A FAST-CONSTRUCTION-METHOD FOR DIGITAL BUILDING MODEL BASED ON GAOFEN HIGH-RESOLUTION SATELLITE PHOTOGRAMMETRY

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Abstract
This paper aim to present a new approach for Digital Building Model (DBM) construction with the use of GaoFen IV high resolution satellite images and LiDAR data. Our method combines smart data management and data visualization techniques to improve storage and display efficiency of high volume point-cloud data. It then develops a fast-construction-method based on the fusion of intensive matching of DSM/DEM and Constructive Solid Geometry (CSG) library, in which a normal vector region growing algorithm based point cloud clustering method is used to construct different levels of Bezier surfaces, and to extract building roof footprints. It recognizes the special features of point cloud segmentation and Bezier surface crossing, and apply these features to develop parameter-based model building technique for complicated models, where split-and-merge algorithm is used for transforming building roof footprints into 3D building structural models. In addition, our method utilizes advanced remote sensing and virtual reality technologies to create customized 3D environments, enabling users to freely construct 3D models directly on satellite images, and to automatically generate surface textures. Our method shows significant improvement on model accuracy and construction efficiency compare to traditional techniques.

Keywords: high-resolution satellite photogrammetry; Digital Building Model; point cloud; 3D model construction

INTRODUCTION

At present, the three-dimensional reconstruction methods of buildings at home and abroad mainly include two methods of three-dimensional reconstruction of semi-automated and automated buildings. Domestic and foreign experts and scholars have done a lot of work in a semi-automated manner because semi-automated methods often require manual intervention and the accuracy of the results obtained is high. The automated method is more efficient and does not require manual intervention during the entire process. The lack of accuracy is poor. Regardless of whether the reconstruction of the building model is semi-automated or automated, the three-dimensional reconstruction technology can be divided into two types based on model driving and data-driven building three-dimensional reconstruction technology according to the driving force.

The basic idea of the model-driven approach is to construct buildings by using Constructive Solid Geometry (CSG), and to match the models that have been established with a variety of stereoscopic image elements, and to complete building reconstruction through a combination of methods. The model-driven building extraction and three-dimensional reconstruction techniques are methods proposed by Maas and Vosselman that are only suitable for the reconstruction of standard herringbone-type buildings. The basic idea is to obtain the relevant parameters of the building model by analyzing the point cloud data, obtaining the constant moment, and using this parameter as the basis for realizing the three-dimensional reconstruction of the building. The three-dimensional reconstruction results depend on the distribution of points. It is impossible to achieve a three-dimensional reconstruction of a complex structure. Rottensteiner integrates building parameter estimation and photogrammetry techniques to achieve 3D reconstruction of the building. The basic idea is that a building is composed of a series of simple structures. Therefore, the three-dimensional reconstruction process can be divided into blocks by dividing the building. Finally, Boolean operations or combined operations are used to combine the structures of the blocks to achieve a building. Three-dimensional reconstruction.

Using multivariate data fusion methods, we can give full play to the advantages of each data source. You Hongjian et al. combined high resolution aerial CCD images and airborne sparse laser scanning ranging data in the three-dimensional information research of automatic extraction of urban buildings. According to the aviation CCD image, the geometry and distribution features of the building are clearly expressed. Therefore, an adaptive Canny edge detection algorithm is used to extract all the edge information on the CCD image. Then the bi-directional projection histogram and the line
segment matching method are used to implement the automatic and accurate extraction of the plane outline information of the building. Finally, the height information of the building was extracted from the airborne laser scanning distance measurement data, and the contour information extracted by the CCD was used to realize the three-dimensional information extraction of each building (You Hongjian, 2006). (Wenhan Xie et al., 2008) proposed a DBM-based real-shot image generation method using a constructive solid geometry-based extraction DBM to extract building edge vector data from Lidar data. After feature grouping, generate the upper building outline.

