Research of Modeling Skyline of Hongkong Central with OpenSCAD and Blender

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Abstract. Hong Kong, as an international financial center, is widely admired for its iconic Central skyline. Central is not only the heart of the economy but also a hub for global financial activities, gathering numerous international banks and financial institutions. This study aims to explore the feasibility and efficiency of using OpenSCAD for 3D modeling of some buildings in the Central district of Hong Kong, thereby providing a new tool for architectural design and urban planning.In this study, this paper selected three representative buildings for 3D modeling: the Bank of China Tower, the International Finance Centre II, and the Hong Kong Ferris Wheel. These buildings are not only distinctive in their own right but also occupy significant positions in the Central skyline. Through their modeling, we demonstrated how to generate complex geometric structures using a programmatic approach, fully reflecting the efficiency and flexibility of OpenSCAD as a modeling tool. The results show that OpenSCAD has a clear advantage in handling regular geometric bodies and repetitive structures, especially in parametric and modular model design. In addition, by using OpenSCAD's scripted modeling capabilities, we can easily create buildings with different design intentions and styles, further enriching the three-dimensional visual effects of the city.

Keywords: OpenSCAD, Hongkong central, building model.

1. Introduction

As an international financial center, Hong Kong is renowned for its distinctive and iconic skyline. Central, located on the northern shore of Hong Kong Island, serves not only as the most important commercial and administrative hub but also as the focal point where numerous skyscrapers and historical buildings converge [1,2]. These structures symbolize Hong Kong's rapid economic development and deeply reflect the city's unique cultural and historical background. In recent years, with the rapid advancement of modern technology, three-dimensional (3D) modeling and rendering techniques have become increasingly important tools for showcasing and preserving the historical value and aesthetic characteristics of architecture [3].

OpenSCAD, a free and open-source 3D modeling software, employs programming to design and create models, making it particularly suitable for generating parametric and repeatable geometric shapes. It offers users precise control over model details through a programming language, a feature that is especially critical for complex building models [4,5]. While OpenSCAD excels in geometric shape generation, its capabilities in rendering and material handling are relatively limited. Blender, a powerful open-source 3D creation suite, covers a wide range of areas including modeling, sculpting, animation, rendering, and post-production. Compared to OpenSCAD, Blender provides richer material editing

features, complex lighting settings, and multiple advanced rendering engines (such as Cycles and Eevee). These features give Blender a significant advantage in creating highly realistic visual effects. By importing the geometric models generated by OpenSCAD into Blender, detailed adjustments, material assignments, and lighting configurations can be performed to achieve higher-quality rendering outputs [6].

This study aims to explore the potential of combining OpenSCAD in the field of 3D modeling, specifically targeting the modeling of complex urban skylines. It investigates how these two powerful tools can be utilized to construct and render 3D models of the skyline in the Central District of Hong Kong. Specifically, the study will first use OpenSCAD to build geometric models of representative buildings in the Central skyline, focusing on a procedural approach to ensure accuracy and adjustability.

2. OpenSCAD modeling process

In this part, three buildings IFC II, Hong Kong Ferris Wheel, Bank of China Tower will be modeled separately.

