creation of our web interface using HTML, CSS, and JavaScript, enabling users to choose styles and provide prompts before AI generates designs.

4. International Journal of Computer Applications (2021)

Authors: Priya Sharma and Raghav Gupta

Title: Computer Vision-Based Enhancement of Interior Images  
Methodology Used:

This paper used OpenCV for image sharpening, brightness balancing, shadow correction, and texture enhancement. It improved low-quality interior images captured on mobile devices.

Observations / Remarks:

The findings emphasised that computer-vision post-processing significantly improves photorealism and visual clarity of generated images.

Relevance to Our Work:

Our system integrates OpenCV for colour correction, brightness balancing, and texture enhancement, and combines it with Real-ESRGAN to upscale the final output to higher resolution.

5. OpenAI Research (2023)

Authors: Ramesh et al.

Title: Stable Diffusion Models in Art, Design, and Creative Visualization  
Methodology Used:

The authors described how diffusion models learn complex patterns from billions of images and generate new photorealistic designs based on textual prompts. The model supports style-based customization.

Observations / Remarks:

The study proved that diffusion-based synthesis is highly suitable for creative design tasks due to its controllability and aesthetic consistency.

Relevance to Our Work:

This directly inspired using Stable Diffusion v1.5 as the core generative engine in our virtual interior design system.

### III. METHODOLOGY

The proposed system, Virtual Interior Design Using AI, is developed as a modular and scalable platform capable of generating photorealistic interior designs using Stable Diffusion, OpenCV, and Real-ESRGAN. The methodology integrates AI models, image-processing pipelines, a Flask-based backend, and a web interface into a unified ecosystem that can process user inputs, generate interior scenes, enhance image quality, and display final results.

Each module contributes to a specific function from user input acquisition to AI-driven design generation and post-processing enhancement.

#### A. User Input Acquisition

The system begins by collecting input from the user through a web-based interface. The user can either upload a room image or provide a textual description of the desired interior style. The interface captures style preferences such as modern, minimalistic, luxury, vintage, or Scandinavian themes. Uploaded images are validated for format and resolution, after which they are preprocessed and transmitted to the backend. This module ensures that user-provided information is structured and ready for AI-based processing.

#### B. AI-Based Interior Design Generation

The AI engine is responsible for producing the actual interior design. This is accomplished using Stable Diffusion, an advanced text-to-image generative model that creates photorealistic designs from prompts or reference images. The model encodes the user's text description into a latent vector and iteratively refines noise into a coherent interior scene. If a room image is uploaded, the system applies image-to-image transformation to maintain room geometry while

applying new décor styles. The design generation module forms the core intelligence of the system, enabling high-quality and style-consistent outputs.

**C. Image Enhancement and Post-Processing**

Once an interior design is generated, it undergoes post-processing to improve visual quality. OpenCV is used for brightness adjustment, shadow correction, contrast normalization, and texture refinement. After this stage, the enhanced image is passed to Real-ESRGAN, which performs high-resolution upscaling. Real-ESRGAN improves clarity, reduces noise, sharpens edges, and produces 4K-level details suitable for presentation, printing, or professional use. This module ensures that the final design appears realistic and visually refined.

**D. Style Transformation and Customization**

This module allows the user to regenerate multiple variations of the interior based on preferred styles. When the user selects a new theme, adjusts color preferences, or modifies the room’s aesthetic requirements, the backend reconfigures the Stable Diffusion prompt and generates a new interior. This enables iterative design exploration and ensures that users can experiment freely with décor combinations until a satisfactory output is achieved.

**E. Backend Processing Using Flask**

The backend of the system is built using Flask, which manages all incoming requests, image uploads, model executions, and output delivery. Flask routes communicate with the AI engine, orchestrating prompt processing, image generation, and enhancement tasks. It also handles temporary file management and ensures stable communication between the frontend and the AI modules. By managing asynchronous operations efficiently, Flask ensures that the system remains responsive even during heavy model processing.

**F. Frontend Interface**

The frontend interface is implemented using HTML, CSS, and JavaScript. It provides an interactive environment where users can upload images, specify design styles, and view generated interiors. The interface displays loading indicators while the backend processes the request and presents the final enhanced output once ready. The frontend ensures

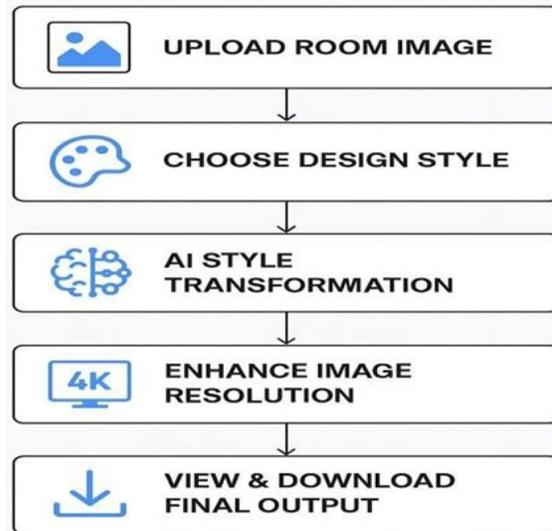
smooth user interaction and maintains a clean, intuitive layout to simplify the design workflow.

