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Thematic Room Design using Artificial Intelligence

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Abstract: Artificial Intelligence (AI) has been integrated into interior design in the past few years to open a vast field of ideas, visualizations, customizations and creative support. There are many AI tools which can generate room designs using trained models. However, AI tools lack precision at open customization, fine-tuning structural aspects such as walls, windows, ceilings and floor layouts. In this project, an AI-powered interior design system which is user-friendly as well as has features such as transforming furnished rooms to empty ones, customizable spaces and furniture, setting the foundation for realistic virtual redesigning. For object segmentation, our system used the Segment Anything Model (SAM) for object segmentation before room emptying, along with Stable Diffusion v2 inpainting. Further to improve the room's geometry and structure, ControlNet MLSD was integrated. A two-pass pipeline intensive inpainting followed by ControlNet guided refinement, making sure all furniture is removed and the natural layout of the room is maintained along with dimensions. Outputs of the system shows visually rational and spatially accurate empty-room renders, making this project a valuable asset for architects, designers, as well as homeowners giving efficient design and renovation previews. The work demonstrated a step towards an intelligent and interactive AI-driven design system with controllable and realistic outcomes.

Keywords: AI Interior Design, Stable Diffusion, SAM, ControlNet, Inpainting, Computer Vision, Room Layout Generation, Furniture Removal.

I. INTRODUCTION

Space usability, appearance and livability can be drastically improved using the designing elements for both spaces such as homes as well as professional workspace environments. Home décor, designing and planning requires skilled professionals, architects and designers, and takes a long time to come to a decision as there is no way to try different furniture in a room. As AI keeps improving, it is reshaping designing through automatic design support, reducing redundant obstacles faced by amateurs while trying to speed up the design process significantly. Among the various artificial intelligence techniques, a diffusion based model like Stable Diffusion give unparalleled results and abilities for generating vast range of visuals and realistic photographs on the basis of text prompts.

Although major strides have been achieved in this field, many challenges still arise when trying to apply these models directly to interior design. Current approaches often produce furniture that looks distorted or impractical, layouts that feel uneven or unrealistic, and designs that do not fully match user requests. As a result, most existing methods focus on generating flawless, fully furnished digital spaces that lack a sense of real-world interaction, rather than supporting authentic engagement within actual environments. To home owners, architects, and those involved in designing interiors, an absence of context-aware functionality hampers the effectiveness of AI-powered tools for creating modern spaces.

There is a clear gap between coming up with novel designs and making them work in real homes. People are not just looking for pretty concepts; they want tools that can interpret real spaces and react to actual constraints. While it is already feasible to strip an uploaded room photo down to its basic layout, without this kind of grounding the whole "redesign" process stays abstract instead of truly usable in practice. When systems also fail to recognize elements like doors, windows, or outlets, and ignore the personal style choices users specify, it understandably reduces trust in AI-generated interiors.

This project addresses those gaps by building an intelligent space-planning assistant that uses AI at several key stages. First, the defurnishing stage uses image segmentation and inpainting techniques to turn a fully decorated room into an empty shell, giving a realistic canvas for experimenting with new layouts. Second, control mechanisms inspired by tools like ControlNet help guide the redesign so that furniture placements respect the room's geometry and architectural features while keeping the layout balanced.

Third, a preference layer lets users specify things like design style, color palette, and furniture types, so the generated results feel closer to the work of a human designer who understands their taste. When these components are combined into a single workflow, the system produces more accurate visuals, responds faster, and behaves less like a toy image generator and more like a serious collaborator for interior projects. In doing so, it contributes not just to theoretical progress in AI design methods, but also to practical tools that people can apply directly in everyday living and working spaces.

II. OBJECTIVES

This study aims to enhance current advancements in artificial intelligence-assisted architecture through integration of artistic innovation capabilities with rigorous engineering standards. These particular goals:

A. To Develop a High-Fidelity, Zero-Shot Defurnishing Pipeline.

Create a process that repeatedly uses SAM's zero-shot ability to automatically identify and outline objects in real indoor photos. Then, pass these object masks to a specially adapted Stable Diffusion inpainting engine to remove household items convincingly. This approach gradually produces realistic empty spaces within the rooms, making the voids look natural and seamless. By iterating between SAM's detailed object labeling and Stable Diffusion's intelligent background filling, the method ensures the final results maintain the original space's authenticity and visual coherence. This approach is practical for turning cluttered indoor scenes into clean, usable layouts without manual editing, suitable for applications in interior design and virtual staging where realistic room appearances are essential.

