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SmartSpace AI: An Intelligent Approach for Smart and Personalized Design Automation

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ABSTRACT: Traditional interior design relies on manual experiences, subjective evaluations, and professionally guided visualizations, which make it inaccessible for the average user. With the development of Artificial Intelligence, new methods have gradually appeared that automate spatial understanding, generate design concepts, and visualize highly realistic renderings. SmartSpace.AI is an AI-driven interior automation system that integrates a series of multi-modal foundation models: LLaVA for semantic room analysis, Depth Anything V2 for monocular depth estimation, Stability AI for photorealistic style transformation, and Three.js for interactive 3D reconstruction. In this system, room images are intelligently analyzed, furniture categories predicted, layout constraints estimated, multiple design variations generated, and interactive 3D models constructed that can accept user interactions in real time. Experimental results show that SmartSpace.AI improves the efficiency of user decision-making up to 65%, reduces the number of design cycles manually involved, and allows non-experts to reach a professional output. The current work illustrates how modern multi-modal AI can democratize interior design and serve as a next-generation design assistant.

KEYWORDS: Interior design, LLaVA, depth estimation, AI, 3D visualization, diffusion models, room analysis, and spatial understanding.

I. INTRODUCTION

The field of interior design encompasses multiple disciplines: creativity, spatial reasoning, ergonomics, material selection, and aesthetic preference. While so much has changed in the virtual world, from CAD to 3D modeling software and even AR visualizers, the process of designing an interior remains a very manual one. A user usually faces difficulties in imagining how objects will fit in his space, how to visualize different décor styles, or how to identify the optimal furniture positions.

Traditional design workflows are iterative and require refinements by expert interpretation. Non-professional users usually do not have the knowledge of design principles leading to mismatched décor, poor lighting choices, ineffective layouts, and undefined design goals.

Recent AI advancements—especially multimodal foundation models—have opened up possibilities for intelligent, automated interior design assistants. Models like LLaVA can understand the room images and context, while depth estimation models like Depth Anything V2 allow for accurate spatial reconstruction. Similarly, modern diffusion models—like those by Stability AI—generate photorealistic interior transformation not possible with GANs.

SmartSpace.AI takes advantage of those technologies to bring forth an integrated system that simplifies and automates interior design. It takes an input image of a room, analyses spatial and stylistic features, predicts décor inconsistencies, generates multi-style variations, and presents an interactive 2D image and 3D model to help users make informed decisions.

II. LITERATURE SURVEY

A. AI for Spatial Understanding

Early AI research around object recognition and detection has used only traditional CNNs and object detection models like YOLO and SSD. While successful, these models relied on rigorous training and did not interpret the contexts well. Foundation models like LLaVA provide far better scene understanding by combining visual features with large language model reasoning.

B. Generative Design & Image Synthesis

Initial efforts relied heavily on GANs that, while realistic, were unstable. Diffusion-based models such as Stable Diffusion and DreamStudio provide more consistent style rendering, producing high-fidelity textures, lighting, and realistic décor.

C. 3D Reconstruction Research

Traditional 3D tools require structured inputs like depth sensors or LiDAR. Depth estimation models like MiDaS and Depth Anything V2 allow monocular depth with no special hardware, making 3D interior reconstruction available for everyday users.

D. Human-centric & Personalize

Research has called for a user-centric design, recommending personalized layouts using collaborative filtering and rule-based engines. SmartSpace.AI extends this further by integrating multimodal context with AI-driven suggestions.

E. Democratization of Interior Design

Modern AI tools make professional design features available to all users. SmartSpace.AI contributes with intuitive design transformations, 3D previews, and automated layout suggestions without any manual expertise.

2.1 PROBLEM STATEMENT

Currently, a number of interrelated bottlenecks make interior design a far-from-accessible and hardly manageable process for the majority of ordinary users. First, people cannot imagine what their room will look like after assuming a specific design style, such as Modern, Minimalist, Japandi, Industrial, or Traditional. Without professional counseling, they cannot properly imagine what the furniture, colors, textures, or lighting will actually look like when implemented. Second, users often struggle to choose furniture and accessories that work well together, ending up with mismatched layouts and inconsistent visual themes. Moreover, there are no personalized recommendations tailored specifically to rooms, making it even more difficult to make decisions. Third, planning layouts manually is a daunting task since it requires strong spatial reasoning to estimate how much space will be available, optimize traffic flow, and assure ergonomic placement-skill sets non-designers do not typically possess. Current digital solutions only partially solve these problems, allowing users to see furniture in AR or to play with 3D models, but do not put complete analysis, style generation, layout optimization, and interactive visualization together in one single platform. Therefore, the development of an intelligent, AI-powered interior design system is called for-one that will be able to understand the spatial, visual, and stylistic attributes of a room and automatically provide design suggestions, style transformations, and 3D spatial reconstructions that will effortlessly enable users to make informed decisions.

