AI-Driven Diffusion and Lora Models for Customizable 3D Room Visualization and Design Enhancement

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Abstract - *Artificial Intelligence (AI) has emerged as a transformative technology in the field of architectural visualization and interior design, enabling the creation of intelligent, efficient, and highly customizable design solutions. Traditional room visualization methods often require extensive manual effort, specialized software expertise, and significant rendering time, making the design process complex and resource-intensive. To address these limitations, this research presents an AI-driven framework that integrates Diffusion Models and Low-Rank Adaptation (LoRA) techniques for customizable 3D room visualization and design enhancement. The proposed system generates photorealistic interior room designs from simple user inputs such as text descriptions, sketches, and floor plans. By utilizing diffusion-based image generation, the framework produces realistic design concepts, while LoRA fine-tuning enables rapid adaptation to specific interior styles, furniture collections, and user preferences without requiring complete model retraining. Furthermore, the generated two-dimensional visualizations are transformed into interactive three-dimensional environments using depth estimation and neural rendering techniques, providing immersive visualization experiences. The system supports real-time customization of layouts, materials, lighting conditions, and furniture placement, thereby improving collaboration between designers and clients. The proposed approach significantly reduces design time, enhances creativity, and offers a scalable and cost-effective alternative to conventional interior design workflows. Experimental evaluation demonstrates the framework's capability to generate visually appealing, personalized, and high-quality room designs suitable for modern architectural and interior design applications. This work highlights the growing potential of generative AI technologies in revolutionizing digital design processes and creating intelligent design assistance systems for future smart environments.*

Key Words :Artificial Intelligence, Diffusion Models, LoRA, 3D Room Visualization, Interior Design, Stable Diffusion, ControlNet, NeRF, Generative AI, Deep Learning, Computer Vision, AR/VR, Neural Rendering.

1. INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) has significantly transformed the way digital content is created, analyzed, and visualized across various industries. In the field of interior design and architectural visualization, AI technologies are enabling the development of intelligent systems capable of generating realistic design concepts with minimal human intervention. Traditional room design workflows often depend on professional designers using complex Computer-Aided Design (CAD) software and 3D modeling tools, which require considerable technical expertise, time, and computational resources. As a result, creating multiple design alternatives and visualizing them effectively can be both expensive and labor-intensive.

Recent developments in generative AI, particularly diffusion models, have introduced new possibilities for automated content generation. Diffusion models are capable of producing highly realistic images from textual descriptions, sketches, and structural layouts. These models learn complex visual patterns from large datasets and generate outputs that closely resemble real-world scenes. Their ability to understand design concepts and translate user requirements into visual representations has made them increasingly valuable for interior design applications.

Alongside diffusion models, Low-Rank Adaptation (LoRA) has emerged as an efficient fine-tuning technique that allows large AI models to be customized for specific design styles and user preferences without modifying the entire model architecture. This approach reduces computational costs while enabling rapid personalization. Designers can adapt AI systems to generate outputs that align with particular furniture collections, architectural themes, color palettes, or regional design trends, thereby improving user satisfaction and creative flexibility.

Despite these advancements, many existing AI-based design solutions remain limited to two-dimensional image generation and do not provide immersive visualization capabilities. Users often require a deeper understanding of spatial arrangements, furniture placement, lighting conditions, and overall room aesthetics before making design decisions. Converting generated designs into interactive three-dimensional environments can significantly improve the design evaluation process and enhance communication between clients and designers.

To address these challenges, this research proposes an AI-driven framework that combines diffusion models, LoRA-based personalization, and 3D reconstruction techniques for customizable room visualization and design enhancement. The framework enables users to generate realistic interior designs from simple inputs such as text prompts, sketches, or floor plans. The generated designs are further transformed into interactive 3D environments through depth estimation and neural rendering methods, allowing users to explore and customize spaces more effectively.

The proposed system aims to simplify the interior design process by reducing manual effort, accelerating design generation, and providing a user-friendly platform for both professionals and non-technical users. By integrating intelligent design generation with immersive visualization capabilities, the framework contributes to the development of next-generation design systems that support creativity, efficiency, and personalization. The study demonstrates how modern AI technologies can bridge the gap between conceptual design ideas and realistic visual representations, ultimately enhancing the overall design experience.

2. PROBLEM STATEMENT

Interior design and room visualization play a crucial role in modern architectural planning and space management. However, traditional design workflows rely heavily on manual modeling, professional expertise, and specialized software tools such as AutoCAD, SketchUp, Revit, and Blender. These methods require significant time, technical knowledge, and computational resources to create realistic room layouts and visual representations. As a result, generating multiple design alternatives and incorporating client feedback often becomes a lengthy and expensive process.

