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Research on 3D Model Calculation of Green and low-carbon New Buildings

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Abstract: Due to the widespread use of solid clay bricks in building houses in China, the annual destruction of farmland by burning bricks amounts to about 100000 acres. Faced with these problems, China has an extremely urgent demand for green and low-carbon buildings. Therefore, this article conducts computational research on the 3D model of a new type of green and low-carbon building. Due to the significant differences in the geometric form and texture representation of a large number of green and low-carbonl new buildings, it is difficult to uniformly quantify their level of detail. This article considers the usefulness and accessibility of 3D model calculation data separately. The shadow length is generally the distance from the selected building's facade roof to the end of the shadow, which can avoid the influence of building shape on its length. The determination of these two points and the calculation of the distance between them will directly affect the accuracy of shadow length calculation. Therefore, when users need to add an application subsystem to the system, they must add information such as the input and output data structures of the subsystem to the module. The height information calculation method uses the building and shadow imaging geometric modeling to calculate the building height by establishing the relationship between the shadow length and the corresponding building height.

Keywords: Low-carbon; New Landscape Buildings; 3D Model Calculation.

1. Introduction

In recent years, due to the rapid development of China's economy, the pollution caused by human beings in construction activities, such as waste water discharge, accounts for about 34% of all pollution. Because of the widespread use of solid clay bricks to build houses in China, burning bricks destroys about 100 thousand mu of land every year. Faced with these problems, China has an extremely urgent demand for green buildings. Therefore, in this paper, the 3D model of green low-carbon new building is calculated and studied [1]. The so-called green low-carbon new building is a building that can save resources, protect the environment and reduce pollution to the maximum extent, provide healthy, comfortable and efficient use space for human beings and live in harmony with nature during the whole life cycle of the building. As an important part of the city, the new green low-carbon building's location and shape information are important data in urban planning, urban construction project management and urban activities, and its 3D information is one of the important bases for urban construction and urban management [2-3]. At present, the establishment of digital 3D city has also become one of the research hotspots concerned by people. There are several ways to obtain 3D information of cities: in photogrammetry technology, 3D information of buildings is calculated by constructing stereo image pairs; Laser ranging, such as using LiDAR and InSAR technology to obtain building elevation information and shadow height measurement of a single high-resolution image [4]. Because of the great differences in geometric shapes and texture representations of a large number of new green low-carbon buildings, it is difficult to uniformly quantify the details, and it is necessary to consider the usefulness and accessibility of the calculated data according to the 3D model. So far, how to effectively plan and express the multi-level details of the new building model of green low-carbon, and plan the characteristics of each level of detail model according to different application scope and data acquisition conditions has become one of the urgent problems to be solved in the application of 3D model of new building of green low-carbon and urban construction [5].

2. 3D Model Calculation Process

2.1. Calculation Principle of Building Height

Green low-carbon new buildings mainly refer to providing comfortable, healthy, and efficient usage space for people throughout the entire life cycle of the building, while also maximizing energy conservation and reducing environmental damage. The entire lifecycle of green buildings is almost identical to that of traditional buildings, mainly including a series of processes such as engineering planning, site selection, engineering design, construction, usage management, renovation and final demolition. The extraction of building height information depends on its geometric relationship with the sun and satellites, so in order to obtain building height information, the first step is to analyze the positional geometric relationship of these three factors [6].

Build a basement with a floor height of 5m and a 1.5m insulation layer. The basement uses a floor height of 3.5m as a regulator for the automatic air conditioning system. In order to better regulate indoor temperature. Design a U-shaped underground horizontal pipeline with a height of 2 meters, a width of 2.4 meters, and a buried depth of 3 meters, connected to the basement. When the direction of the sunlight rays is opposite to the direction of the satellite's line of sight, the building in the image obtained by the satellite will produce an umbra; And when the two directions are the same or close, there will be no umbra. Due to the fact that changes to the basic structure of the structure will affect the work of each subsystem, such changes, such as changes to the structural geometry, need to be independent and handled by specific modules in the modeling engine. After editing and modifying the basic structure, the engine is responsible for sending messages [7]. Notify the relevant subsystems to correct the corresponding model data. The working process of the 3D modeling engine is shown in Figure 1.

