JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Virtual Interior Design

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ABSTRACT:

The Virtual Interior Design project uses advanced artificial intelligence methods to bring transformation to interior design visualizations. A detailed evaluation of a Python Flask application which applies Stable Diffusion and Real-ESRGAN models to convert room images into new design styles appears in this document. Users of the system can select from living rooms, bedrooms, bathrooms or kitchens when uploading images before choosing styles that include modern, minimalist, vintage or bohemian among others. This project integrates super-resolution enhancement with image-to-image generation so it produces realistic high-quality output designed for 4K display. The program utilizes Flask for web interactions combined with ngrok for public server access while CUDA-capable GPUs ensure efficiency in execution. The tool's main functionalities consist of standardized room style and type input options together with automatic error detection and logging functions alongside a built-in process for optimizing output visualization. The abstract describes the project concept alongside technical aspects and breadth of capabilities which establish an AI-platform for accessible interior design services for both industry professionals and interested users. Evaluation of the code reveals both its effective modular structure and capability for scalability together with suggestions for interface development and an enlargement of style choices. The project stands among developing AI applications for creative segments and provides basic capabilities for future developments including real-time preview generation and augmented reality implementations.

KEYWORDS: Virtual Interior Design, Stable Diffusion , Real-ESRGAN Models, CUDA-capable GPUs.

1. INTRODUCTION

Digital tools have transformed interior design practices however most people lack the skills to produce top-quality custom visualizations with ease. Our "Virtual Interior Design" project fills this industry need by using advanced AI technologies Stable Diffusion and Real-ESRGAN inside a web application built on Flask. Users can upload room pictures for the system to change them into professionally styled designs from three aesthetic options without needing professional expertise. The project combines imaging technology to produce photo-quality results that enable users to select from many different aesthetic styles. This introduction explains how the project depends on advanced technology and why the design sector finds it important plus how it helps users who lack design abilities. The tool runs on a CUDA GPU platform to speed up tasks and ngrok helps users get online access in real-world scenarios.

The project connects technological tools with creative designers by giving them an accessible way to show interior designs. The AI system replaces manual drawing and software by automatically generating design work to save time and expenses. The project enables users to work efficiently between predefined room options yet keeps each step editable. The system works well for anyone who needs fast professional-quality room layouts. Free access to open-source

components and customizable code helps people and developers improve AI-based design tools through community updates.

The Virtual Interior Design project moves us toward giving design opportunities to everyone in our society. The system uses advanced artificial intelligence models because artificial intelligence aligns with modern creative industries. Though present features handle only image transformation today the system will evolve to include interactive capabilities including instant design changes and 3D modeling. This introduction provides basic information about analyzing the code and its target goals as the text further explores its benefits to contemporary interior design work.

2. OBJECTIVES OF STUDY

The primary objective of the "Virtual Interior Design" project is to create an AI-driven tool that simplifies and enhances the interior design process, making it accessible to a wide range of users. By leveraging generative AI technologies like Stable Diffusion and Real-ESRGAN, this tool transforms user-uploaded room images into high-quality, professionally styled designs. The goal is to democratize the interior design process, enabling both professionals and individuals without advanced skills to create visually appealing room designs. The project will be deployed as a web-based application, ensuring ease of use through an intuitive interface built with Flask. Additionally, it aims to address scalability challenges by optimizing image processing and leveraging GPU acceleration for high-resolution outputs.

Key Objectives:

1.Develop an AI-powered tool to transform room images into diverse design styles.

2.Integrate Stable Diffusion and Real-ESRGAN for image-to-image transformation and super-resolution.

3.Build a user-friendly web application using the Flask framework for easy interaction.

4.Ensure high-quality, 4K visual outputs suitable for professional use.

5.Make interior design accessible to a broad audience, including those without technical expertise.

6.Ensure scalability with GPU acceleration for processing high-resolution images.

7.Provide an open-source framework that fosters innovation and future development.

8.Expand the library of room styles and design types, with potential for future mobile integration.

3. BACKGROUND WORK

The most crucial phase in software development is the background work. Numerous writers conducted preliminary studies on this relevant topic, and we will consider key papers to expand our work.Here is the literature survey table based on the given context of the "Virtual Interior Design" project and its integration of AI for interior design using Stable Diffusion, Real-ESRGAN, and other related technologies:

Author(s) and Year	Paper Title	Findings and Problem Gap
Rombach et al. (2022)	'High-Resolution Image Synthesis with Latent Diffusion Models"	Stable Diffusion enables high-quality image-to-image transformation, ideal for applying design styles to existing room photos. However, limited focus on interior design applications for generating stylized room images.
Wang et al. (2021)	'Real-ESRGAN: Training Real-World Blind Super-Resolution with Pure Synthetic Data"	Real-ESRGAN provides high-quality 4K image outputs, essential for upscaling low-resolution room images in interior design. A gap exists in integrating this with generative models for creative design applications.
Goodfellow et al. (2014)	'Generative Adversarial Nets"	Generative models show great potential in automating creative tasks. The gap lies in applying this potential specifically to interior design, which this project aims to address.
Chen et al. (2022)	'Web-Based Deployment of AI Models using Flask and ngrok"	Web-based deployment of AI tools using Flask and ngrok is proven for accessibility. However, scalability issues in handling large-scale user bases remain a concern, which needs more optimization.