Existing room visualization systems provide limited automation and customization capabilities. Most solutions require users to manually select furniture, adjust layouts, configure lighting, and perform rendering operations, which can reduce productivity and increase project costs. Additionally, non-technical users often find it difficult to communicate their design preferences effectively, leading to misunderstandings between clients and designers and resulting in repeated modifications.

Although recent advancements in Artificial Intelligence have enabled automated image generation and design assistance, many existing AI-based systems focus only on producing two-dimensional visual outputs. These solutions frequently lack personalization features, real-time customization, and immersive three-dimensional visualization capabilities. Furthermore, maintaining consistency between user requirements, generated designs, and interactive 3D environments remains a significant challenge.

Therefore, there is a need for an intelligent and efficient design framework that can automatically generate realistic room visualizations from simple user inputs such as text descriptions, sketches, or floor plans while supporting style personalization and immersive 3D exploration. The proposed research addresses this challenge by integrating diffusion models, LoRA-based customization, and 3D reconstruction techniques to create a scalable, user-friendly, and cost-effective room visualization system that enhances creativity, reduces design effort, and improves overall user experience.

3. OBJECTIVES

This study aims to develop an innovative Artificial Intelligence-based framework for customizable room visualization and design enhancement. The primary objective is to create a system that can automatically generate realistic interior design concepts from simple user inputs such as text descriptions, sketches, and floor plans. The research focuses on improving design efficiency by reducing the manual effort required in conventional interior design processes while maintaining high visual quality and design accuracy. Another objective is to incorporate adaptive learning techniques that enable the system to produce personalized room designs based on individual preferences, design styles, furniture arrangements, and aesthetic requirements. The study further seeks to integrate three-dimensional visualization capabilities, allowing users to explore generated room designs in an interactive and immersive environment. Additionally, the proposed framework aims to support real-time modifications of room elements, including lighting, textures, colors, and spatial layouts, thereby providing greater flexibility during the design process. By combining intelligent design generation with interactive visualization, the research intends to enhance collaboration between designers and clients, accelerate decision-making, and improve overall user experience. Ultimately, the study aims to demonstrate how advanced AI technologies can be utilized to develop a scalable, efficient, and user-centric solution for modern interior design and architectural visualization applications.

4. METHODOLOGY

The methodology adopted in this study follows a systematic approach for developing an Artificial Intelligence-driven room visualization and design enhancement system. The process begins with the collection and preparation of interior design data, including room images, floor plans, furniture layouts, and style references obtained from publicly available datasets and design resources. The collected data is cleaned, organized, and processed to ensure consistency and suitability for model training and evaluation. This prepared dataset serves as the foundation for generating realistic and visually appealing room designs. After data preparation, a generative design framework is established using advanced image synthesis techniques. User inputs such as textual descriptions, sketches, or floor plans are analyzed and converted into design instructions that guide the generation process. The system interprets these inputs to create room layouts that reflect the desired style, furniture arrangement, color combinations, and spatial organization. To support personalization, an adaptive learning mechanism is incorporated, enabling the framework to produce outputs that align with specific design preferences and aesthetic requirements.

Once the initial room visualization is generated, image enhancement and structural refinement processes are applied to improve visual quality, realism, and consistency. The generated designs are then processed through depth estimation and spatial reconstruction techniques to obtain three-dimensional representations of the interior environment. This stage enables users to view and interact with room designs from different perspectives, providing a more comprehensive understanding of the proposed layout and design elements.

An interactive customization module is integrated into the framework to allow users to modify various room components, including furniture placement, lighting conditions, textures, colors, and decorative features. The system updates the visualization dynamically based on user modifications, ensuring flexibility and ease of design exploration. Throughout the development process, functional testing and performance evaluation are conducted to assess design quality, usability, responsiveness, and overall system effectiveness.

Finally, the generated room models are stored and made available for visualization, editing, and export. The completed framework provides a seamless workflow that transforms user ideas into realistic and interactive room designs while reducing the complexity, time, and effort associated with traditional interior design methodologies. This methodology demonstrates the practical integration of Artificial Intelligence, intelligent visualization, and interactive design technologies to create an efficient and user-centered design solution

5. LITERATURE SURVEY

The rapid growth of Artificial Intelligence has created new opportunities for innovation in architectural visualization, interior design, and digital content generation. Researchers have explored various intelligent techniques to automate design creation, improve visualization quality, and enhance user interaction. Among these developments, generative models have gained considerable attention due to their ability to produce realistic visual content from simple user instructions. These advancements have encouraged the adoption of AI-based solutions in design-oriented applications where creativity, efficiency, and customization are essential.

Recent studies have demonstrated the effectiveness of deep learning models in generating high-quality interior design concepts. Image synthesis techniques have shown remarkable capability in understanding textual descriptions and transforming them into visually meaningful outputs. Such approaches reduce the need for manual modeling and allow designers to rapidly explore multiple design alternatives. The increasing quality of generated images has made AI-assisted design systems a practical option for conceptual visualization and early-stage planning.