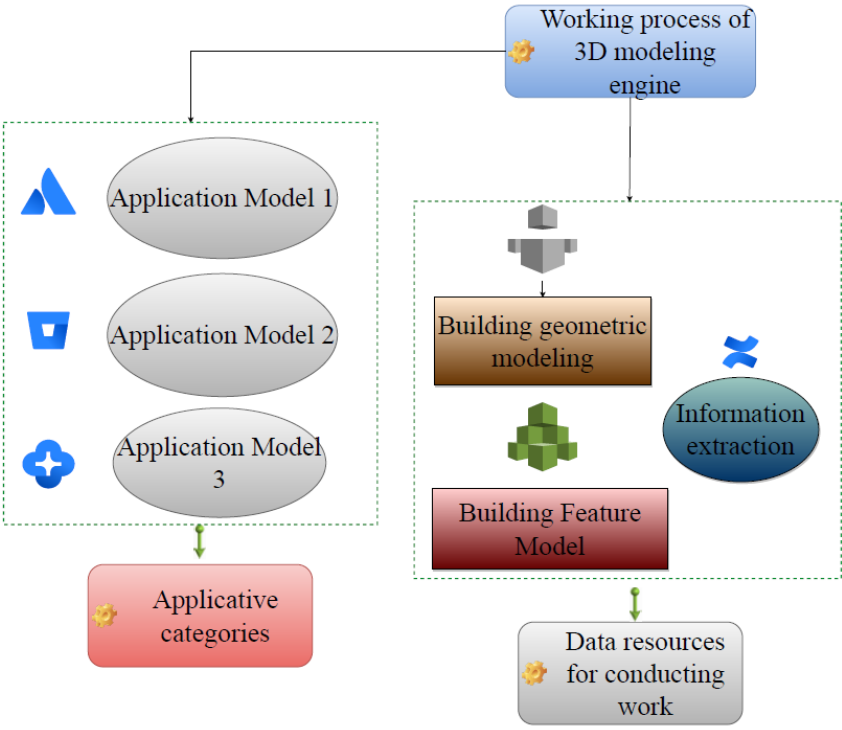

Figure 1. Schematic diagram of the working process of the 3D modeling engine

Using a 3D model to calculate the backscatter coefficient of its single scattering. When the sun and satellite are located on the same diagonal side of the building, there are two situations: one is that the shadow of the building on the image is a part of the falling shadow, and the other part is obscured by the building's image. Through analysis, the following geometric relationship can be obtained:

$$L_2 = L - L_1 \tag{1}$$

Shadow length of buildings:

$$L = H / \tan\beta \tag{2}$$

The shadow length can be expressed as:

$$H = L_2 \times \tan\alpha \times \tan\beta \tag{3}$$

At this time, the shadow of the building seen on the remote sensing image has changed its shape because of the influence of the umbra, and it is no longer the real shadow of the building. Cooperate with 3D modeling engine to identify the corresponding features from the feedback information and modify the system feature model. When users need to add an application subsystem to the system, they must add information such as the input and output data structure of the subsystem to the module, so as to expand the application interface of the 3D modeling engine into a new model, and carry out comparative analysis and experimental development on key technical issues, thus having strong practicability and feasibility [8-9].

2.2. Building Height Calculation

The calculation of building height is obtained by establishing the geometric relationship between shadow length and building height, so the accuracy of shadow length acquisition directly affects the accuracy of height measurement. The shadow length is generally the distance from the top of the selected building facade to the end of the shadow, which can avoid the influence of building shape on its length [10]. The determination of these two points and the calculation of the distance between them will directly affect the accuracy of shadow length calculation. In theory, obtaining the imaging parameters of satellites is necessary to calculate the height of buildings, but in many cases these parameters cannot be obtained [11]. In this special case, a simple linear relationship can be established by measuring the actual height of a building on the measured image:

$$H = L \times k \tag{4}$$

Reverse the value of constant k and calculate the height of the building using equation (4), where k is a constant for the same image.

According to relevant regulations and standards, height information is an important data foundation for establishing urban 3D models, and on this basis, building boundaries extracted from images can be reconstructed in 3D. Complete the improvement of building height calculation, generation of analysis data, processing of building energy consumption analysis result data and visual simulation, adjust and optimize the envelope scheme and the setting of relevant parameters according to the simulation calculation results, and achieve the expected control of energy saving standards in the design process [12-13].

2.3. Building Height Extraction

If the positioning error of "overlap" or shadow is large, it will directly lead to a decrease in height extraction accuracy. In response to the above issues, this article comprehensively considers the scattering intensity difference and spatial position distribution between the geometric feature areas of buildings, and adopts a building height extraction method based on matching the simulated 3D model image of the building with the actual 5AR image. The calculation starts from a pixel object, and is based on the spectra of surrounding objects Merging different shapes until the set threshold is exceeded is an iterative process. The final result of extraction is the thematic information map of building height, that is, the binary image of building height. Extract corresponding feature descriptions and constraint relationships, construct required feature objects, and provide them to other modules within the 3D modeling engine. The programmable application interface is responsible for accepting data requests from external subsystems and providing corresponding data.

Spot retrieval is required, and the acquisition of this result requires optimization of the information extracted from the above process. Simulate the 3D model using the same imaging parameters as the actual image, and obtain the simulated image under the condition of inspection height. In terms of data input, the creation and modification of geometric and topological structures of building entities should not be carried out in specific subsystems, but should be completed through the geometric modeler of the 3D modeling engine. Otherwise, it will lead to inconsistent system model data, resulting in imperceptible errors, and modification of structural attribute features such as mechanical features. Finally, iterative testing is performed on the height values of the buildings to obtain the height values corresponding to the simulated image with the optimal target matching function as the estimated height values of the buildings.

