AI-Driven Diffusion and LoRA Models for customizable 3D Room Visualization and Design Enhancement

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Introduction

Existing 3D design tools lack real-time customization and are not user-friendly. This project uses **Diffusion Models** for room generation and **LoRA** for interactive refinement, enabling intuitive, multimodal 3D room design from text, sketches, or mood boards.Previous tools focused on static AR/VR visualizations but lacked real-time customization and support for multimodal user input—key gaps this project addresses.

Motivation

To make 3D room design faster, more intuitive, and accessible by replacing complex tools with an AI-driven system that supports real-time, personalized customization.

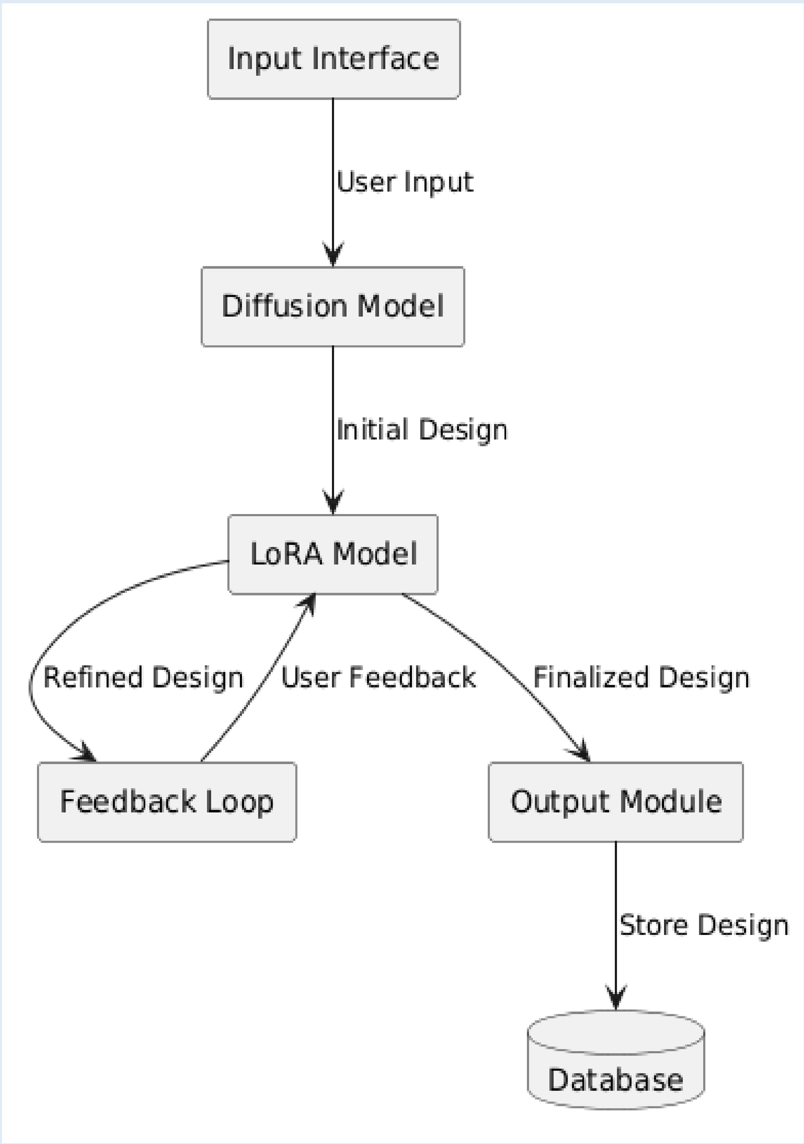
Scope of the Project

An AI-powered 3D modeling tool designed for ease of use and accessibility.
Key Features:

- Text, sketch & mood board input
- Diffusion & LoRA models for design & customization
- Photorealistic 3D output with iterative feedback
  Tech: PyTorch-based, optimized for performance
  Deliverables: Prototype, docs, performance report, future roadmap
  Not Included: CAD integration, full-scale architecture, real-time VR

Aiming to make 3D interior design intuitive and accessible for all.

Methodology



System Architecture of the AI-Driven 3D Modeling Tool

This project implements a modular, AI-driven pipeline for generating and customizing 3D room visualizations based on multimodal user inputs.

1. Input Acquisition

The system accepts:

•**Textual descriptions** processed via NLP to extract design semantics.

•**Sketches**, analyzed using OpenCV for spatial structure detection.

•**Mood boards**, evaluated using CNN-based feature extraction to infer stylistic themes.

2. Diffusion-Based 3D Generation

A pretrained **diffusion model** converts structured input into a preliminary 3D room layout. This includes basic architectural components, textures, and furniture placement, synthesized through iterative denoising.

3. LoRA-Based Customization

The **Low-Rank Adaptation (LoRA) module** allows real-time, user-driven modifications such as furniture replacement, material changes, or lighting adjustments. This process is non-destructive and preserves design context.

4. Iterative Refinement

User feedback is integrated through an iterative loop, enabling granular control and progressive enhancement of the 3D output. This supports adaptive co-creation and design personalization.

5. Rendering & Output

Finalized scenes are rendered photorealistically using high-resolution visualization techniques. Outputs are exportable in common formats (e.g., PNG, FBX) for integration with external tools or presentations.

Results

1. Design Quality (DQ)

Users evaluated the generated 3D room layouts based on realism, spatial coherence, and aesthetic alignment with input prompts.

- Average User Rating: 9.2 / 10
- Users highlighted strengths such as:
  - Lighting realism
  - Accurate material rendering
  - Consistency of spatial layout

The architectural coherence, including logical furniture placement, proportional room dimensions, and natural traffic flow, contributed to the realism and usability of the outputs.