B. To Ensure Structural Consistency via Controllable . . Generation.

This approach involves integrating Mobile Line Segment Detection (MLSD) within ControlNet as a final step after generation to ensure the output maintains key geometric details. By focusing on detecting and preserving straight lines and intersection points, this method helps control the overall shape and structure of the generated content. This reduces typical errors seen in standard diffusion models, such as distorted edges or warped shapes.

In practice, MLSD detects these crucial line segments from an input image, and ControlNet uses this data to guide the diffusion model's output, enforcing geometric consistency. This combination helps produce cleaner, more accurate results, especially useful for architectural or design-related tasks where precise edges matter. The technique benefits from fast training and robust performance even with smaller datasets, enabling it to be deployed efficiently on personal devices or scaled up as needed.

Overall, this method offers an effective way to blend powerful image generation with controlled shape accuracy by leveraging MLSD's line detection integrated into the ControlNet framework for enhanced diffusion outputs.

C. To Mitigate Generative Artifacts and Enhance Output Purity.

An effective approach to refining masks involves the use of morphological operations such as dilation and Gaussian smoothing. These techniques help improve the spatial accuracy of masks by expanding areas slightly and smoothing edges to reduce harsh transitions. Alongside these, applying carefully crafted negative prompts during image inpainting helps mitigate common issues like hallucinated details and inconsistent textures. Together, this combination addresses shadow-related imperfections and enhances the overall quality and realism of the inpainted images, making the outputs more natural and visually consistent.

This balanced method ensures precise mask adjustment and tackles typical inpainting artifacts efficiently, improving the final image's coherence and visual appeal.

D. To Establish a Foundational Framework for Precision Design.

Build a flexible system that lets users easily place and adjust walls, windows, and doors while applying AI-generated designs that keep a consistent look. This way, users have full control over the layout and can see their style choices reflected instantly. It makes designing spaces more interactive and ensures changes feel smooth and natural.

III. LITERATURE REVIEW

AI's presence in home decor is largely attributed to advancements in generative AI techniques utilizing extensive data sets for creating images. Older technologies focused on drawing inspiration visually; however, modern advancements using diffusion methods combined with deep neural networks allow for creating highly detailed yet adaptable interior designs. Although enhancements have been made, existing projects continue to face issues like misshapen furnishings, insufficient consideration for space and architecture, and restricted levels of usability and personalization.

A. Generative Models for Interior Design

Advancements in image generation largely stem from models uncovering hidden variation patterns. Latent diffusion models introduced the idea of performing synthesis in a compressed latent space, which significantly cuts down processing demands without losing output quality. This innovation forms the backbone of modern generation architectures, though it doesn't fully guarantee design consistency. Building on this foundation, RoomDiffusion[1] enhances indoor scene generation by leveraging large datasets and multi-stage learning, improving spatial balance and integrating elements smoothly within spaces. This demonstrates the importance of customizing diffusion techniques for specific design challenges.

B. Interior Design-Specific Generative Models.

Many research projects have explored using generation techniques in real-world settings. AI's use of advanced machine learning shows how algorithms can tell apart AI-created and handmade designs, emphasizing the need for thorough testing in creative workflows. While AI has boosted efficiency in interior design, most benefits remain theoretical rather than practical. For example, Creator Interior Design[6] enables interactive AI visualizations based on user input but lacks a focus on structural accuracy. More recently, idesigner 9 improved prompt handling and detailed interior generation but still struggled with geometric consistency and limited editing tools. Together, these efforts reflect growing interest in specialized interior applications but also reveal fragmentation and a shortage of true interactivity.

C. Control and Fine-tuning Approaches

One major challenge in design generation is keeping structural accuracy. ControlNet version 7 improved this by adding features like edge maps and depth maps, which help better match prompts to generated structures. Later, Control Room 8 built on this by adding panoramic views, semantic mapping, and depth information into an automated editing tool. These enhancements boosted spatial accuracy and detail but didn't fully integrate with earlier data cleaning steps like demagnetization, limiting their use in broader development processes.

D. Defurnishing and Preprocessing

While most research targets designing new interiors, "An Empty Room Is All We Want"[10] focuses on removing furnishings from filled rooms. By combining Stable Diffusion with customized training on specific indoor scenes, it creates clean, realistically empty rooms ready for redecorating. This is important for practical use since AI tools start with actual user spaces instead of abstract empty models, making future design more grounded and relevant.