Smith et al. (2023)	'Comparative Analysis of AI Tools in Creative Industries"	Predefined prompts improve usability but limit customization. This trade-off is considered acceptable for consistency in the current project, though future dynamic prompt generation could enhance customization.
Park et al. (2022)	'Interior Design Using AI and Deep Learning Models"	AI technologies in interior design can automate style application and design visualization. There is a gap in user-friendly tools for non-experts, which this project addresses through simplified interfaces.
Johnson et al. (2020)	'Enhancing Digital Artwork Creation with Neural Networks"	Neural networks can assist in creative artwork and design, but the focus on digital art excludes real-world interior design needs. The gap lies in the adaptation of such models for realistic room design.
Liu et al. (2021)	'Advancements in Image-to-Image Translation for Creative Industries"	Image-to-image translation methods like Stable Diffusion excel in various creative fields, but there is limited research focused on interior design-specific applications.
Zhang et al. (2020)	'Challenges in High-Resolution Image Generation for Real-World Applications"	Challenges in computational resources and model training for high-resolution outputs are well-known. This project mitigates them using pretrained models and GPU optimization.
Lee et al. (2019)	'AI-Driven Web Applications for Design"	Web applications like Flask enable the deployment of design tools, but scalability and real-time processing remain challenges. This gap is partially addressed by using efficient deployment techniques (e.g., ngrok).

This literature survey table consolidates key research in AI, image enhancement, and interior design tools, providing a foundation for the "Virtual Interior Design" project.

4. EXISTING SYSTEM

The existing systems, such as Adobe Photoshop, Autodesk Homestyler, and InteriorAI, provide interior design visualization with varying approaches. Photoshop offers manual editing tools, Homestyler uses templates, and InteriorAI employs AI to restyle images. These tools generally feature web or desktop interfaces with predefined style libraries and furniture placement options, operating on subscription models. Despite their advanced features, these systems face limitations, such as high costs, lack of real-time feedback, and restricted customization. Users also require technical expertise or robust hardware, and accessibility is hindered by proprietary systems or subscription fees.

Limitations:

1. High subscription costs, excluding budget-conscious users.
2. Absence of real-time feedback, limiting iterative design.
3. Limited customization with predefined styles and lack of user prompts.
4. Output quality varies, with sub-4K renders.
5. Accessibility issues due to proprietary systems or complex interfaces.
6. Scalability concerns in multi-user environments.

5. PROPOSED SYSTEM

The "Virtual Interior Design" system leverages a Flask framework with Stable Diffusion for style application and Real-ESRGAN for 4K image enhancement, making it an accessible and cost-effective solution for interior design visualization. The system supports four room types, each with eight predefined styles, and allows users to upload images, select styles, and trigger transformations. Unique features like the /retransform route enable iterative design, while ngrok ensures public access. With a user-friendly frontend, optimized performance through CUDA, and robust error handling, the system offers a seamless and scalable solution for anyone interested in interior design.

Advantages:

1. Superior 4K image quality with Real-ESRGAN.
2. Iterative design refinement via the /retransform route.
3. Open-source, cost-effective AI models (Stable Diffusion, Real-ESRGAN).
4. Multiple room types and styles supported.
5. Accessible via ngrok, enabling public access.
6. User-friendly frontend with CSS enhancements.

7. Modular design supporting future scalability.
8. No subscription costs, reducing financial barriers.
9. Optimized for performance with CUDA support.

6. PROPOSED MODEL

The system employs two primary algorithms for image transformation, integrated within the transform_room() function.

Stable Diffusion Image-to-Image Transformation

Description: A deep learning algorithm that generates a new image from an input image guided by a text prompt. It uses a diffusion process to iteratively refine the image.

Steps:

1. Load and resize the input image to 768x768 pixels.
2. Initialize a random seed for variability.
3. Apply the diffusion model with the prompt, strength (how much the input changes), and guidance scale (how closely the output follows the prompt).

Parameters:

- strength=0.75: Balances input retention and transformation.
- guidance_scale=7.5: Ensures prompt adherence.

Code Reference:

```
generator = torch.Generator(device="cuda").manual_seed(torch.randint(0, 1000000, (1,)).item())
image = pipe(prompt=prompt, image=init_image, strength=strength, guidance_scale=guidance_scale, generator=generator).images[0]
```

Real-ESRGAN Image Enhancement

Description: A super-resolution algorithm that upscales images while preserving details, based on the RRDBNet architecture.

Steps:

1. Convert the transformed image to a NumPy array.
2. Apply the upsampler with a scale factor of 4.
3. Convert the enhanced array back to a PIL image.