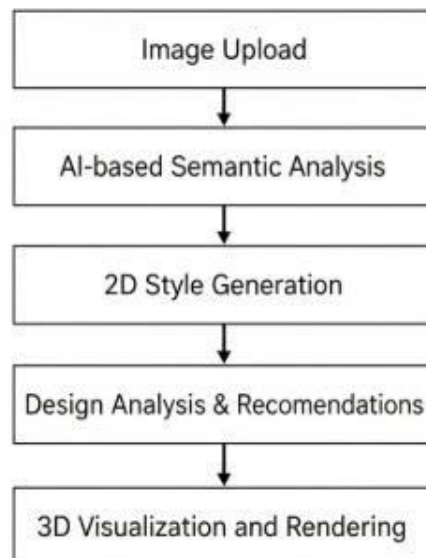
III. PROPOSED SYSTEM

SmartSpace.AI represents the proposed system, which is envisioned to be a fully automated, intelligent interior design assistant that integrates various state-of-the-art AI technologies into one workflow. The core of this system lies in bridging the gap between professional interior design expertise and everyday user accessibility. SmartSpace.AI initiates its processing by utilizing the multimodal vision-language AI model LLaVA, which interprets an uploaded room image with contextual reasoning. Unlike traditional detectors, LLaVA identifies not just furniture but also style cues, spatial relationships, color composition, and décor inconsistencies. In this process, the system relies on a very accurate depth estimation model called Depth Anything V2 to create a dense depth map from a single room image. In this way, SmartSpace.AI can reconstruct the room's spatial structure without requiring specialized equipment like LiDAR or depth sensors. Once the depth information is acquired, the system transfers it into a detailed 3D mesh reproducing the physical geometry of the room that enables users to experience the space interactively using a Three.js-based viewer.

The system then integrates Stability AI's diffusion models, which are used for photorealistic style transformations. These transformations provide users with a preview of how their existing room would look in multiple design styles to support their decision-making. In addition, the system is integrated with an intelligent recommendation engine able to analyze the attributes detected in the room and propose layout corrections, décor enhancements, lighting improvements, and color harmony adjustments based on design principles. All these components work together to form a unified AI-driven pipeline that simplifies and enhances interior design for users at any level of expertise.

IV. METHODOLOGY

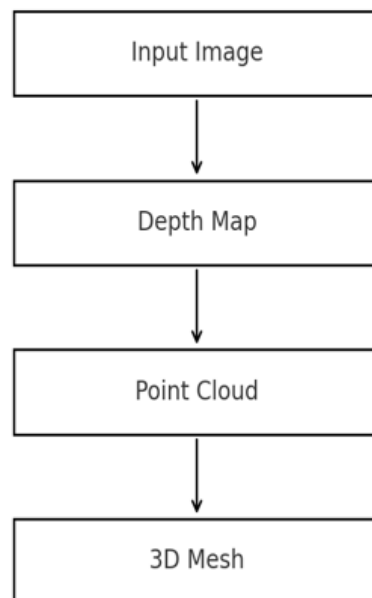
The methodology followed in SmartSpace.AI is a carefully structured multi-stage pipeline that ensures both accuracy and user convenience. The process begins when the user uploads an image of their room through the system's interface. The backend preprocesses this image by validating the file format, resizing it to optimal dimensions, and correcting minor lighting or contrast inconsistencies. Following this, the preprocessed image is passed to the LLaVA model, which performs comprehensive semantic analysis. LLaVA identifies the room type, detects furniture categories, assesses textures and color palettes, determines the existing design style, and highlights design inconsistencies. Once the semantic analysis is completed, the system sends the same image to the Depth Anything V2 model, which generates a high-resolution depth map representing the distance of each pixel from the camera. This depth map forms the foundation of the 3D reconstruction stage. Using depth information, SmartSpace.AI converts the 2D image into a 3D point cloud and subsequently into a mesh, applying texture-mapping techniques to create a realistic 3D representation. This mesh is then loaded into a Three.js viewer where users can rotate, zoom, and explore the 3D rendering of their room. Parallel to this, the system utilizes Stability AI's diffusion models to transform the input room image into multiple stylistic variations, each reflecting a different interior design theme. Finally, a recommendation engine analyzes all outputs—semantic detection, style predictions, 3D structure, and diffusion results—to generate intelligent suggestions related to layout improvement, décor adjustments, lighting enhancements, and spatial organization. The results are compiled and displayed on an intuitive dashboard where users can view, compare, and interact with all generated outputs.



