Applied Science and Innovative Research
ISSN 2474-4972 (Print) ISSN 2474-4980 (Online)
Vol. 8, No. 4, 2024
www.scholink.org/ojs/index.php/asir

Original Paper

Research on 3D Assisted Planning and Approval of Urban Infrastructure Projects Based on UAV Oblique Photogrammetry

Fuli Wang[1], Cheng Wei[2,3], Haiying Ji[1], Qiuxiang Wang[1]

[1] Qingdao City University, Qingdao, China

[2] Qingdao Surveying & Mapping Institute, Qingdao, China

[3] Qingdao Key Laboratory for Integration and Application of Marine-terrestrial Geographic Information, Qingdao, China

[*] Fuli Wang, E-mail: fuli.wang@qdc.edu.cn

Received: October 2, 2024 Accepted: October 23, 2024 Online Published: October 25, 2024

doi:10.22158/asir.v8n4p73 URL: http://doi.org/10.22158/asir.v8n4p73

Abstract

The approval of urban infrastructure project planning and design schemes are an important part of urban planning and a planned blueprint formulated for urban development. Quickly realizing the three-dimensional planning and approval of urban infrastructure projects plays an important role in the reasonable layout and spatial arrangement of cities. Based on UAV oblique photogrammetry, this paper fuses the real-scene three-dimensional model with the planned MAX model for scene integration, and conducts three-dimensional effect simulation from various perspectives, reflecting the efficiency, intuitiveness, and scientific nature of urban three-dimensional assisted planning and approval. The feasibility of this method is verified by the actual case of three-dimensional planning and approval in Laoshan District.

Keywords

urban planning, three-dimensional planning model, real-scene three-dimensional model, three-dimensional assisted planning and approval

1. Introduction

The approval of architectural planning schemes is the core module of urban planning, construction and management, and has a long-term impact on the construction of smart cities and the construction and development of cities (Luo, 2003). Traditional two-dimensional urban planning approval is relatively mature in data management and effect display, but it is difficult to meet the needs of modern cities in terms of refined management, spatial analysis and planning decision-making. As a result, there are many deviations in the color and layout of buildings from the surrounding environment after planning acceptance (Zheng, 2022).

The emergence of new measurement technology UAV oblique photogrammetry to create three-dimensional models and three-dimensional technology and its application in planning approval provide a new possibility for three-dimensional planning approval technology. In the past, the single expression method using renderings in this work has gradually been replaced by planning three-dimensional models (Chen, 2018 & Hou, 2020). For infrastructure projects in urban planning, three-dimensional assisted planning approval combines the fusion technology of planning three-dimensional schemes and surrounding high-resolution real-scene three-dimensional models. Through data fusion, three-dimensional display and auxiliary analysis of planning schemes can be realized. This paper mainly introduces the methods of creating and refining real-scene three-dimensional models and three-dimensional models of planning design schemes, as well as model fusion and application, and verifies the feasibility of this technical route through specific infrastructure projects.

2. Technical Route

Three-dimensional assisted planning and approval for urban infrastructure projects mainly includes content such as reconstruction and refinement of surrounding real-scene three-dimensional models, refinement and format conversion of three-dimensional models of planning and design schemes, model fusion, and output of results.

3. Operation Methods and Processes

3.1 UAV Oblique Photogrammetry

UAV oblique photogrammetry technology uses a UAV equipped with a five-lens oblique aerial camera to simultaneously obtain image data from multiple angles. Combined with high-precision ground control point data and POS data, it generates various types of result data such as real-scene three-dimensional models, digital orthophoto images, and point cloud results (Wei, 2020).

3.1.1 Field Acquisition of UAV Oblique Photogrammetry

Expand the project scope line by 1 kilometer as the field flight area. Under the premise that the airspace is approved, the ground resolution of field aerial data acquisition is better than 3 centimeters. The heading and lateral overlaps are 80% and 70% respectively. To assist subsequent data processing, the control points adopt the regional network layout mode. Use the QDCORS system (Wei, 2018) to set up field control points and check points. The survey area range is shown in Figure 1.