3. 3D Model Reconstruction of Green low-carbon New Building

Building reconstruction after detecting the roof is a relatively simple operation. Based on the extracted roof plane, the 3D coordinates of the boundary and other key corner points can be used to determine the key corner points projected onto the ground and the outer boundary of the roof projected onto the ground. For some complex buildings, capturing fine geometric details is relatively difficult, while capturing texture images is relatively simple and cost-effective. For this reason, we can use the medium geometry detail model to obtain the visual perception effect equivalent to the high detail geometric modeling when using texture. As shown in Figure 2, the geometric structure of a building is the foundation of the spatial form of the building model. Although people can identify buildings based on the geometric structure, realistic texture images can significantly improve the fidelity of the scene, giving observers a richer impression of geometric details.

Figure 2. Building Geometry

Based on the determined feature model, we can start designing the various components of the 3D modeling engine. In order to establish a system feature model, we designed a feature based integrated modeler. In this modeler, the geometric modeler is used to process the geometric and topological information of building entities. The feature recognizer identifies the attribute features of building entities from the process of feature modeling, the addition of feature information after geometric modeling, or the feedback of subsystem information. By using these properties of shadows to determine the height information of surface buildings, and combining it with information such as ground object boundaries extracted from image processing technology, a 3D model of the building is constructed. The height information is calculated by building and shadow imaging geometric modeling, and building height is calculated by establishing the relationship between shadow length and corresponding building height.

Therefore, for the 3D model of green low-carbon new buildings, determining the principles that IDD models need to meet and establishing LOD specification sequences suitable for different application needs is of great significance for the standardized production of green low-carbon new building 3D models. This article utilizes the above parameters and the height information of the building to construct a 3D model of a new type of green low-carbon building, including the roof plan, wall sides, and ground projection plane.

4. Conclusion

Green low-carbon new building has always been considered as the most important feature type, which can be applied to almost all 3D city model applications. A large number of users with different backgrounds, such as government management agencies at all levels, urban and rural planners, environmental agencies, telecommunications and public utilities companies, architectural designers, etc., also have different levels of detail requirements for building models. For the calculation of the elevation of green low-carbon new building, the visual information exchange is aimed at the perception of 3D scene and the identification of specific areas. Due to the influence of the ground debris near the building, the secondary scattering structure of the dihedral corner of the building wall is incomplete, which brings great difficulties to automatically extract and determine the location of the building. Therefore, this paper tries to study the calculation of the 3D model of the new building with green low-carbon. For some complex buildings, it is difficult to collect fine geometric details, while the collection of texture images is relatively simple and low-cost. Therefore, we can use the medium geometric detail model to obtain the visual perception effect equivalent to the high geometric detail model under the condition of using texture. For the calculation of building height, the algorithm for extracting height information from shadow is mature, but when the shadow contains umbra, how to accurately establish the relationship between shadow length and building height is still a difficult problem to be studied.

References

[1] Foster S. GREEN BUILDING[J]. ASHRAE Journal, 2021, 20(1):63-72.

[2] Dwaikat L N, Ali K N. The economic benefits of a green building – Evidence from Malaysia[J]. Journal of Building Engineering, 2022, 18(5):448-453.

[3] Chan A, Darko A, Olanipekun A O, et al. Critical barriers to green building technologies adoption in developing countries: The case of Ghana[J]. Journal of Cleaner Production, 2023, 172(11):1067-1079.

[4] Newsham, Guy, R, et al. Effect of green building certification on organizational productivity metrics[J]. Building Research & Information, 2023, 46(15):25-53.

[5] Dabaieh M, Mahdy D E, Maguid D. Living labs as a pedagogical teaching tool for green building design and construction in hot arid regions[J]. International Journal of Architectural Research, 2022, 12(1):338-457.

[6] Yueer, He, Thomas, et al. How green building rating systems affect designing green[J]. building energy efficiency, 2022, 45(15):30-47.

[7] Gao Y, Jia R, Yao Y, et al. Evolutionary Game Theory and the Simulation of Green Building Development Based on Dynamic Government Subsidies[J]. Sustainability, 2022, 14(4):45-62.

[8] Li P, Chen H. Evaluation of green building suppliers based on IVPLTS-CBR decision-making method[J]. International Journal of Intelligent Computing and cybernetics, 2022, 45 (001): 015-033.

[9] Yang N. journal of world architecture research in context discussion on application of green building design based on bim technology[J]. Shanxi Architecture, 2019, 11(4):36-51.

[10] Le D L, Nguyen T Q, Pham H C. Life cycle energy analysis of a green building in Vietnam[J]. IOP Conference Series: Materials Science and Engineering, 2022, 1212(1):012004-012022.

[11] Yoklic M, Knaebe M, Martinson K. Integrating Net-Zero Energy and High-Performance Green Building Technologies into Contemporary Housing in a Cold Climate[J]. LLP International Educational Corporation, 2022, 36(5):15-20.

[12] Isina A Z, Ten A N. International experience in the development of green building and examples of ecological urbanism[J]. LLP International Educational Corporation, 2021, 20 (1):15-30.

[13] Xu L, Wu J. Research on the green building design of a parent-child theme park[J]. Shanxi Architecture, 2020, 12(4):16-23.