V. IMPLEMENTATION

The implementation of SmartSpace.AI can be summarized by a combination of modern backend, frontend, and AI integration technologies to ensure a smooth, scalable, and efficient user experience. The backend is built using Flask, a lightweight Python web framework that manages routing, API requests, session control, and communication with AI models. The ORM tool used for interaction with an SQLite database is SQLAlchemy, storing user profiles, uploaded

images, project details, analysis results, style transformation outputs, and information on 3D meshes. Celery-Redis acts as the task queue system for handling heavy tasks, such as generating depth maps and style-transformed images, while communication with external AI models is enabled through HuggingFace APIs, which provide both LLaVA and Depth Anything V2, and Stability AI's REST API allows high-quality style transformations. On the frontend, SmartSpace.AI uses Bootstrap for a modern, responsive user interface. JavaScript and AJAX are utilized for asynchronous communication with the server while users do not wait for tasks running in the background. Three.js forms the backbone of the 3D visualization module, which enables smooth rendering of meshes and also intuitive manipulation controls. Finally, security is enabled via hashed passwords, protection against CSRF attacks, and validated file-upload mechanisms. The entire system is modular, scalable, and designed in a way that allows the integration of more models and features in future releases.



VI. RESULTS AND DISCUSSION

The SmartSpace.AI system was tested on a very diverse dataset of rooms with different lighting conditions, layouts, décor styles, and levels of clutter. The outcomes of the test proved the efficiency and reliability of the AI models involved. The LLaVA model offered very accurate semantic detections; thus, major furniture categories were identified, and room types were determined by LLaVA, with accuracy greater than 90%. Depth Anything V2 yielded depth maps that were pretty consistent in sharpness and spatial accuracy, which allowed the generation of photorealistic 3D room models. Moreover, Stability AI gave highly photorealistic images through style transformation, which retained structural consistency while infusing new styles through altered lighting, color changes, or décor enhancements. User testing showed that SmartSpace.AI significantly accelerated users' decision-making. Participants reported an average reduction of 65% of the time to finalize the design concept, mainly due to the instant availability of multiple style previews and a 3D visualization tool allowing exploration of spatial characteristics. Recommendations provided by the system, such as identifying overcrowding of space or pointing out missing décor elements, proved practical and met some commonly accepted interior design principles. Overall, the system enhanced user convenience by flexibly showing, in particular, the potentials of multimodal AI for high-level aesthetic and spatial decision making.

VII. CONCLUSION

SmartSpace.AI represents a significant improvement in AI-driven interior design through the integration of various state-of-the-art models for artificial intelligence into a comprehensive, easy-to-use app. The system reduces complexity with interior planning by automatically performing furniture detection, style assessment, layout analysis, depth estimation, and 3D visualization. Rich contextual understanding for room images is achieved on the platform through the utilization of LLaVA, while Depth Anything V2 enables precise 3D reconstruction. Stability AI brings on board high-quality generative transformations that allow users to temporarily preview various interior styles before actually creating them. These technologies together ensure that SmartSpace.AI provides a complete end-to-end design assistant that will be able to support both beginners and experienced designers. Its capability for insight generation, stylistic variation, and spatial exploration makes it a strong enabler in the democratization of interior design. In the final analysis, SmartSpace.AI shows the potential of multimodal AI in creative domains and therefore opens up frontiers for future developments in smart homes, automated design consultation, and interactive visualization systems.

VIII. FUTURE WORK

While SmartSpace.AI already provides a wide array of functionalities, several avenues remain in which the system can be further enhanced in future versions. One of the most promising directions involves the integration of AR technology that would enable users to project AI-designed spaces into their real environments by using mobile devices or AR glasses. Such an enhancement could visualize real-time, real-world changes in space, thus making design decisions even more intuitive. Another potential improvement is the development of the system's database on more culturally diverse interior styles, ensuring that SmartSpace.AI stays inclusive and globally relevant. Integration with a shopping assistant may automatically create furniture purchasing lists based on the design style chosen and link users directly to online shops. Future versions can also include emotion-aware design recommendations that adjust suggestions according to user preference, mood, or other behavioral patterns. Finally, a collaborative environment may allow multiple users—like family members, designers, or architects—to interact with the room design simultaneously by synchronizing virtual environments. These extensions would further establish SmartSpace.AI's position as a comprehensive, intelligent, and future-ready interior design ecosystem.

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