2.1. Preparation before modeling

Before using OpenSCAD, relevant technical data and reference materials need to be collected to ensure the precision of the model and the accuracy of the scale. The buildings covered in this paper include IFC II, Bank of China Tower and Hong Kong Ferris Wheel, each of which has a unique structure and design style, thus requiring in-depth data collection and scale confirmation separately. Accurate and authoritative data sources are crucial for the authenticity of the model. We use the official website of the Hong Kong Ferris Wheel and a website dedicated to the data of high-rise buildings, providing information such as height, floor distribution and design maps of buildings. According to the data on this website, the height of IFC is 412 meters, the height of Bank of China Tower is 367.4 meters, and the height of the Ferris wheel is 60 meters. The specific proportions are shown in the figure 1.
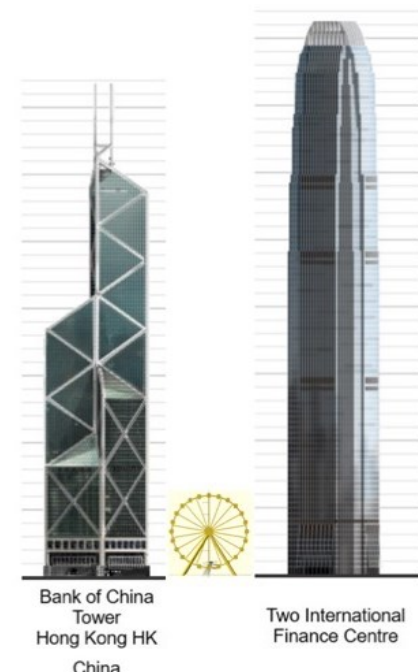

Figure 1. The proportions of the three buildings (Photo/Picture credit : Original)

2.2. Modeling of bank of China tower

The design of the Bank of China Tower is unique, containing multiple triangular prisms and triangular cones. These geometric shapes intertwine to form the iconic appearance of the building, to accurately

reproduce this structure in OpenSCAD, we broke down the building into the following main parts as Figure 2 shows.
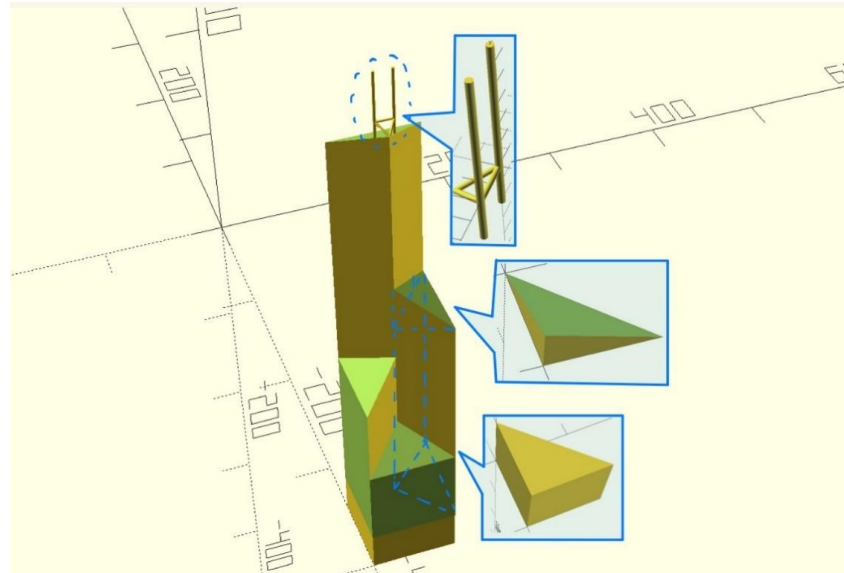

Figure 2. Main components of Bank Of China Tower (Photo/Picture credit : Original)

