Training and Generating Apartment Plan Graphic Images for Commercial Uses

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Abstract –

This paper introduces a methodology utilizing image generation AI to create 3D floor plan images for Korean-style apartments. The growing interest in spatial dynamics, driven by changes in residential preferences, has elevated the importance of widespread comprehension and the demand for floor plans. Specifically, apartment floor plans, crucial for commercial purposes, require visually compelling representations that are both diverse and detailed yet easily comprehensible. Traditional 2D floor plans face limitations in public understanding due to the use of architectural terminology and specialized symbols. As an alternative, 3D floor plan images offer a comprehensive understanding of three-dimensional structures and arrangements, with potential applications across various commercial sectors. The recent emergence of image generation AI presents opportunities for the automated creation and alteration of architectural images. Fine-tuning the generated results can be achieved through detailed prompt settings and additional training techniques. The methodology for constructing a 3D floor plan image generation model for Korean-style apartments involves: 1. Creating a 3D Building Information Modeling (BIM) model based on Korean-style apartment floor plans and extracting 3D floor plan images based on different areas. 2. Training the floor plan image generation AI model by combining the extracted images with text and utilizing the trained model to automatically generate 3D floor plan images. The resulting images can find applications not only in architecture but also in real estate, design, advertising, and other diverse commercial fields. This approach suggests the potential development of a versatile model applicable across various domains, especially when integrated with generative models.

Keywords –

Architectural Visualization, 3D Floor Plan, Image Generation AI

1 Introduction

This paper proposes a methodology for automatically generating 3D floor plan images of residential spaces. Due to the rapid changes in housing types and the increase in single-person households [1], there is a growing interest in the form and spatial usage of residential spaces [2]. In response to these changes, floor plans play a crucial role in satisfying the demands of residents. Among architectural drawings, floor plans, especially in 3D, are essential sources of information in the architectural and design processes, clearly depicting aspects such as spatial dimensions, gaps, and arrangements. Unlike traditional 2D floor plans, 3D floor plans convey the three-dimensional form and visual information of a space more vividly. 3D floor plans facilitate an intuitive understanding among users, enabling them to assess the layouts and specific details of the floor plans [3]. For example, in cases of selecting apartment blueprints, clients achieve a deeper understanding and expedite their decision-making process through 3D representations as opposed to 2D drawings [4]. Recent advancements in image generation AI models have significantly improved the representation of such visual information [5, 6, 7, 8]. These models can be utilized to create high-quality 3D floor plan images.

2 Background

2.1 Evolution of 3D Floor Plan Visualization

Architectural visualization is a crucial process in expressing architectural design and concepts visually. It is utilized from the early stages of design in architectural projects to effectively convey ideas and concepts to designers, stakeholders, and even construction personnel. Utilizing various forms and tools such as drawings, blueprints, photos, and 3D models architectural visualization is particularly exemplified by the use of floor plans, which accurately capture detailed spatial information, serving as a key element in conveying initial design requirements [9].

Among these, floor plans encompass essential spatial information, including precise dimensions, material specifications, and the arrangement of architectural elements, making them indispensable documents throughout the architectural process. Traditional 2D floor plans have the advantage of simplicity and clarity in conveying basic information. However, their representation of space in 2D has limitations in realistically visualizing both external and internal designs, especially posing challenges for non-professionals or the general public to comprehend [10]. On the other hand, 3D floor plans emphasize visual effects, providing a clear depiction of 3D information. For example, according to Kashlev(2008), 3D building models not only appear to be more aesthetic to ordinary people than architectural drawings, but also can benefit architects in detecting any inconsistencies in their designs [11]. Additionally, according to V Stojanovic et al.(2019), 3D floor plans can enhance stakeholder engagement by improving 3D visualizations or providing an initial assessment of the building's state [12].

They enable a detailed understanding of spatial form and layout, contributing to seamless collaboration and communication among architectural stakeholders [13, 14]. These advantages highlight the selective utilization of 2D and 3D floor plans based on various stages and purposes within architectural projects.

2.2 Floor plan and Generative AI

The evolution of image generation AI [15, 16, 17, 18] has progressed over time through continuous technological innovation. In the early stages, predominantly noise-based methods were employed using simple algorithms for image generation. Subsequently, with the advancement of deep learning technology and extensive research on generative models, the field of image generation has undergone revolutionary changes. Notably, the introduction of deep learning models such as Generative Adversarial Networks (GAN) has significantly enhanced the quality and diversity of image generation [19]. For example, there exists research on generating images by design style utilizing image generation AI model and large language model (LLM), employing these advanced technologies to foster innovation in the field of image generation [20, 21].

In the realm of image generation, two primary approaches are recognized: text-to-image (txt2img) and image-to-image (img2img). Txt2img involves generating images based on given text descriptions, utilizing semantic information extracted from the text [22]. On the other hand, Img2img is a technique that generates new images based on given input images. The image generation AI model understands the features and structure of the image from the input and produces an output image. Training image generation AI models for specific scenarios or types according to their intended purposes enhances the effectiveness of obtaining results. Such image generation AI finds applications in diverse fields, including education, architecture, art, virtual reality, and is anticipated to expand into even more varied domains in the future [23].