Researchers have also investigated methods for personalizing generated content according to user preferences and design requirements. Adaptive learning techniques enable models to learn specific styles, furniture arrangements, material selections, and decorative themes without requiring extensive retraining. These methods improve flexibility and allow users to obtain customized results that better reflect their expectations. Personalization has become a key factor in improving user satisfaction and supporting diverse design scenarios.

Another important area of research focuses on transforming two-dimensional visual outputs into three-dimensional environments. Various depth estimation and scene reconstruction techniques have been developed to generate spatial representations from images, enabling immersive visualization and interactive exploration. These technologies provide a more realistic understanding of room layouts and assist users in evaluating design decisions before implementation. The integration of three-dimensional visualization has significantly enhanced the practical value of AI-generated design solutions.

Several studies have highlighted the importance of user interaction in intelligent design systems. Modern visualization platforms increasingly incorporate real-time editing and customization features that allow users to modify design elements such as furniture placement, color schemes, lighting arrangements, and decorative components. These capabilities support collaborative design workflows and facilitate better communication between designers and clients. As a result, users can participate more actively in the design process and make informed decisions based on realistic visual representations.

Despite substantial progress in AI-assisted visualization, existing solutions still face challenges related to personalization, spatial consistency, computational efficiency, and user adaptability. Many systems focus on specific tasks and do not provide a unified framework that combines intelligent content generation, customization, and immersive visualization. Therefore, there remains a need for a comprehensive approach capable of integrating these functionalities within a single platform. The findings from previous research indicate that combining advanced generative techniques with interactive visualization technologies can significantly improve design quality, user experience, and overall workflow efficiency. This study builds upon these research directions to develop a more flexible, intelligent, and user-centric room visualization framework.

6. SYSTEM DESIGN

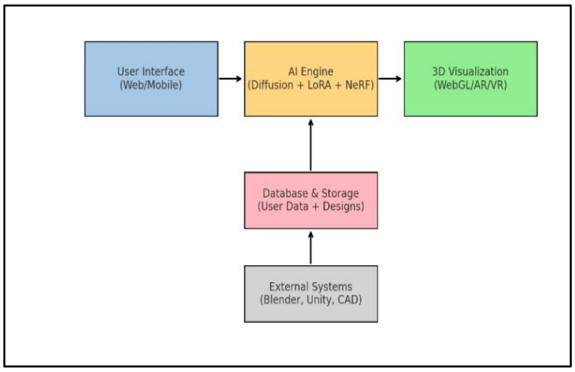

Figure 1: System Architecture

illustrates the overall architecture of the proposed AI-driven room visualization and design enhancement system. The architecture consists of five major components: the User Interface, AI Engine, Database and Storage Module, 3D Visualization Module, and External Systems.

The process begins with the User Interface (Web/Mobile), where users provide design inputs such as text prompts, sketches, or floor plans. These inputs are transmitted to the AI Engine, which serves as the core processing unit of the system. The AI Engine utilizes advanced technologies, including Diffusion Models, LoRA-based personalization, and Neural Radiance Fields (NeRF), to generate realistic and customized room designs based on user requirements.

The Database and Storage Module supports the AI Engine by storing user information, project details, generated designs, templates, and system configurations. It ensures efficient data management and enables the retrieval of previously saved projects and design assets whenever required.

After processing, the generated outputs are sent to the 3D Visualization Module, where room designs are rendered into interactive three-dimensional environments. This module supports WebGL and AR/VR technologies, allowing users to explore room layouts from multiple perspectives and experience immersive visualization.

The architecture also includes External Systems, such as Blender, Unity, and CAD applications, which provide additional capabilities for advanced editing, rendering, and professional design integration. These systems can exchange data with the storage module, enabling seamless export and further refinement of generated designs.