Triangular Prism: The main part of the building is composed of multiple triangular prisms, which are arranged at different heights and orientations to form the basic form of the building (Figure 3). In OpenSCAD, those triangular prisms can be generated by the difference set operation.
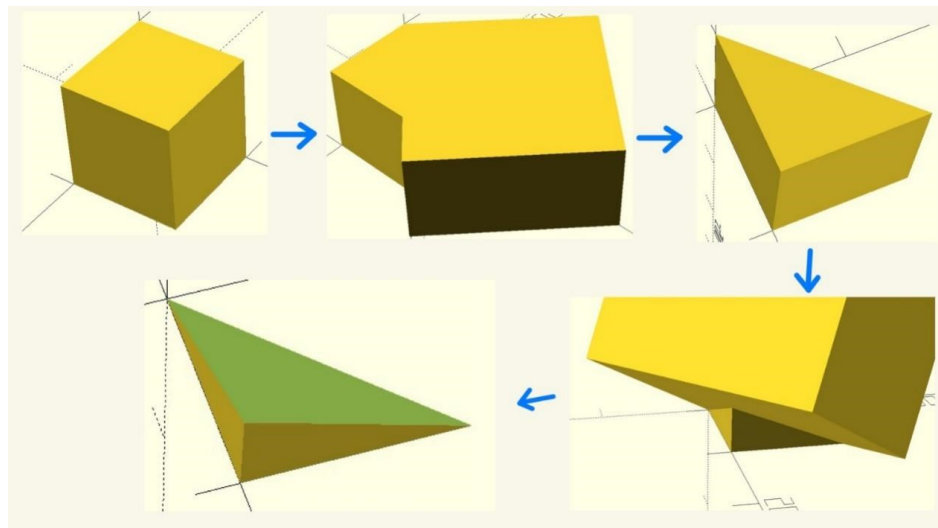

Figure 3. Steps of making a triangular prism and a triangular pyramid (Photo/Picture credit : Original)

Specifically, a cube is first created as the base shape, and then another larger cube is rotated by 45 degrees after performing the difference set operation with the first cube. In this way, a prismatic shape with triangular cross sections can be generated. This triangular prism will be used as the basic module of the main body of the building, which will form the core geometry of the building modeling through appropriate positioning and scaling. This approach is straightforward and can be implemented only with rotate and difference functions, whereas other approaches may require learning more complex syntax rules.

Triangular Pyramid: At the top of the Bank of China Building, the geometry gradually transitions from a tri-prism to a tri-pyramid. This transformation makes the building look sharper and more abrupt by extending the structure upward. The implementation of the tri-pyramid is based on the tri-prism. First, a tri-prism is generated by the difference set, and then a rotated cube is added to its top. By subtracting part of the volume, a tapered tip is formed that gradually Narrows. This tri-pyramid module will be placed on top of the building and will be seamlessly connected to the tri-prism below by appropriate scaling and rotation.

Antenna: The antenna section is located at the top of the building and is composed of multiple cylinders to further enhance the height and visual impact of the building. Each cylinder represents a major building block of the antenna, and these cylinders are generated by specifying their height and radius. The individual cylinders are not simply arranged vertically, but cross each other at a certain Angle. rotate each cylinder with the rotate command so that they form a stable triangular structure. This arrangement is not only beautiful, but also enhances the structural stability of the antenna. To ensure coordination between the cylinders, the parameters of all cylinders were fine-tuned, and finally the complete antenna structure was generated at the top of the building.

Without changing the shape of the tri-prism, the scale function is used to stretch the four tri-prism to different heights, and then they are placed on a cuboid base after 45 degrees rotation along the z-axis. Finally, the tri-pyramid and antenna are adjusted to the appropriate position by the same method, and the modeling part of BOC is completed.