TECHNOLOGY ROADMAP AND IMPLEMENTATION SCHEME

The rapid building technology of the building/structure simple model (DBM) with high satellite number 7 satellite data mainly includes three aspects: rapid construction based on simple model with dense matching DSM/DEM, and DBM model based on CSG body library fusion. Establishing, interactive, parametric modeling methods for integrated visualization and complex models of multi-source data.

Rapid construction of simple models based on densely matched DSM/DEM

Using densely matched DEM and DSM data, the extracted building LIDAR point cloud data can be divided into building roof point clouds and ground point cloud, and on this basis, a simple building white model can be reconstructed.

In the three-dimensional modeling scene, the top contour of the building on the LIDAR data is modified to generate a closed building top contour and then converted into a building top datum plane.

Integrated visualization of multi-source data and interactive parametric modeling methods for complex models

Based on the interactive modeling of image stereo pairs, the goal is to extract three-dimensional models from existing image sequences and camera parameters. Using the multi-perspective nature of GF-7 high-resolution images can effectively improve the accuracy of the model and complete the complex Building model reconstruction. Among them, the interactive modeling techniques mainly include solving spatial points and spatial planes.

The three-dimensional model is composed of a series of three-dimensional points. How to reconstruct the spatial three-dimensional points through two-dimensional images is very important. According to the remote sensing image parameters, using the remote sensing image imaging model and using the redundant observations of multi-view remote sensing images, the spatial point three-dimensional coordinates of image pixels in the field can be solved. The spatial plane can be determined by three spatial points that are not collinear. The interactive user manually specifies the matching points on the two images. According to the remote sensing image imaging model, the spatial point can be solved to construct the spatial plane. When switching to other images, the surface is found. When there is an offset, you can drag the plane point to adjust it in real time. The Boolean operation between surfaces can form a three-dimensional space and complete the reconstruction of a three-dimensional model of a building.
Specifically, first, two overlapping satellite remote sensing images of the same modeling area are selected to form a stereo pair and the images are displayed in the form of dual screen mapping.

![Stereo image pair](image)

*Figure 2. Stereo image pair*

The purpose of measuring the feature points is to determine the reference height of the modeling model. In the geometric modeling, the geometry of the buildings at different heights needs to obtain the feature points where the geometric structure is located. By manually obtaining the pixels of the same feature point on the two images of the stereo pair, the three-dimensional coordinates of the feature point can be obtained by the method of forward intersection.

![Feature point measurement](image)

*Figure 3. Feature point measurement*

Then select a top view containing the building so that there is a global view of the building and use polygon drawing tools to draw the outline of the selected building.

![Drawing building outline](image)

*Figure 4. Drawing building outline*
Finally, select a side view of a building to observe the top and bottom images of the building. Push and pull the tool to push the outlined outline according to the image to the bottom of the building to obtain the column profile of the building.

Figure 5. Figure Building Creation

According to the principle of maximum coverage and the principle of orthogonality, the most suitable image is automatically selected for each patch of the model, cut into textures, and attached to the patches. If there is an artifact in the resulting automatic texture map texture, it can be manually modified.

Figure 6. Figure Automatic Mapping of Textures
Modeling Quality Control and Inspection

The coordinates of the corner points of the model are related to the triangulation network. From the local perspective, when the model selects points and hooks, the corner point coordinates are taken from the triangulation model; the coordinates of the model ground point are taken from the ground triangulation network. As a whole, the model surface is fitted to the triangulation network to further reduce the geometric error of the model.

Specifically, it can be realized by multi-angle simulation and fitting of images and LIDAR data. By selecting the loaded image and LIDAR data, three-dimensional scenes can be created from multiple angles, and modeling work based on images such as observation, sketching, adjustment, and detail construction can be performed. In addition, the alignment of model and image and LIDAR data can also be compared.

Provides feature point checking tools, and collects several representative horizontal and prominent points in the point cloud or triangulation model, and calculates the vector difference between the point coordinates and the model surface point coordinates.