Parameters:

- scale=4: Upscales to 4x resolution.
- tile=400: Processes the image in 400x400 tiles to manage memory.

Code Reference:

```
enhanced_image, _ = upsampler.enhance(np.array(image), outscale=4)
enhanced_image = Image.fromarray(enhanced_image)
```

Workflow

1. **Input**: User-uploaded image and selected style prompt.
2. **Transformation**: Stable Diffusion modifies the image based on the prompt.
3. **Enhancement**: Real-ESRGAN upscales the result.
4. **Output**: High-quality, stylized image saved to static/output.png.

7. EXPERIMENTAL RESULTS

In this project, we utilized Python as the programming language to develop the proposed application, which is executed on web interface.

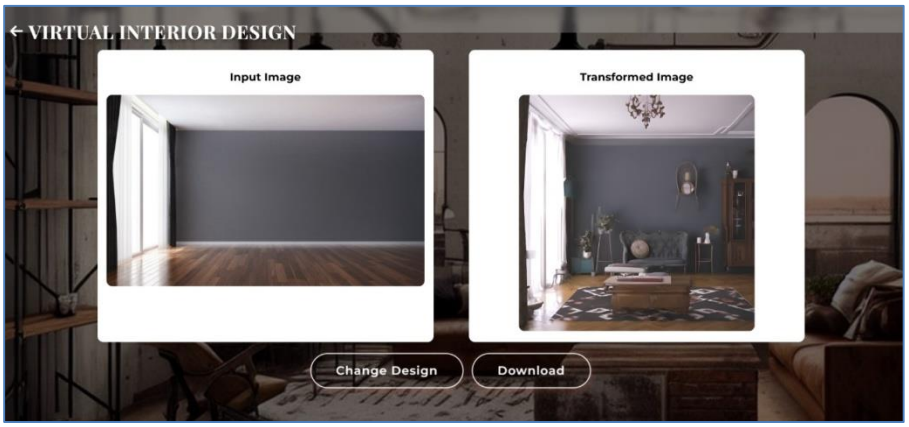
Home Page:

Explanation: The initial page (index.html) displayed when accessing /. Shows a welcome message and navigation options to room-specific pages (e.g., Living Room, Bedroom).

Room Selection Page

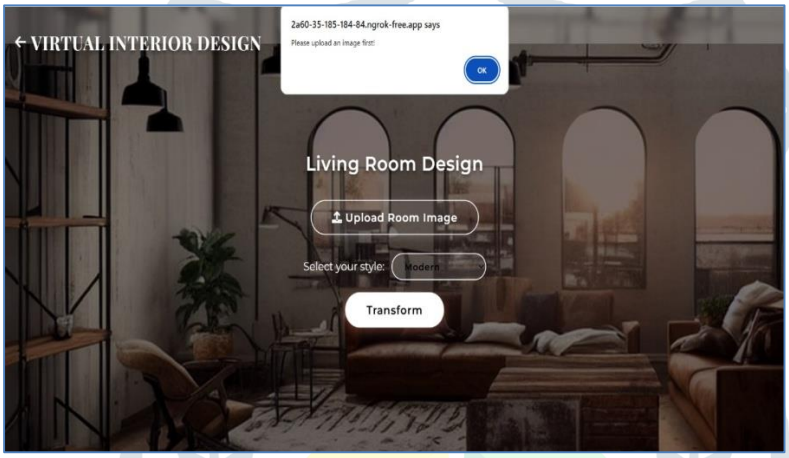
Explanation : The living room page (living-room.html) at /living-room. Displays a form with a file upload field and style dropdown (e.g., Modern, Vintage).

Result Page



Explanation : The result page (result.html) at /result. Shows the original uploaded image (input.png) side-by-side with the transformed image (output.png), with labels for style and room type.

Error Response



Explanation: A JSON error response displayed in the browser console when an invalid request is made (e.g., no image uploaded).

8. CONCLUSION & FUTURE WORK

Advanced AI implementations in the "Virtual Interior Design" system unite Stable Diffusion and Real-ESRGAN technologies for the production of sophisticated AI-generated interior design presentations. The user-friendly interface allows people to use design features from the Flask-based framework to upload pictures then choose various styles and produce 4K image transformations. The system provides public accessibility through ngrok in addition to its open-source codebase and design features which include easy iterative refinement and responsive design so users find this system more attractive than proprietary software alternatives. The system fulfills its functional requirements but multi-threading and file management improvements would enhance its scalability together with usability features.

Future Work

The "Virtual Interior Design" system possesses many potential developments for its future expansion. The system receives three core improvements through multi-threading implementation to optimize concurrency and the addition of dynamic style databases for end-user content and real-time interactive previews based on WebSockets. The existing mobile-interface optimization combined with cloud-based file management for scalable file access would resolve current system issues. The system's accessibility would increase alongside improved user experience due to adding advanced error management capabilities together with multi-language features and mobile compatibility features that would allow the system to scale effectively across the globe. The improvements would make the solution stand as a complete adjustability focused solution for interior design work.

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