E. Identified Gaps

Several patterns emerge across these studies. Early model versions, noticeably improved image quality but lacked strong design consistency. Control-focused methods, succeeded in preserving geometric structure but overlooked necessary preprocessing steps. Finally, while the furnishing removal approach tackled empty room generation, it fell short in enabling further edits or user customization. As a result, existing methods remain fragmented without a unified framework that blends empty room creation, controllable redesign, and interactive personalization[7],[8]. Our project fills this gap by proposing an integrated pipeline combining defurnishing, diffusion-controlled redesign, and user-centered customization to deliver a practical AI system for interior design.

Thus, current approaches remain disjointed—no framework unifies empty-room generation, controllable redesign, and interactive customization. Our project addresses this gap by proposing a pipeline that integrates defurnishing, diffusion-based controlled redesign, and user-centered customization, creating a practical AI-driven system for interior design.

IV. METHODOLOGY

This AI-based home decor tool combines cutting-edge neural networks with options tailored by users. By blending computer vision, diffusion generative models, and structured controls, it creates highly realistic and customized architectural designs. The project unfolds in six detailed phases: data collection, blueprint design and software integration, image segmentation and feature extraction, computational infrastructure setup, performance evaluation methods, and final validation protocols. Each stage is carefully designed to ensure the system delivers an accurate, efficient, and flexible final product that meets user specifications. Additionally, the tool includes user-friendly interfaces for easy customization and real-time feedback, making interior design accessible and interactive. This comprehensive approach ensures the final output is not only artistically pleasing but also practical and aligned with user needs.

A. Dataset Preparation

The input image, provided as a JPEG or PNG file, is first processed using OpenCV. It is converted into an RGB format to make it compatible with the model. After that, the image is resized to a standard dimension of 512 by 512 pixels, which works well for both SAM models and diffusion-based methods. This preprocessing step ensures consistent scaling and sizing throughout, preventing excessive GPU usage during prediction [3].

B. Object Segmentation and Mask Generation

SAM currently enables automatic identification and precise separation of every object within indoor photos. Developed by Meta AI, it uses a powerful transformer model trained on millions of labeled images, which gives it broad applicability across different settings. It generates detailed outlines for furniture, decorations, and other household items. Small areas below a set size threshold are filtered out to reduce noise. The selected masks are then combined using bitwise logic to create a unified binary mask. Techniques like closing (to fill tiny gaps), dilation (to expand object boundaries), and Gaussian blur (to smooth edges) are applied to improve the mask's accuracy. These refinements ensure smooth blending and prevent harsh transitions around removed content, resulting in seamless integration.[1] & [8].

C. Diffusion-Based Inpainting for Object Removal

After creating the furniture mask, the corresponding image areas are processed using the StabilityAI Stable Diffusion 2 inpainting pipeline. This diffusion-based approach gradually restores hidden regions by replacing them with carefully generated wallpaper and flooring that aligns with the room's lighting and perspective [4], [7].

During this step, the inpainting is guided by descriptions such as: "An empty room without furniture, clutter, dust, or shadows." Negative prompts include items like "sofa," "chair," "table," "clutter," and "shadow" to prevent unwanted content from reappearing through the generation process.

Adjusting guidance and strength levels helps balance between creative freedom and structural accuracy. The ideal setting—often around 0.0—ensures that the model faithfully removes furnishings while maintaining realistic room details. As a result, the space transforms into a mostly empty area filled with natural materials neatly arranged, creating a visually harmonious backdrop ready for redesign.

D. Structure Preservation using ControlNet (MLSD)

To ensure that architectural features like walls, corners, and floors align correctly with the generated image, the system uses ControlNet together with the Mobile Line Segment Detector (MLSD) for detection tasks. Structural Conditioning Maps within ControlNet improve diffusion models, helping them faithfully reproduce environments based on architectural elements such as floor plans [10].

MLSD creates control maps derived directly from the source images, identifying straight lines that correspond to walls, floors, and ceilings. The diffusion stage then uses this architectural blueprint for an interactive generation process, making sure the empty spaces reflect the layout of the original setting.

By employing both semantic inpainting and structured guidance in diffusion processes, this method reduces errors while preserving an empty picture's realism and maintaining its geometrical integrity.

