



AUTO-MODELING OF BIM FAÇADE COMPONENTS USING PATTERN GENERATION

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Introduction

Automated modeling has been a significant topic of research in architectural design, helping to reduce repetitive tasks and enhance flexibility in design modifications. Among various building elements, the facade plays a crucial role in defining a structure's aesthetic identity (Jo et al., 2024) and is often designed with repeating patterns applied to individual panel units. Maintaining the alignment and continuity of these patterns is essential, but manual modeling processes are complex and time-consuming, especially when design changes require modifications or the creation of new panels (Jian et al., 2018; Yoo et al., 2024). Therefore, an automated modeling approach is necessary to efficiently generate precise patterns and improve adaptability (Montali and Henriksen, 2022). This study proposes an automatic modeling method that utilizes AI-generated pattern images and converts them into structured BIM components, allowing the transformation of patterned facade panels to be carried out more efficiently through an image-based auto-modeling algorithm.

Methodology

System overview

To improve the efficiency of BIM façade modeling by automating pattern design, we implemented a C#-based Revit add-in that integrates AI image generation with a 3D auto-modeling algorithm. The proposed system consists of a prompt-based pattern generation process, automated 3D panel modeling, and BIM component application. The process is illustrated in Figure 1, showing the transition from AI-generated 2D images to Revit-integrated BIM panel components.

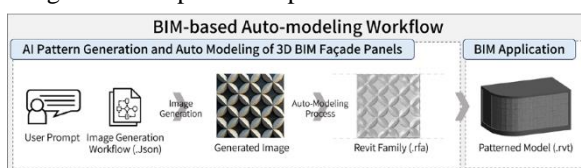


Figure 1: Workflow overview

Auto-modeling system

The auto-modeling system is operated through a dedicated Revit add-in interface, allowing users to input panel size and adjust the maximum extrusion height (Figure 2).

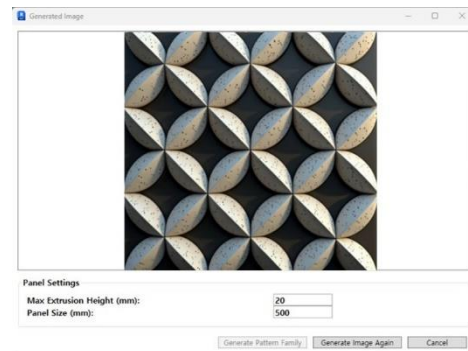


Figure 2: Revit add-in interface for panel settings

The system employs a grid-based 3D conversion process, beginning with image analysis that extracts brightness information from the AI generated pattern image. This brightness data is converted into height values, creating a grid of feature points representing spatial depth vector value. In a subsequent post-processing stage, the edge points of the panel grid are specifically adjusted to ensure seamless geometric continuity between adjacent panels. The heights of these points are then proportionally scaled based on the maximum extrusion height parameter defined by the user through the add-in interface. Finally, the scaled feature points are utilized to generate structured 3D geometry, effectively preserving the intended geometric features of the pattern while significantly enhancing modeling efficiency compared to conventional manual methods.

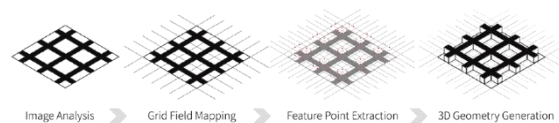


Figure 3: Auto-modeling algorithm

Results

Through this system, 3D models of pattern-based façade panels, including the AI generation process, can be generated within approximately 5–7 minutes. The resulting façade models are produced as individual panel elements, seamlessly integrated into the BIM environment, thus readily applicable for patterned wall configurations without additional adjustments. By employing the proposed system, approximately 150 distinct 3D pattern geometries were created from a diverse set of AI-generated images. To quantitatively evaluate geometric fidelity, edge-based structural similarity (SSIM) analysis was conducted on four representative panels. The mean edge-SSIM score was 0.70 ± 0.05 ($n = 4$), indicating that the auto-generated 3D geometries captured the edge structure of patterns while reducing manual modeling effort.

Conclusions

This system is based on an approach that structures pattern designs in conjunction with automated modeling for use in BIM environments. The proposed automated modeling system converts AI-based designs into 3D models through an automated algorithm, making them immediately applicable in the BIM design process. It transforms 3D models from images in a consistent manner and implements them as panel object units in the BIM environment, reducing repetitive tasks and providing a way to flexibly respond to design changes. This automated modeling technique can be utilized not only for patterned exterior panels in the construction process but also for efficiently generating various architectural elements by applying similar principles. In particular, by automatically converting and applying pattern data in BIM environments during the early design stages, the system reduces design work repetition and enables more consistent pattern modeling. Furthermore, considering scalability in BIM environments, it is expected that this approach can be developed into a parametrically adjustable automated modeling method or expanded to apply to various architectural elements beyond patterns in the future.

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