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Daejeon, Korea

Sketch-to-Architecture: Generative AI-aided Architectural Design

Pengzhi Li[1] , Baijuan Li[2] and Zhiheng Li[1]

1. Shenzhen International Graduate School, Tsinghua University, Shenzhen, China

2. Shenzhen University, Shenzhen, China

ABSTRACT

Recently, the development of large-scale models has paved the way for various interdisciplinary research, including architecture. By using generative AI, we present a novel workflow that utilizes AI models to generate conceptual floorplans and 3D models from simple sketches, enabling rapid ideation and controlled generation of architectural renderings based on textual descriptions. Our work demonstrates the potential of generative AI in the architectural design process, pointing towards a new direction of computer-aided architectural design.

INTRODUCTION

Figure 1. We explore how generative AI technology can be effectively utilized in the early phases of architectural design.

In this paper, as shown in Figure 1, we present a comprehensive workflow for the preliminary stages of architectural design that has not been explored previously. We explore how generative AI technology can be effectively utilized in the early phases of architectural design to generate conceptual plans and 3D models based on initial sketches. By leveraging this information, we can rapidly conceive and develop creative ideas. Additionally, we employ text-to-image generation techniques to achieve controlled generation and editing of architectural rendering images. Throughout our entire system, we can generate a range of visual cues, including architectural plans, elevations, handcrafted model, and architectural renderings, which serves as a wealth of inspiration and provide architects with many creative prompts. Our approach significantly reduces the time required for the initial stages of architectural design while offering boundless possibilities for designers' creativity. To the best of our knowledge, this is the first systematic presentation of a complete generative AI-guided workflow for the preliminary stages of architectural design. Our study reshapes the architectural design process and suggests new directions for the advancement of architectural design by state-of-the-art computer technology.

METHODOLOGY

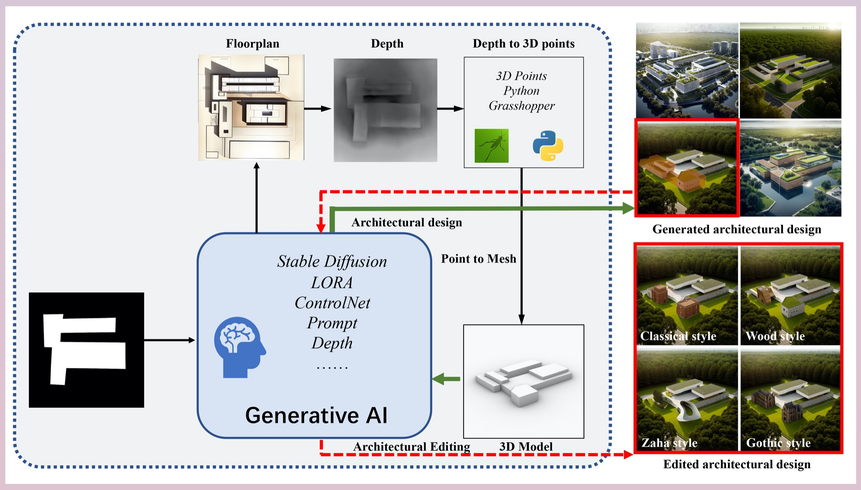

Figure 2. We present the workflow of AI-generated architectural design.

The overall workflow is described in Figure 2, our approach is based on the state-of-the-art Stable Diffusion model and involves fine-tuning it for different design tasks. To achieve this, we collect numerous images of architectural floorplans encompassing various categories, such as residential, commercial, and museum designs. We utilize different kinds of floorplan data for fine-tuning the LoRA model, specifically adapted to different types of architectural design tasks. LoRA injects trainable layers into each transformer block instead of using pre-trained model weights, significantly reducing the number of trainable parameters and resulting in faster computation and lower computational requirements while achieving comparable results to those obtained by fine-tuning the entire large model. Additionally, we incorporate the recently ControlNet model to achieve more precise control in generating floorplans with the diffusion model.

RESULTS

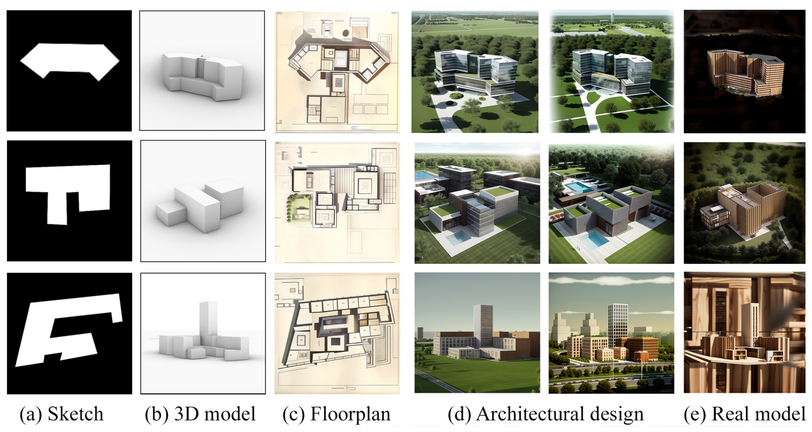

Figure 3. We generate floorplans and architectural 3D massing models based on the sketches. Then, we employ the generated massing models to achieve the end-to-end generation of architectural renderings. This process is controlled by fine-tuned models and textual descriptions, allowing us to integrate various design requirements and obtain the desired preliminary architectural design results.