2.3. Modeling of Hong Kong ferris wheel

In the process of modeling the Hong Kong Observation Wheel in OpenSCAD, it mainly involves the modeling of the wheel rim, spokes, cabin and support. These parts are constructed into a complete Ferris wheel model through modular design and clever use of for loops. In the following, the modeling process of each part will be detailed, especially the modeling of the cabin and the application of the for loop. The modeling of the Hong Kong Ferris Wheel can be divided into the following main parts (Figure 4).
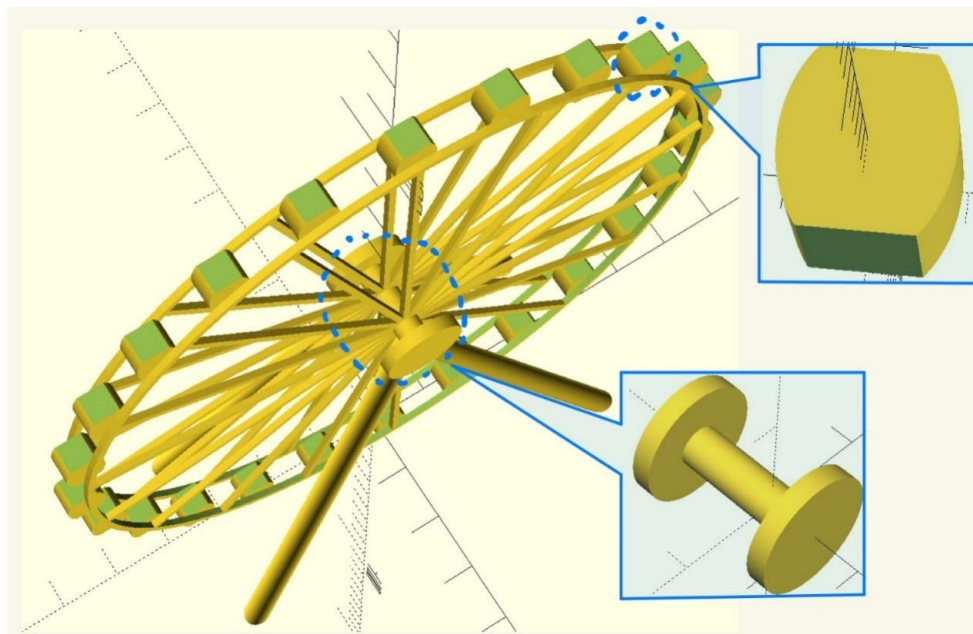

Figure 4. Main components of Ferries wheel (Photo/Picture credit : Original)

Rim: The outer circular structure of the Ferris wheel that connects all the pods. In the code, the cylinder command creates a large cylinder as the external structure, and then subtract a smaller cylinder

by the difference set operation to form a circular rim. The two rims are located at the front and back of the Ferris wheel, forming an overall outer ring.

Spokes: Support structures that extend outward from the central hub to support the rim and maintain overall stability. In OpenSCAD, for loops are used to generate uniformly distributed spokes. The for loop iterates over the Angle values from 0 to 360 degrees, equaling the number of spokes within 360 degrees. Positioned on the outside of the hub by the translate command, the rotate command makes it point to the outer ring, finally forming the spoke structure of the entire Ferris wheel.

Cabins: The cabin is an important part of the Ferris wheel and is used for passengers. In order to ensure the stability and aesthetics of the cabin structure, the cabin is designed using the difference set operation, which is formed by combining a cylinder with multiple cubes. The modeling process of the cabin is as follows:

First, the basic circular part of the cabin is created by the scaled cylinder by decreasing the scale only in the x direction (x: y: z=0.7:1:1). Two cubes were then generated on each side of the cylinder, and these cubes were partially subtracted from their volume to form a cutting effect on the front and side of the cabin. This cutting not only makes the cabin more aesthetic, but also increases the actual space for the passengers. The final shape of the cabin is formed by subtracting two cubes using the difference command. The difference set operation makes the cabin have a complex geometry rather than just a simple cylinder.

Positioning of the cabin: The cabin is evenly distributed on the outer ring of the Ferris wheel. Through a for loop, the code places each cabin evenly along the rim. The positioning of each cabin is determined by the translate command, while the rotate command ensures that the cabin always remains vertically oriented, even at different positions of the rim (Figure 5).
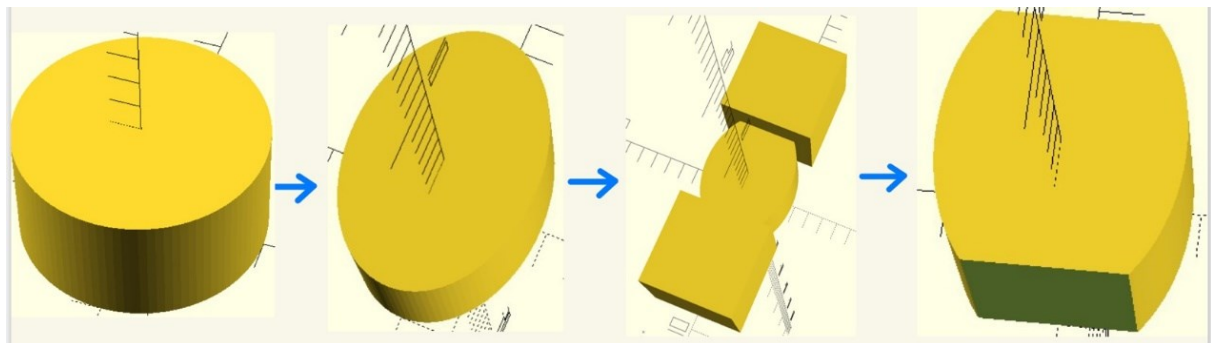