3 Model Fine-tuning for 3D Floor plan

3.1 Overall process

This paper employed the Stable Diffusion (SD) among various image generation AI models to fine-tune a model for 3D floor plan. SD maintains stable pixel values during the image generation process by utilizing the diffusion algorithm [1]. Consequently, it can generate high-quality, stable, and consistent images while minimizing noise. To train the base model, we utilize the Low-rank Adaptation (LoRA) method, which updates only a select few parameters for efficient model fine-tuning with minimal data. This approach allows for quick adaptation to new tasks by leveraging the knowledge from the base model without extensive retraining. High-quality, consistent training data, composed of image-text pairs, is crucial, as detailed and specific text descriptions enable the model to generate more accurate and expressive images [24]. Successful few-shot learning with LoRA necessitates high-quality training data with consistent representation [25].

3.2 Data Preparation

For high-quality dataset, we collected floor plans of Korean apartments from ‘X’ apartment and ‘R’ apartment which are reputational brands in Korea. The datasets are consisted of approximately 1,000 floor plans. We focused on the 2Bay and 3Bay structures characteristic of Korean apartments, generating for each floor plan, a single 3D Building Information Modeling (BIM) model. From these BIM models, 3D floor plans are extracted and used as training data. The 3D BIM models are created using 'R' software, and the 3D floor plans are rendered from them using 'E' software. Additionally, we resized the floor plans to the 500 pixels in width and height and prepared the text descriptions of the 3D floor plans for the LoRA training. We acquired the text datasets by observing and describing the 3D floor plans personally for raising the quality of training datasets, which are directly connected with the performance of the model. We produced the pairing datasets, matching the pairs of image and text data one on one. And we paired 100 pairing datasets in total. The example of the dataset for LoRA training is shown in figure 1.

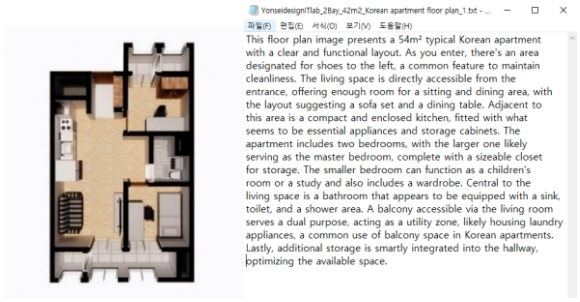

Figure 1. The example of the dataset for 3D Floor plan

3.3 Training and Test

Based on the training datasets, we trained the base model with LoRA. The training was required about 30 minutes per one training session with RTX 3060 GPU. As a result, we build a 3D floor plan model with the extension ".safetensors" and a size of 144 megabytes. Inserting the 3D floor plan model file into the SD Web-UI's Model Management folder allows for the application of the model via text description. Consequently, this facilitates the generation of images based on the text data used for training when such data is inputted [24]. We proceeded performance test for evaluating the 3D floor plan model and comparing the base model and the trained model. The result of the floor plans generated with base model is on the left, and the other generated with trained model is on the middle and right. The result of comparison is presented in Table 1. The 3D floor plans of base models are not discriminated as bay structures unlike the plans of trained model.

Table 1. The result of comparison

model	Type	Output
Base model	2 & 3Bay apartment	
Trained model (3D floor plan model)	2bay apartment	
	3Bay apartment	

The results from the base model were observed to be of low quality and resembled floor plans with errors. In contrast, the trained model applied to the LoRA model produced high-quality floor plans that are easy to understand. Furthermore, the trained model with LoRA created more accurate and well-discriminated floor plans compared to the base model. This performance test suggests that the importance of the LoRA trained model.

4 Demonstration

Table 2. The result of image generation from 3D floor plan model

Type	Trained model (3D floor plan model)
2 Bay Apartment	
3 Bay Apartment	

We found that the results of 3D floor plan are high-quality and improved in performance. The layout of the floor plan is obvious and the factors such as doors are distinct. In addition, the furniture in the space is detailed. It is shown in table 2.

5 Conclusion

This paper proposes a process that leverages an image generation AI model for generating 3D floor plans. The research focuses on architectural visualization, with a particular emphasis on 3D floor plans that vividly represent spatial dimensions. We validated the potential effectiveness of utilizing image generation AI, specifically for Korean-style apartment spatial structures, to efficiently generate 3D floor plans. We discovered that this process can be utilized not only for the Korean-style apartment, but also for the layouts, such as those for other styles of apartments, houses, and offices. Moreover, we found that this model could be beneficial for architects in the field as well as for the public who struggle to understand traditional floor plans offering them intuitive understanding. We expect that this model to be useful not just for interior design but also for building construction, designing ships, and other architecture work.

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