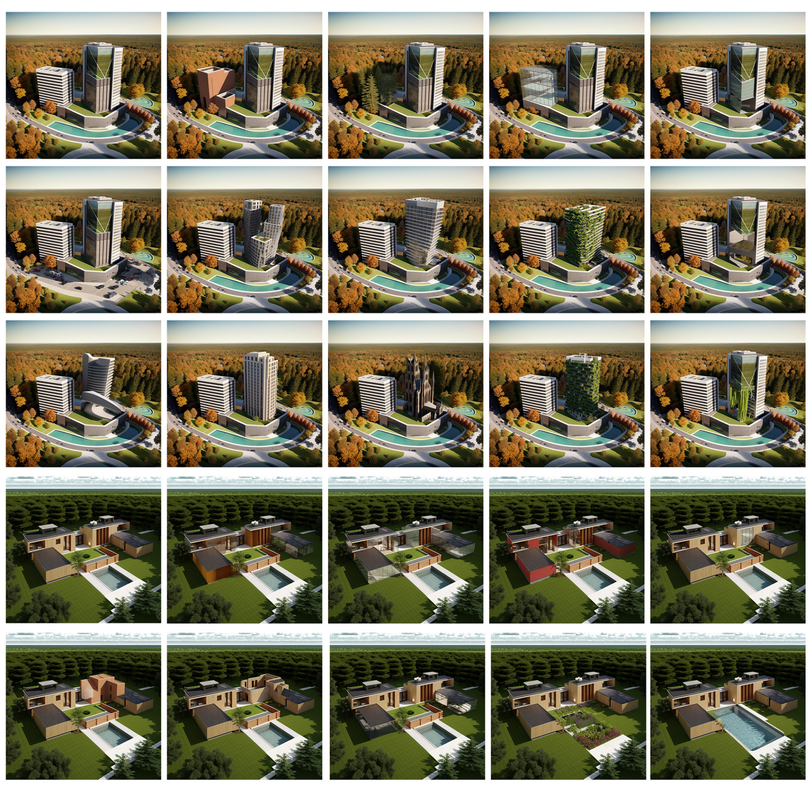

Figure 5. We show some of the most critical terms in architectural design, covering various architectural styles, architectural types, architectural materials, architectural landscape and architectural renderings. These terms then convert to textual descriptions.

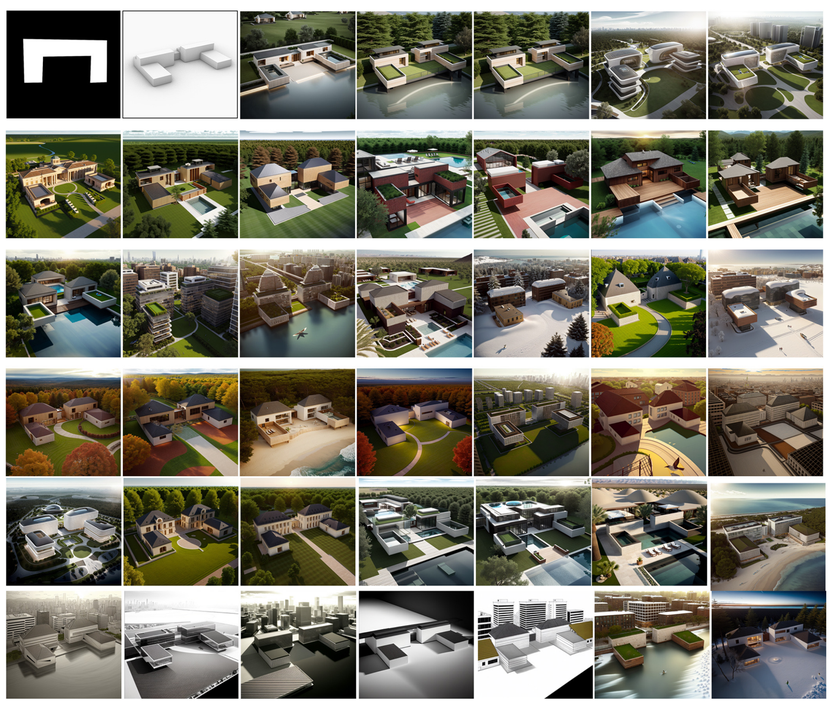

Figure 4. We first extract core terms from conceptual architectural design, which are crucial in determining the final architectural design. The core elements are in Figure 5. Our method revolves around this series of design elements. Our method still employs the fine-tuning approach of the diffusion model, utilizing the simultaneous input of text and images to generate entirely many new results that align with specific core elements.

Figure 6. The visualization results of architectural editing. By utilizing masks, specific regions of the generated building are modified. we extensively explore local architectural design edits based on the architectural terms discussed earlier. Our approach allows desired modifications to specific elements while preserving the rest of the architectural rendering unchanged.

清華大學 Tsinghua University

深圳大學 SHENZHEN UNIVERSITY