![Figure 7. Diagram of model and triangulation](image)

KEY TECHNOLOGY

**Rapid construction of simple models based on CSG body library fusion**

This project studies the rapid construction of simple models based on CSG body library fusion. Based on the analysis of the geometric characteristics of the two typical quadric surfaces (planes and spheres) and the advantages and disadvantages of other feature extraction techniques, the initial iteration points of the algorithm are analyzed. The selection method is improved, the quadratic surface parameters are solved for the first time, and the iterative method is used to automatically perform the area segmentation of the depth image data according to the scanning surface density of the space point. Finally, the accurate value of the parameter of the quadric surface after the segmentation is calculated, and the linear least square method is adopted. The segmented quadric surface is accurately fitted and all the regular geometric models are extracted.
Building block detection and repair technology for satellite imagery

Building block detection and repair is the most critical technical process in true radiographic production. At present, the production of true radiographic images is mainly aimed at aerial remote sensing images. There is very little research on the production of true radiographic images based on satellite images. Aeronautical remote sensing images have high resolution and large overlap, and each image has an accurate external orientation element. The satellite remote sensing image resolution, even with high resolution satellite remote sensing images, is generally difficult to achieve the resolution of aerial remote sensing images, and many remote sensing satellite images cannot provide orbital parameter data. Satellite No. 7 of high score has front and rear view images, the front view angle is 26°, and the rear view angle is 5°. After analyzing the rear view image, a building with a height of about 9.1 metres can create a pixel. Blocking. In urban areas, there are many high-rise buildings and the situation of shelter is widespread. In this research project, when researching the true radiographing technology, we first pass the RPC parameters, reverse the orbital parameters, and use the extracted DBM data to detect and repair the building's occlusion, which can improve the accuracy of occlusion detection and ensure the efficiency of production of real radiographic images. And accuracy.

Orthorectification is based on the image geometry positioning model and DTM to eliminate the projection difference caused by topographic relief on the image. The geometric positioning model of satellite imagery is divided into a strict geometric model and a general geometric model. Strict geometry model requires information such as sensor attitude and orbital parameters, and such information is usually not disclosed; general geometry model uses the most commonly used rational function model (RFM) to express the correspondence between the space coordinates of the image and the space coordinates of the object space, and its expression formula as follows:

\[
X = \sum_{i=0}^{m_1} \sum_{j=0}^{m_2} \sum_{k=0}^{m_3} a_{ijk} X^i Y^j Z^k \sum_{i=0}^{m_1} \sum_{j=0}^{m_2} \sum_{k=0}^{m_3} b_{ijk} X^i Y^j Z^k
\] (1)

\[
Y = \sum_{i=0}^{n_1} \sum_{j=0}^{n_2} \sum_{k=0}^{n_3} c_{ijk} X^i Y^j Z^k \sum_{i=0}^{n_1} \sum_{j=0}^{n_2} \sum_{k=0}^{n_3} d_{ijk} X^i Y^j Z^k
\] (2)
Where: \((x, y)\) and \((X, Y, Z)\) represent the image coordinates and the object-side coordinates; \(a_{ijk}, b_{ijk}, c_{ijk}, d_{ijk}\) are rational polynomial coefficients (RPCs); \(m_1, m_2, m_3, n_1, n_2, N_3\) is the power of the object coordinates, usually less than 3.

CONCLUSION

In the three-dimensional model, the main need is still the building / structure model, the general building / structure has a certain rule, such as in the orthogonal two directions, there are several common forms of combination, usually have a certain degree of symmetry, The parametric representation model can greatly reduce the storage memory of the model. Therefore, it can be seen that the automatic parametric modeling work based on high-resolution satellite imagery is of great significance. It does not require human interaction to specify, and the modeling problem becomes simple. Can reduce operating costs and improve operational efficiency. From the point of view of typical buildings/structures in urban buildings/structures, the problem of 3D reconstruction of buildings/structures is resolved from the perspective of parametric models, and technologies such as computer vision and image analysis are used to extract buildings from high-resolution satellite data. Three-dimensional information of objects/structures for three-dimensional reconstruction. This model of building/structure automation parameters based on high-resolution satellite data is modeled from the perspective of the model, guided by an initial model, and refined by analyzing data. High modeling efficiency has significant research significance.

REFERENCE