Figure 5. Steps of making a cabin (Photo/Picture credit : Original)

Pillars: The pillars that support the whole Ferris wheel, ensuring that the wheel is erect and stable. The rim of the Ferris wheel is the most visible part, consisting of two parallel cylinders, which are operated by the difference set to form the internal space.

The support is the foundation part of the Ferris wheel to erect and stabilize. The support is formed by a combination of multiple cylinders, which are tilted at two different axis and connected to the ground, providing the required support force for the Ferris wheel.

By realizing the rim, spoke, cabin and support parts of the Ferris wheel one by one, a complete model of the Hong Kong Ferris Wheel was finally constructed. The application of for loop in modeling enables the efficient generation of complex geometric structures, and the detailed modeling process of the cabin ensures the accuracy and aesthetics of the model in details. This modular modeling method not only improves the readability and maintainability of the code, but also makes the model highly flexible, which can be adjusted and extended according to the needs.

2.4. Modeling of IFC II

The unique feature of IFC II is the shrinking prism structure at the top of the building, which gives the building a simple and modern aesthetic. To accurately reproduce this structure in OpenSCAD, we divide the building into the following two main parts:

Bottom structure and middle part: The bottom is a cuboid structure, which constitutes the main part of the building, and the middle part is realized by multiple gradually shrinking cuboids, which are reduced in the vertical direction layer by layer. In order to enrich the architectural details, exterior decorative structures were added to the four sides of the building. These structures are composed of multiple elongated cubes that extend along the vertical direction of the building. In the code, the cube command creates cubes of different sizes and translates them up in turn, forming the intermediate structure of the whole building.

these exterior decoration structures are precisely positioned and translated so that each cube stays close to the main structure of the building. At the same time, proper rotation and scaling ensure that these structures are in harmony with the overall design of the building.