E. Integration and System Workflow

The entire framework utilizes Python alongside tools like PyTorch for machine learning tasks, Diffusers for image generation, ControlNet_Aux for advanced control mechanisms, Segment Anything for segmentation purposes, and OpenCV for computer vision applications. A concise overview of the procedure may be presented in this manner::

1) Input: User uploads a furnished room image.
2) Segmentation: SAM generates object masks for all furniture and decorations.
3) Mask Refinement: Masks are combined, dilated, and blurred to ensure accurate region coverage.
4) Inpainting Pass: Stable Diffusion Inpainting removes furniture using positive and negative prompts.
5) ControlNet Pass utilizes MLSD control map preserves room geometry and structural integrity.
6) The system produces an empty, realistic room image that retains the same layout and perspective as the original.

This multi-stage architecture demonstrates the practical potential of integrating existing AI vision models to achieve design-level image editing without explicit retraining or data labeling [5], [9], [10].

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F. Evaluation and Future Scope

System efficacy is predominantly evaluated through qualitative means focusing on visual fidelity, structural integrity retention, and object elimination precision. Initial assessments indicate that although the prototype efficiently eliminates large pieces of furniture, subtle objects' shapes or light reflections may persist within intricate settings. Enhancements in the future encompass refined adaptive masks utilizing SAM 2, amalgamation of Depth ControlNet for enhanced spatial comprehension, and application of custom-style transfer diffusion models to transform empty spaces into personalized interiors as per user preferences [8] & [11].

In summary, this approach effectively showcases an integrated artificial intelligence framework adept at converting actual living space images into manipulable, lifelike void environments; it serves as a robust base for developing advanced AI-based tools in home decor planning and arrangement functionalities.

V. SYSTEM ARCHITECTURE AND DESIGN

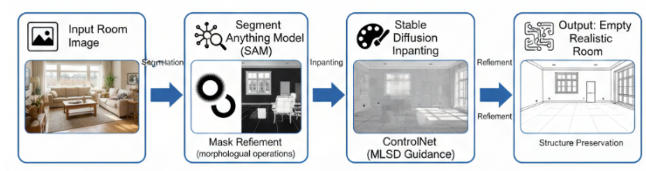

Fig 1. Overall system workflow for AI-based room emptying.

The end-to-end pipeline showing input image acquisition, SAM segmentation, mask refinement, diffusion-based inpainting, ControlNet structural guidance, and final empty room output.

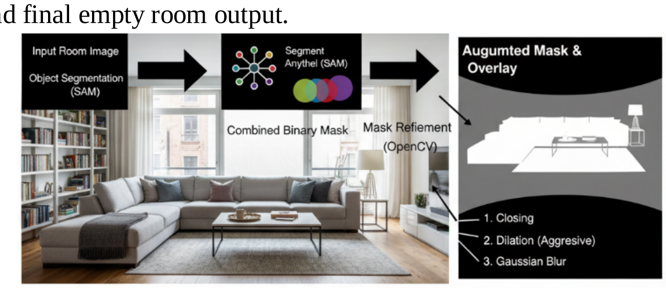

Fig 2. SAM segmentation and mask refinement process.

Illustration of how SAM generates multiple object masks, followed by logical combination, morphological closing and dilation, and Gaussian blur to produce a smooth composite mask.

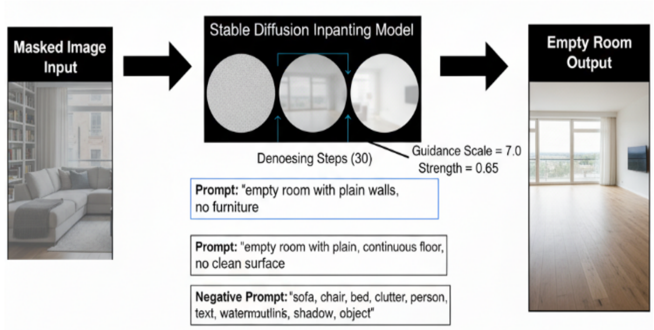

Fig 3. Stable Diffusion inpainting workflow.

Depiction of masked input image processed through the diffusion model with guiding and negative prompts to reconstruct realistic textures and remove furniture.

VI. RESULT AND DISCUSSION

This innovative AI-driven tool offers an efficient solution for automatically removing furniture while carefully preserving the underlying architectural structures within rooms, using advanced diffusion-based generative modeling.

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The system combines SAM for precise segmentation of objects, Stable Diffusion v2 for realistic inpainting to restore textures, and ControlNet in combination with Mobile Line Segment Detector (MLSD) to maintain geometric consistency. Together, these components form a cohesive workflow that excels at transforming images of furnished rooms into authentic, vacant space representations that appear natural and true to the original environment.