7. SCREENSHOTS

1. HOME PAGE

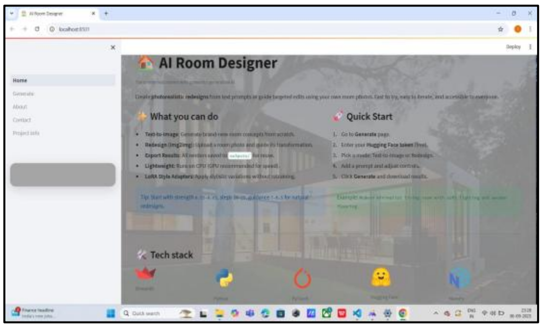

Figure 2: Home Page

2. GENERATE

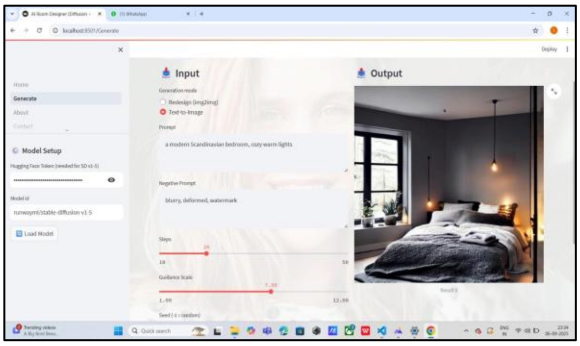

Figure 3: Generate

3. ABOUT US

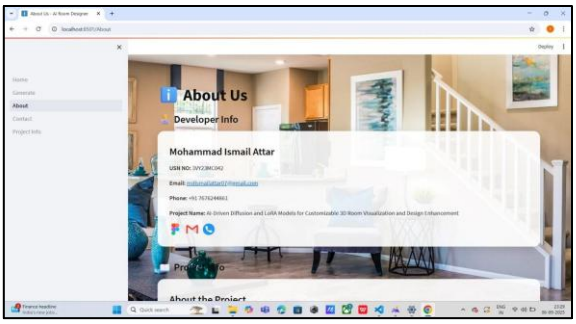

Figure 4: About Us

4. CONTACT US

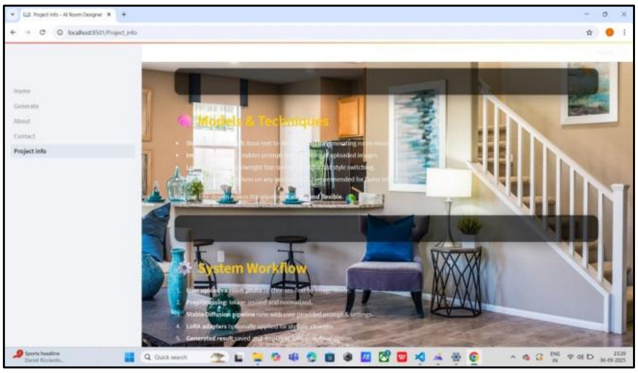

Figure 5: Contact Us

5. PROJECT INFO

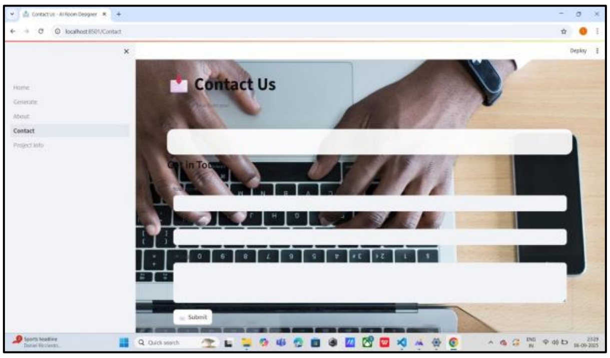

Figure 6: Project Info

8. CONCLUSION AND FUTURE SCOPE

This study presented an Artificial Intelligence-based framework for customizable room visualization and design enhancement aimed at simplifying and modernizing the interior design process. The proposed system utilizes intelligent design generation techniques to transform user requirements into realistic and visually appealing room designs while minimizing manual effort and technical complexity. By integrating generative design capabilities, adaptive personalization mechanisms, data management functions, and interactive visualization features, the framework provides a comprehensive solution for creating customized interior environments. The system enables users to generate room designs from text descriptions, sketches, and floor plans, while also supporting design modifications and immersive exploration of generated spaces. The implementation and evaluation of the framework demonstrate its effectiveness in improving design productivity, enhancing user experience, and facilitating better communication between designers and clients. The results indicate that intelligent automation can significantly reduce the time and resources required for design development while maintaining high-quality visual outputs. Therefore, the proposed framework represents a practical and scalable approach for modern interior design and architectural visualization applications.

Despite the successful achievement of the study objectives, several opportunities remain for future enhancement. The framework can be extended by incorporating advanced virtual reality and augmented reality technologies to provide more immersive design experiences. Future versions may support real-time collaborative design environments where multiple users can simultaneously participate in project development and decision-making. Additional intelligent recommendation features can be integrated to automatically suggest design alternatives, furniture arrangements, color schemes, and decorative elements based on user preferences and design trends. Voice-based interaction capabilities may further improve usability by allowing users to modify designs through natural language commands. The system can also benefit from cloud-based deployment, mobile application support, and integration with smart home technologies to increase accessibility and functionality. Furthermore, future research may explore larger-scale architectural visualization, commercial space planning, and urban design applications. These advancements have the potential to transform the framework into a more comprehensive intelligent design platform capable of supporting a wide range of visualization and planning requirements in the evolving digital design landscape.

9. REFERENCES

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