Figure 1. Schematic Diagram of the Survey Area Range

3.1.2 Reconstruction of Real-scene Three-dimensional Model

The reconstructed real-scene three-dimensional model requires that the mean errors of the model plane and elevation are not greater than ±0.03 centimeters. The three-dimensional model building has no distortion, the texture is clear without streaks, and the texture and shape of the highly reflective area are normal. The reconstructed real-scene three-dimensional building model is shown in the following figure:

Figure 2. Reconstruction of Real-scene Three-dimensional Model

3.2 Fine-tuning of Three-Dimensional Models

3.2.1 Fine-tuning of Real-scene Three-dimensional Models

Use professional three-dimensional fine-tuning model software such as Dp-Modeler and Rubik's Cube to fine-tune the real-scene three-dimensional model, and complete tasks such as texture mapping, geometric structure optimization and repair, material and detail finishing, lighting and shadow processing, rendering and post-processing.

After the fine-tuning of the real-scene three-dimensional model is completed, a series of fine and clear requirements must be strictly met. First of all, there must be no fragments at the bottom of the data, and the data edges must be neat and regular, presenting a clear and regular shape to ensure overall coherence and integrity. Secondly, there cannot be obvious color differences in the data texture. The color should be kept uniform and coordinated to present a natural and realistic visual effect. Moreover, the treatment of the water surface is crucial. It must maintain its integrity and there cannot be situations such as holes and color differences. It is necessary to show a smooth and natural water surface state. In addition, there cannot be obvious misalignments in road textures. For main roads, ground features such as vehicles, remaining road signs and tree trunks must be carefully deleted to make the road texture clear and smooth and conform to the actual situation. Finally, there cannot be problems such as deformation, streaking, damage, and holes on the building facade. The color of the building should be consistent without color differences to show the stability and beauty of the building. Only by meeting all the above requirements can the real-scene three-dimensional model provide accurate, reliable, and highly valuable basic data and a clear and realistic visual presentation for related applications. The comparison before and after the fine-tuning of the real-scene three-dimensional building model is shown as follows:

Figure 3. Comparison before and after the Fine-tuning of the Real-scene Three-dimensional Model

3.2.2 Fine-tuning of Three-dimensional Models of planning Schemes

In the process of fine-tuning the planning and design model using 3Dmax software, a series of fine and crucial tasks need to be carried out, including reducing the number of model faces, carefully optimizing model materials, fully resolving the problem of model flickering, carefully adjusting model textures, and accurately calibrating model colors, etc., and finally exporting a three-dimensional design model that can fully meet the fusion requirements.

The three-dimensional planning and design model after fine-tuning needs to truly meet a series of strict and specific requirements. First of all, the model must be exactly the same as the design material renderings without any deviation. It must be able to show the delicate structure, real materials and various details of the building in detail, so as to create an extremely realistic and vivid visual effect. Secondly, the model must not have coplanarity and flickering at all. It must ensure that the visual presentation is stable and smooth in any perspective and scene, and will not cause any discomfort to the viewer. Moreover, the position of the model must be exactly the same as the model range set by the planning and design. There must be no slightest deviation to ensure the accuracy of the model in spatial position. Finally, the model should be integrated into a tight whole, and its coordinate points must be zeroed, so as to provide convenient conditions and a solid foundation for subsequent related operations and extensive applications. Only by fully and accurately meeting all the above requirements can the excellent quality and excellent usability of the three-dimensional planning and design model be effectively guaranteed.

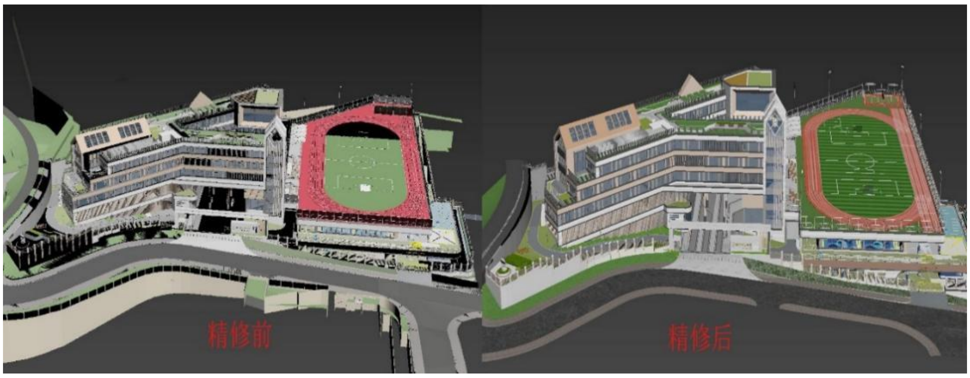

Figure 4. Comparison before and after the Fine-tuning of the Three-dimensional Planning and Design Model

3.3 Model Fusion, Result Output and Application

3.3.1 Model Fusion

Relying on the SuperMap platform to carry out the fusion of the two models. Through operations such as flattening and fine-tuning of the model, the perfect fusion of the two models is achieved, and the real environment around the project is restored as shown in the following figure.