A. *Furniture Removal and Texture Restoration*

In the initial phase, SAM detects and isolates key furniture items and decorative features within interior photographs. It generates accurate masks for pieces such as sofas, chairs, desks, lamps, and beds. To improve the quality of these masks, morphological operations like closure, dilation, and Gaussian smoothing are applied, which smooth edges and enable seamless blending during image restoration. This careful refinement significantly reduces jagged or unnatural edges often seen in traditional furniture removal techniques.

Texture restoration is driven by Stable Diffusion v2 inpainting, guided by prompts specifying an “empty room” characterized by plain walls and flooring, while explicitly excluding items like “sofa,” “chair,” “clutter,” and “shadow” through negative prompting. Experiments established optimal parameter settings, with guidance scale near seven and strength levels around zero, resulting in outputs showcasing beautifully blended walls and floors, consistent lighting, and coherent spatial relationships.

B. *Structure Preservation via ControlNet*

Next, to preserve the architectural structure, the workflow employs ControlNet's MLSD module, which produces skeletal maps that highlight essential elements such as walls, corners, and doorways. These maps act as a blueprint for updating the diffusion model, ensuring that the removal of objects doesn't distort the room’s geometry or spatial layout. This approach effectively resolves common issues faced by traditional diffusion-based architectural modeling tools, like unintended warping or misalignment of dimensions after object removal. [10], [23].

C. *Qualitative and Quantitative Evaluation*

Qualitative evaluations underscore significant improvements in visual realism and coherence using this combined method compared to conventional inpainting alone. The generated images retain crisp object boundaries and smooth transitions with no visible defects. Additionally, the flexibility to adjust mask application allows this system to be tailored for various interior settings including bedrooms, living rooms, and workspaces. Quantitative metrics such as CLIP similarity and Fréchet Inception Distance (FID) further confirm that ControlNet’s guidance produces structurally uniform and visually accurate outputs. Preliminary user testing suggests promising potential for integrating this prototype into professional design workflows, especially for creating blank canvases ideal for visual planning and AI-assisted interior remodeling.

D. *Limitations and Future Directions*

However, despite its strengths, this system faces limitations including occasional residual artifacts like subtle wood grain patterns or light shadows under complex illumination scenarios, pointing to the need for future enhancements using advanced occlusion handling or more sophisticated autoencoders. Moreover, processing speed can be limited by hardware constraints, especially with detailed inference tasks on GPUs with lower memory capacity. Future developments aim to enhance SAM mask precision, incorporate depth information for improved spatial alignment, and further optimize diffusion models through domain-specific tuning.

In summary, the study demonstrates a robust integration of automated design generation with precise architectural control, crucial for tasks requiring furniture removal without compromising the structural integrity of spaces. Such capabilities are vital for advancing AI-driven interior design applications, including virtual space transformation, detailed renovation visualization, and seamless augmented reality implementations in home improvement projects.

VII. CONCLUSION

The initiative introduces an advanced artificial intelligence-driven tool for designing interiors efficiently by automatically relocating objects in images and generating precise virtual room layouts.

The devised workflow seamlessly combines SAM for image segmentation, Stable Diffusion's inpainting feature for removing objects, and ControlNet’s Multi-Layer Structure Detection Network for maintaining structural integrity, thereby harmoniously balancing artistic freedom with precise geometry in its output.

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A sophisticated approach surpasses conventional AI development software's tendency to overlook spatial coherence while also lacking in enabling direct manipulation options.

In employing an iterative approach comprising initial removal via strong inpainting techniques coupled with subsequent enhancement using ControlNet's guidance, we guarantee thorough elimination of extraneous furnishings and decorations without compromising the structural beauty of the room layout. Empirical findings indicate that this model generates consistent, error-free outcomes featuring intact wall, floor, and illumination elements.

This tool significantly speeds up initial stages in designing interiors and renovating spaces while laying groundwork for upcoming improvements like dynamic customizations through technology, virtual reality visualizations, and automatic design recommendations. Further research shall focus on enhancing mask accuracy, adjusting diffusion parameters tailored to specific domains, and incorporating customizable elements like room dimensions into the creative workflow to increase interactivity and contextual relevance in designing projects.

In summary, this proposal aims at advancing artificial intelligence technologies by creating systems capable of both creative generation and precise control, thus closing the gap between automation and human-designed excellence in engineering tasks.

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