Top prism structure: The most striking part of IFC II is undoubtedly the top prism structure, which gives the building a modern and dynamic feel through its gradually shrinking shape. To implement this part in OpenSCAD, a new function truncated_pyramid() is used, which generates the pyramid by linear stretching and translation operations (Figure 6).
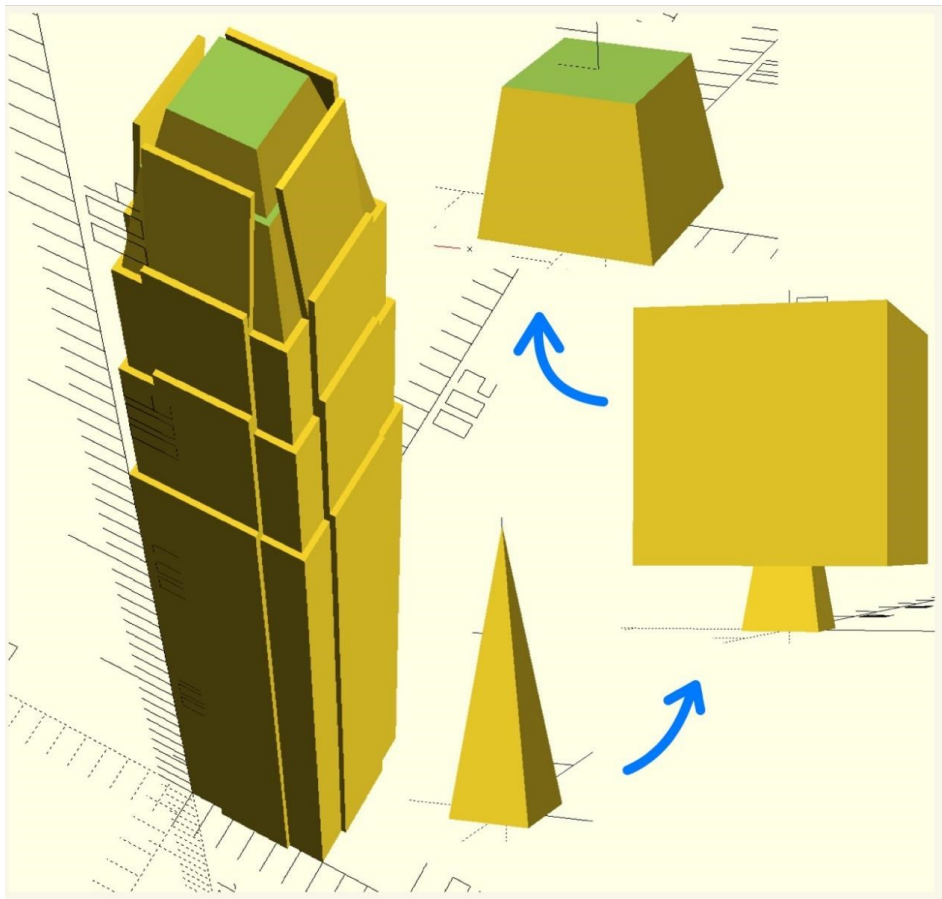

Figure 6. Steps of making a prism (Photo/Picture credit : Original)

The concrete realization of the truncated_pyramid function:

Linear Extrusion: First, a square is stretched and scaled by the linear_extrude command to form the basic shape of a prism. The height of the stretch and the zoom ratio determine the height of the prism and the reduction of the top.

Difference Operation: Next, a larger cube is subtracted from the generated prism by the difference command, making the prism form a cutout corner shape. This operation makes the prism show a gradual shrinkage effect on the top, which is consistent with the design of the actual building. To ensure the vertical alignment of these prisms, the translate and scale commands are used in the code to place the generated prisms one by one in the correct position and to adjust their scale.

By using prism functions and basic geometric operations, a complete model of IFC phase II was successfully constructed in OpenSCAD. In particular, the introduction of the prism function makes the modeling of the top structure more concise and efficient. In addition, the layered superposition design method makes the whole model not only have good symmetry, but also can clearly show the layered sense of the building.

3. Results and analysis

3.1. Experimental setup

In this experiment, OpenSCAD is used to model three landmark buildings in Central, Hong Kong, which are Bank of China Tower, Ferris Wheel, and International Finance Centre II. The construction of these models aims to investigate the capability of OpenSCAD in dealing with geometrically complex buildings, as well as its advantages in parametric design.

3.2. Process of experiment

Select buildings: The most representative buildings in Central with some degree of difficulty were selected for modeling to test the performance of OpenSCAD in modeling complex buildings.

Modeling using OpenSCAD: OpenSCAD is used to build the geometry of each building step by step.

Model display: After the construction is completed, the final appearance of the building is displayed through the rendering function of OpenSCAD, and the corresponding model diagram is generated.

Scoring setup: Evaluators are invited to rate the modeling results, mainly in four aspects: appearance, coordination, detail and visual effect.

3.3. Experimental evaluation index and meaning

In order to comprehensively evaluate the quality of each model (Figure 7), the following four evaluation metrics are used in this experiment:

Appearance: This evaluates the overall visual effect of the model, including whether the model accurately reflects the shape characteristics of the building.

