Majumdar, R. et al. (Eds.) (2025). Proceedings of the 1st International Conference on Learning Evidence and Analytics. Asia-Pacific Society for Computers in Education

Human-AI Co-Creation for Interior Design: Integrating Scene Graphs, Diffusion Models, and Lighting Transfer

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Abstract: The interior design process is often complex and time-consuming, posing significant challenges for designers. To address this issue, this study proposes an AI-assisted design platform that integrates Large Language Models (LLMs), ControlNet, and Diffusion Models, while incorporating the LumiNet model to enhance the realism and consistency of lighting in generated interior design images. The platform architecture is grounded in the Double Diamond design thinking framework, following four key stages: problem discovery, requirement definition, idea development, and prototype testing. This approach aims to significantly improve both the efficiency and creativity of the interior design process.
An interactive prototype platform was developed, enabling designers to generate design drafts and photorealistic images with realistic lighting by simply inputting spatial layout images and style preferences. By utilizing prompts, designers can quickly adjust object relationships and obtain outputs that align with their expectations. The usability and user experience of the platform were evaluated through practical testing conducted by professional interior designers. The evaluation employed the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ) to assess the platform's practical effectiveness and application potential.

Keywords: Interior Design, Generative Artificial Intelligence, Diffusion model, Design Thinking, System Usability Scale (SUS), User Experience Questionnaire (UEQ)

1. Introduction

Generative Artificial Intelligence (AI) technologies are significantly reshaping interior design processes, traditionally reliant on manual sketches, intuition, and extensive communication between designers and clients (Zhang et al., 2024). Recent advancements, including ControlNet and LumiNet, have enhanced the precision and visual realism of AI-generated images, yet there remains limited seamless integration into designers' actual workflows (Chen et al., 2025). This research aims to bridge this gap by introducing a collaborative human-AI platform structured around the Double Diamond framework, emphasizing both creativity and efficiency enhancement during the interior design process.

2. Related Work

This study integrates recent advances in generative AI across three key areas: text-to-image generation, indoor lighting control, and human-AI collaborative design. Text-to-image models like DALL·E 2, Stable Diffusion, and Imagen enable high-quality synthesis, while models such as LFR-GAN and RaT2IGen improve spatial and semantic alignment. For lighting generation, methods like LightIt and Intrinsic Image Diffusion achieve more precise control through geometry and material-light separation. In design collaboration, multimodal interaction and participatory approaches have been shown to enhance usability and real-world adoption. Building on these developments, the proposed platform combines scene graph editing, diffusion-based generation, and lighting transfer to support a user-centered, AI-augmented design workflow.

3. Methods

This study employs a mixed-methods approach based on the Double Diamond design model, combining user research, AI system development, and usability testing. Interviews with four interior designers identified key early-stage design challenges, such as inefficient sketching and poor lighting simulation, which shaped the platform's feature requirements. The prototype, initially built in Figma and refined with expert input, supports semantic scene editing, structural image input, style prompts, rapid sketching, and lighting transformation. The system integrates three AI modules: SGEdit for scene graph-based semantic editing, ControlNet for structure-preserving sketch generation, and LumiNet for realistic lighting transfer. Usability was evaluated through designer-led tasks using SUS and UEQ metrics, along with qualitative feedback for iterative improvement.

4. Expected Outcomes

This study aims to develop an AI-assisted interior design platform that leverages LLMs, SGEdit, ControlNet, and LumiNet to support tasks like spatial layout, style exploration, and lighting simulation. By combining semantic scene editing and prompting, the system enhances user control and design flexibility. LumiNet adds realistic lighting transfer for improved visual accuracy. The platform is expected to boost design efficiency and creativity. Usability will be evaluated through expert testing using SUS and UEQ, generating both quantitative and qualitative feedback for further refinement.

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