**G. Deployment and Hosting Framework**

Deployment is handled using Ngrok for real-time demonstration and optional cloud hosting services such as PythonAnywhere, Render, or AWS. These platforms support GPU execution for Stable Diffusion and ensure secure access using HTTPS. Temporary data storage and environment isolation are used to protect user inputs. The system is capable of scaling based on cloud resources, ensuring reliable operation under varying workloads.

**H. System Flow Description**

The overall flow of the system begins with the user providing an image or textual description. This input is received by the frontend and passed to the Flask backend. Stable Diffusion processes the input and generates the initial interior design. The output is then refined using OpenCV and Real-ESRGAN before the final image is sent back to the user interface for display or download. This structured flow ensures smooth processing from input to final visualization.



Flow Chart

**IV. RESULTS**

The Virtual Interior Design Using AI system was successfully developed and tested for real-time interior visualization, style transformation, and high-resolution image enhancement. User inputs, including room

photographs and text-based style descriptions, are processed through the Flask backend and passed to the Stable Diffusion model, which generates photorealistic interior designs based on the chosen theme. The AI model was able to consistently maintain room structure while transforming décor, furniture style, color palette, lighting, and texture details according to the user's preferences.

Once the interior design is generated, the enhancement pipeline refines the output using OpenCV and Real-ESRGAN. OpenCV adjustments such as brightness correction, shadow balancing, and texture cleanup produced visually coherent results. Real-ESRGAN further upscaled the images to high resolution, improving clarity, sharpness, and fine detail, which made the outputs suitable for presentation or professional use.

During testing, the system demonstrated strong stability and responsiveness. On GPU hardware, the average generation time for a complete interior design ranged between 10 to 15 seconds, while CPU execution showed slightly longer durations but maintained functional reliability. The regenerated designs also responded accurately to changes in user-selected styles, demonstrating the adaptability of the AI model across modern, minimalistic, luxury, vintage, and Scandinavian themes.

Users reported that the generated interiors appeared realistic and well-styled, with accurate lighting distribution, balanced color composition, and coherent furniture arrangement. The overall system effectively integrated AI-based design generation, web-based interaction, and image enhancement, providing an intelligent, interactive, and efficient virtual interior design experience.

## V. CHALLENGES FACED

The Virtual Interior Design Using AI system encountered several challenges during development and testing. One of the major issues was the computational complexity of executing the Stable Diffusion model, which requires significant GPU resources to generate high-quality images. Running the model on lower-end hardware led to increased processing time and occasional rendering failures. Additionally, maintaining consistent lighting, texture quality, and spatial coherence across different room styles proved difficult, as generative AI models sometimes produced artifacts or incomplete elements within the interior scene.

Another challenge involved integrating the AI engine with the Flask backend in a stable and efficient manner. The model's large memory footprint required careful optimization to prevent backend crashes during concurrent requests. Ensuring high-resolution outputs while keeping response time low also demanded fine-tuning of the enhancement pipeline involving OpenCV and Real-ESRGAN. Finally, user expectations for highly realistic designs added pressure on the system to maintain accuracy and aesthetic appeal, making continuous testing and refinement essential for reliable performance.

## VI. FUTURE IMPROVEMENTS

The current version of the Virtual Interior Design Using AI system successfully generates customizable and high-resolution interior designs using Stable Diffusion and image enhancement models. However, several improvements can be incorporated in future iterations to expand capabilities, improve user experience, and enhance overall system performance.

1. **Voice-Enabled Design Assistant:** Future versions may integrate speech-to-text capabilities, allowing users to specify room styles, décor preferences, and color themes through voice commands. This would make the system more accessible and intuitive.
2. **AR-Based Real-Time Room Visualization:** Augmented Reality can be incorporated to allow users to project AI-generated designs directly onto their physical rooms using a smartphone camera, creating a more immersive and realistic design preview.
3. **3-D Interior Layout Generation:** Support for 3-D modeling would enable users to explore room designs through multiple angles and interactive walkthroughs. This would significantly enhance design clarity and spatial understanding.
4. **Furniture Detection and Automatic Placement:** By integrating object detection models, the system can identify existing furniture in uploaded images and generate optimized layout suggestions or recommend furniture replacements.
5. **Mobile Application Deployment:** A cross-platform mobile app can be developed to extend accessibility, allowing users to generate, modify,

and share interior designs directly from their smartphones with minimal processing delays.

6. Cloud-Based Rendering and Collaboration: Using cloud GPU servers can reduce processing time and allow multiple users to work collaboratively on shared interior design projects, improving scalability and performance.

## VII. CONCLUSION

The Virtual Interior Design Using AI system effectively demonstrates how Artificial Intelligence, generative models, and advanced image-processing techniques can revolutionize the interior design workflow. By integrating the Stable Diffusion generative engine, an enhancement pipeline using OpenCV and Real-ESRGAN, and a lightweight Flask backend, the system is capable of producing realistic, customizable, and high-quality interior designs based on simple text prompts or user-uploaded images. The platform simplifies the design process, reduces manual effort, and enables rapid experimentation with different décor styles and themes.

Experimental results confirmed the system's ability to maintain room structure while transforming furniture arrangements, lighting, textures, and overall aesthetics, providing users with visually coherent and professional-grade design outputs. User testing also indicated high satisfaction with output clarity, design realism, and system responsiveness. Overall, the platform successfully bridges the gap between human creativity and AI-assisted visualization, empowering users to explore diverse interior concepts with minimal technical expertise. It also establishes a strong foundation for future innovations in AI-driven architectural design, augmented visualization, and intelligent space planning.

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