Figure 5. Effect Diagram of Three-dimensional Scene Fusion

Published by SCHOLINK INC.

3.3.2 Result Output and Application

After the model fusion is completed, it is necessary to conduct a comprehensive effect display and in-depth model space assisted analysis of the scheme, and accurately export the results that meet the conditions according to the requirements set by the planning and approval department.

The real-scene three-dimensional planning space assisted analysis mainly covers the following key points:

First, basic display of three-dimensional scenes. This part can accurately query attributes such as spatial distance, height, area, orientation, and coordinates. These detailed data provide a strong basic support for subsequent planning decisions, enabling planners to clearly understand the spatial relationships between various elements and thus make scientific and reasonable planning judgments.

Second, three-dimensional real-scene display. Through carefully preset specific flight routes, targeted displays can be carried out for plot locations, traffic conditions, layout of supporting facilities, characteristics of surrounding features, and overall configuration situations. This display mode provides relevant personnel with an intuitive and clear overall picture of the planning area, enabling them to perceive every detail and overall pattern of the planning area as if they were on the scene.

Third, three-dimensional assisted analysis. This function is of great significance, including building height control analysis, which can accurately control the height of buildings to ensure that they meet planning requirements and effectively avoid unreasonable heights. In addition, it can also conduct dynamic analysis and simulation of sunlight and shadows, accurately predict the shadow range and sunlight conditions generated by buildings at different times, and provide a scientific basis for improving the comfort of the living environment and optimizing energy utilization. At the same time, the red line setback analysis is also included, which can help determine the compliant distance between buildings and the planning red line and ensure the legality and standardization of planning. The result output of three-dimensional assisted planning and approval is shown in the following figure:

Figure 6. Display of Three-dimensional Planning Approval Results

4. Conclusion

This paper comprehensively and in-depth introduces the detailed process and specific technical requirements of three-dimensional planning and approval for infrastructure projects. By creating a real-scene three-dimensional model based on UAV oblique photogrammetry technology and effectively fusing it with the planning three-dimensional model, a rich variety of functions such as spatial measurement, attribute query, visual analysis, and dynamic simulation of sunlight and shadows have been successfully realized. This innovative fusion method significantly expands and enriches the scope and form of three-dimensional planning and approval, and contributes accurate, reliable and comprehensive results to urban planning.

Especially for infrastructure projects, the three-dimensional planning and approval operation mode formed by the real-scene three-dimensional model has outstanding advantages. It can more easily and quickly provide key auxiliary analysis and decision-making basis for decision-makers in urban planning approval. By intuitively and clearly presenting important information such as the spatial layout, building distribution, and supporting facility arrangements of the planning area, it helps decision-makers more accurately evaluate the feasibility of the planning scheme and possible potential impacts. At the same time, this model also provides replicable valuable experience, clear ideas and effective methods for the development of similar projects in the future.

Funding

This paper sponsored by Teaching Research Project of Qingdao City University. Research on the Construction of Ecological Classroom and the Improvement of Teaching Effect of "Civil Engineering Survey" Course under the Background of High-Impact Teaching. Project Number: 2024004B.

References

Chen, Y. H. (2018). Research and application of three-dimensional planning and approval modeling technology. *Technology Innovation and Application*, *19*, 152-154.

Hou, H. B. (2020). A brief analysis of the application of Taiyuan's three-dimensional approval in urban and rural planning. *Shanxi Architecture*, *22*, 28-30.

Luo, M. H. (2003). Digital urban planning and its comprehensive research framework. *Journal of Wuhan University (Industrial Edition)*, *03*, 26-30.

Wei, C. (2018). Design and application of facade data conversion program in facade measurement. *Urban Geotechnical Investigation & Surveying*, *6*, 118-120.

Wei, C. (2020). Application of low-altitude UAV oblique photogrammetry in sunshine analysis modeling. *Urban Geotechnical Investigation & Surveying*, *1*, 98-101.

Zheng, H. X. (2022). Real-scene three-dimensional assisted planning system for small and medium-sized cities. *Geomatics and Spatial Information Technology*, *9*, 133-136.