Coordination: Assesses whether the alignment and proportion between different geometries and building parts in the model are coordinated and reflect the overall design concept of the building.

Detail: Evaluates whether the model captures the complex structure and exterior details of the building, such as the building's facade design, antennas, Windows, etc.

Visual Effects: Consider the visual presentation of the model, including whether it has enough layering and realism, and how well the model performs in the absence of high-level rendering.

The evaluator indicated its performance in the domain by assigning a score from 1 to 10 to each item, and finally calculated the average score of each building model in these four dimensions.
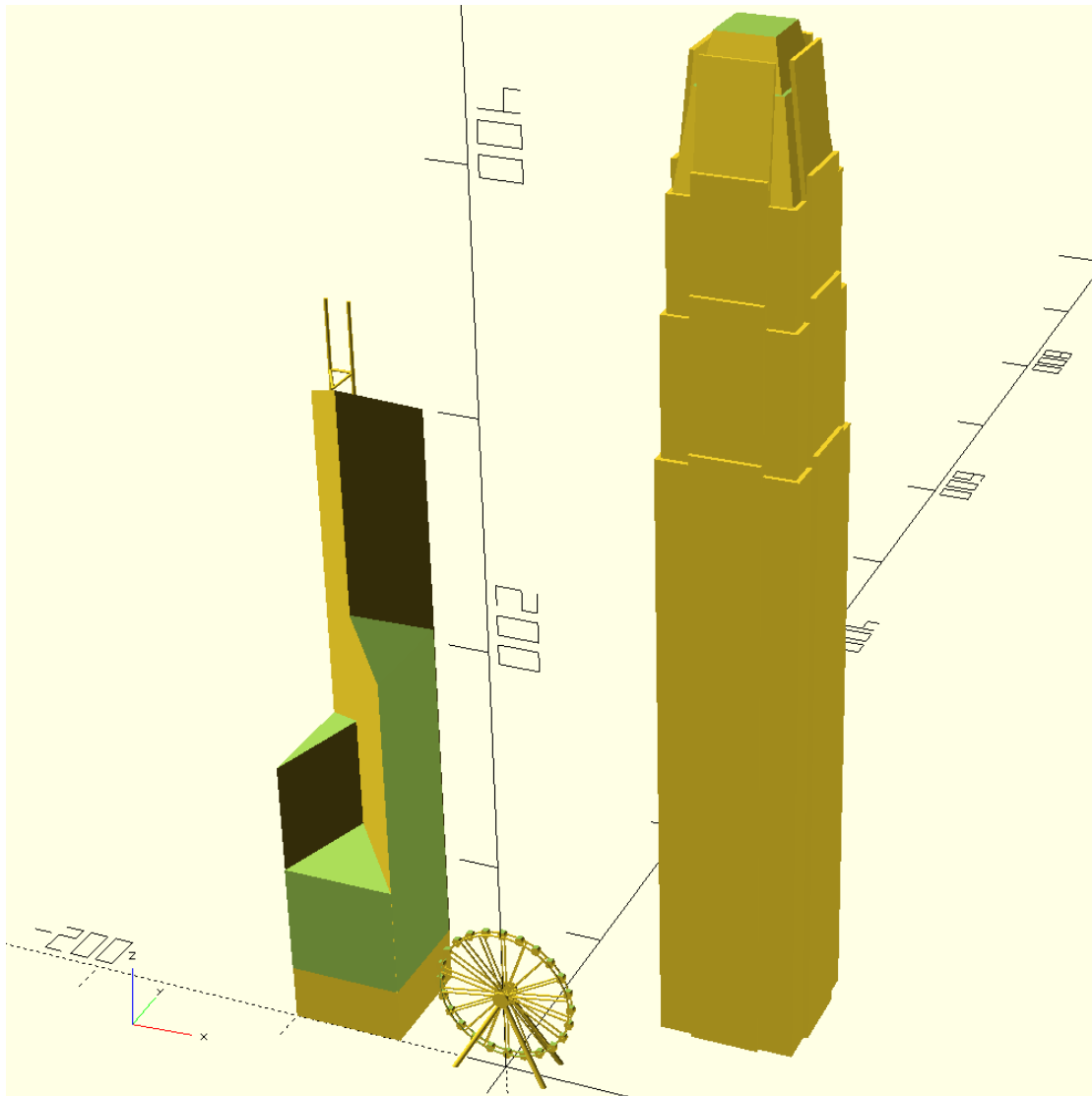
Figure 7. Final results display (Photo/Picture credit : Original)