2. Customization Accuracy (CA)

Customization accuracy was assessed by comparing user-specified modifications with the system's updates.

- Accuracy Score: 96%
- Customization types tested:
  - Furniture repositioning
  - Color and material updates
  - Lighting adjustments

The system successfully applied changes without regenerating the entire scene and preserved unrelated design elements.

3. Performance

Performance was measured through generation and refinement times across various hardware configurations.

- Initial Layout Generation: ~10 seconds
- Iterative Refinement: < 5 seconds

These results validated the system's capability for real-time interaction while maintaining design quality.

4. User Experience and Satisfaction

Usability testing showed high satisfaction across multiple parameters:

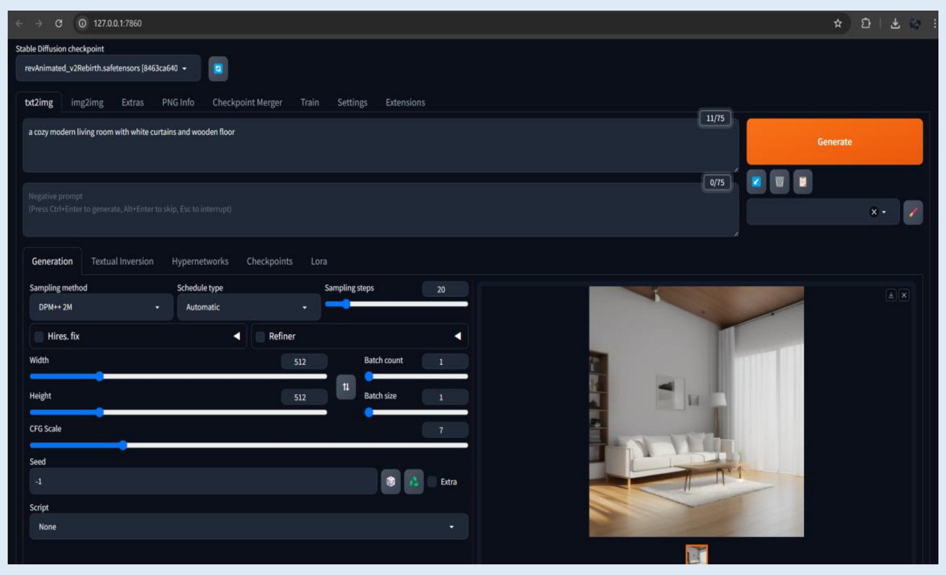
- Ease of input through text, sketch, and mood boards
- Real-time feedback loop supported by LoRA
- Positive reception among both professionals and non-professionals

Qualitative feedback affirmed the system's intuitive design and ability to translate user vision into photorealistic outputs.

Sample Outputs from Project Demonstration

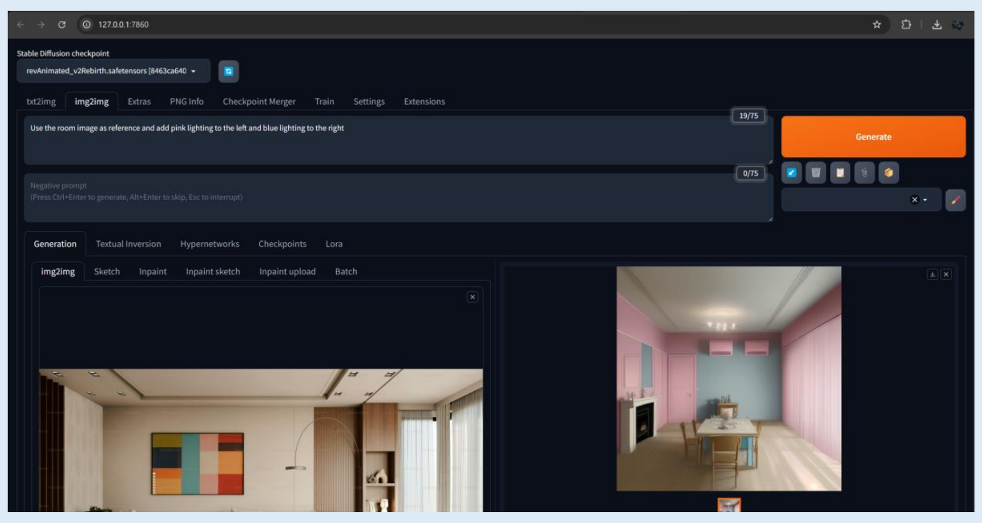
1. Text-to-Image (txt2img)

Prompt: *"A cozy modern living room with white curtains and wooden floor"*



Screenshot of the Web UI with text prompt and resulting image shown in txt2img tab.

2. Image-to-Image (img2img)



Screenshot of the img2img tab with input image and generated output

Conclusion

Our AI-powered system successfully bridges creativity and technology—delivering fast, realistic, and user-customizable 3D room designs from simple text or sketches.
With **96% customization accuracy** and **9.2/10 design satisfaction**, the results strongly validate our approach.

Future scope includes immersive VR integration, voice/gesture input, and real-time collaboration—paving the way for smarter, more inclusive spatial design experiences.

References

1.Patel, R., & Mandekar, A. (2024). *Augmented Reality in Interior Design: Enhancing Client Engagement Through Real-Time Visualization*. International Journal of AR Applications.
2.Dunston, P. S., Arns, L. L., McGlothlin, J. D., Lasker, G. C., & Kushner, A. G. (2011). *An Immersive Virtual Reality Mock-Up for Design Review of Hospital Patient Rooms*. Journal of Building Performance Simulation, 4(3).