3.4. Analysis of result
The table 1 shows the average scores of four aspects (appearance, coordination, detail and visual effects) from surveys of few people.

Table 1. The test result

	Appearance	coordination	detail	visual effects
BOC Tower	9	9	5	6
Ferries wheel	9	6	7	5
IFC II	8	7.5	4	5

The high ratings for appearance and coordination reflect the model's success in capturing the contours and overall proportions of iconic buildings. The lower detail and visual effects ratings indicate that there is still room for improvement in fine parts of the model and dynamic rendering techniques.

Although without rendered, OpenSCAD already provides accurate enough geometry and building structure, it can be speculated that this is the reason for the higher appearance scores:

- The IFC Phase II model reflects the layer-by-layer reduction of the building through the layered structure, especially the prism structure at the top. The modular design effectively captures the layered and decreasing structure of the building, so that the height and scale of each floor are consistent with the characteristics of the actual building.
- The model of Bank of China Building realizes the pyramidal geometry of the building appearance by calling triangular prism and triangular pyramid module many times. The model shows the unique geometry of the building and successfully simulates the complex structure of its top antenna section.
- The model of the Hong Kong Ferris Wheel shows the symmetry of the Ferris wheel and the uniform distribution of the cabin. The model is not only accurate in structure, but also concise and efficient in code design.

The lower average score of coordination, detail and visual effects is obvious, from which we can see that this article has the following limitations:

- Deviation of building proportions: Due to the inability to find authoritative size data for all buildings, this study can only rely on public pictures and limited information for modeling. This leads to the fact that the partial proportions of the buildings may be different from the actual ones, especially the differences in building details and height. In addition, the low coordination score of the Ferris wheel may be caused by the fact that the number of spokes and compartments is not consistent with the reality. In future work, obtaining more authoritative building data will be the key to improve the accuracy of the model.
- Visual limitations: Due to the lack of final rendering, the model lacks realistic materials and lighting effects. The rendering ability of OpenSCAD is limited, and it is unable to show the reflection, lighting and other effects of buildings in the actual environment. Future work can use Blender for light and shadow rendering to improve the visual experience of the model.
- The overall lack of transition and foil of other buildings: the original design aims to build the entire skyline of Hong Kong Central, but only three landmark buildings have been completed in this study, which lacks the filling and foil of other buildings. This makes the visual effect of the model not as rich as the real CBD. The skyline of Central is known for its density and sense of hierarchy of buildings, which cannot be fully reflected by the isolated existence of buildings in this study.

4. Conclusion

This paper utilized OpenSCAD software to model iconic buildings in Hong Kong's Central District, including IFC II, the Bank of China Tower, and the Hong Kong Ferris Wheel. By leveraging modular modeling and procedural generation techniques, the study achieved the efficient construction of complex geometries while ensuring the accuracy of building proportions. The results indicate that OpenSCAD, as a beginner-friendly programming tool, not only possesses a simple and understandable code syntax but also demonstrates significant advantages in handling regular geometric shapes and structures, especially in the realms of parametric design and repetitive structure generation. This tool enables the rapid prototyping of architectural models, supports iterative testing in the initial stages of architectural design, and facilitates the generation of building models at various scales and proportions. Consequently, it assists designers in comparing different schemes during the early phases of a project, thereby contributing to the realization of high-quality architectural designs and rational urban planning.

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