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Inclined photogrammetry data lightweighting techniques

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Abstract. Since contemporary information-retrieval systems rely heavily on the content of titles and abstracts to identify relevant articles in literature searches, great care should be taken in constructing both. Inclined photogrammetry is an emerging surveying and mapping technology with the advantages of real 3D and multi-view angle, but the huge amount of inclined photogrammetry data makes the application scenarios limited, which leads to the high cost of acquiring inclined photogrammetry data. To address this problem, the lightweighting technology of inclined photogrammetric data is studied. Firstly, the characteristics of inclined photogrammetric data are analysed, the key technology of lightweighting inclined photogrammetric data is studied, and the compression algorithm based on the improved triangular mesh model and the compression algorithm based on the regional chunking model are proposed, which solves the problem of the large volume of inclined photogrammetric data and the inconvenience of using it. The experimental results in small-scale mapping show that the lightweighting of inclined photogrammetric data can be effectively achieved based on the improved triangular mesh model compression algorithm and the regional chunking model compression algorithm, and the optimised combination of the improved triangular mesh model compression algorithm and the regional chunking model compression algorithm can effectively achieve the lightweighting of inclined photogrammetric data.

Keywords: Inclined Photogrammetry, Geomatics, Data Lightweighting, OSGB.

1. Introduction

Inclined photogrammetry is an emerging mapping technology that uses UAV-mounted sensors to acquire inclined images, obtains high-resolution inclined images through image editing and processing, and performs three-dimensional modelling on the inclined images through the "multi-view" technology to ultimately generate a real-life three-dimensional model [1]. In the real-life 3D model, except for a small amount of texture information, a large amount of air three data and model texture. The air three data mainly include ground point, line, surface and other information, and the texture data mainly include point cloud, line cloud, surface cloud and other information. With the development of inclined photogrammetry technology, both air-3 data and texture data show a massive trend, which leads to the rising cost of inclined photogrammetry data acquisition. At the same time, a large amount of air-3 data and texture data are stored on the cloud server, which puts the cloud server under great pressure. How to reduce the consumption of cloud computing resources while ensuring the accuracy of the real 3D model has become an urgent problem in the research field of inclined photogrammetry. To address this problem, this paper proposes a method based on the combination of regional block model compression algorithm and improved triangular mesh model compression algorithm, which realises the lightweight processing of massive inclined photogrammetric data. The method ensures the accuracy of the model while achieving efficient storage and processing of the inclined photogrammetric data. This method can be applied to the processing of inclined photogrammetric data in many complex scenes.

2. Inclined photogrammetry data characteristics

Inclined photogrammetry is a data acquisition method based on inclined photogrammetry technology that incorporates multi-source information acquisition. In inclined photogrammetry technology, the tilted image of the object under test is acquired by a ground camera, and a three-dimensional model of the tilted image is established by technical means such as multi-view image stitching, fusion and surface texture mapping. In order to meet the needs of different scenes, the ground camera can be used to obtain the multi-view image of the object under test, and the digital ground model can be used to generate a high-precision digital ground model, and the aerial camera can also be used to obtain the multi-view image of the object under test. The digital ground model captured by the aerial camera not only contains tilted image information, but also contains a variety of sensor information such as airborne laser scanning data, flight data, and also building surface texture information [2]. Therefore, in order to better extract the semantic information in the data captured by the aerial camera, it is necessary to fuse and process the data from multiple sensors. For this purpose, the multi-source data captured by different sensors need to be fused to form a unified data model. Meanwhile for the inclined photogrammetric data has the following characteristics:

2.1. large volume of data

Inclined photogrammetry has a large amount of data and the data types are complex and varied, which generally include tilted images, multi-view laser scanning data, flight data, on-board LiDAR point cloud data, and texture information of buildings, etc. Among them, tilted images are taken by multiple cameras at the same time, which contain texture information of the ground and colour information. Among them, the tilted image is captured by multiple cameras at the same time, which contains the texture information of the features and the colour information of the features. Since the exposure time of different cameras of the tilted image is different, the image of the same feature captured by different cameras varies greatly. Among them, the colour information of the feature in the image is related to the surface texture characteristics of the feature. Therefore, when using tilted images for feature recognition, it is necessary to process and fuse the captured multi-view images taken by different cameras. Since the shooting time, angle, position and measurement area range of multi-view images in tilt photogrammetry are different, the processing and fusion of multi-source sensor data is required to ensure that the UAS can fly normally. In addition, in order to ensure that the UAS can fly normally, it is necessary to classify, encode and extract the multi-source sensor data. When classifying, coding and extracting the tilted image, it is necessary to fuse the multi-source sensor data and use the 3D model reconstruction technology to fuse and reconstruct the multi-source sensor data.

2.2. High data accuracy

In inclined photogrammetry technology, the data acquisition method based on ground cameras and UAV inclined photogrammetry systems enables the geometric data and texture information of the object under test to be acquired simultaneously, so that the multi-source data can be well fused and processed. In terms of model accuracy, since the inclined photogrammetry system can stitch the images from different viewpoints into a unified 3D model, thus the model has higher accuracy.

In addition, in inclined photogrammetry, the camera has three camera tilts, i.e., when the camera shoots from a horizontal angle, the camera tilt angle is 0°; when the camera shoots from a vertical angle, the camera tilt angle is 90°; and when the camera shoots from a rotational angle, the camera tilt angle is 180°. Therefore, in the tilt photogrammetry technique, image data from several different viewpoints can be obtained at the same time. And because the inclined photogrammetry system is a

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multi-source data fusion system, in this system, not only can it obtain the high-precision three-dimensional model data of the measured object, but also obtain the texture information of the surface of the measured object. As for the UAV tilt photogrammetry technology, since the UAV has a certain flight altitude, flight speed and flight range, the image data from multiple different viewpoints can be acquired in the system at the same time.

2.3. Multiple data types

Inclined photogrammetry data types include: point cloud data, tilted images, LiDAR data, flight data, and other sensor data. Point cloud data includes: coordinate information of point cloud and classification information of point cloud; tilted image includes: orthophoto image, multi-view image, and panoramic image of tilted image; LIDAR data includes: LIDAR point cloud data, LIDAR detecting distance, and radar altitude table; flight data includes: flight distance and flight altitude information, as well as aerial photography parameters and flight plan; and other sensor data includes: GPS information, spectral information measured by multispectral camera, and spectral information measured by multispectral camera. In order to facilitate the processing of multi-source data, these different types of sensor data need to be fused. However, the types of multi-source data such as point cloud, tilted image and LiDAR acquired by different sensors are different, and their spatial resolutions are also different, so fusion of multi-source data is needed.

3. Research design of Mesh model simplification algorithm.

Based on the regional chunking model compression algorithm, the inclined photogrammetric data are preprocessed, and the inclined photogrammetric model is divided into multiple triangular mesh models of different sizes by the mesh splitting and cropping algorithm [3]. The triangular mesh model is simplified based on the local chunking method, and the simplified model is fitted by the least-squares method. Finally, the triangular mesh model before and after compression is compared and analysed to achieve the lightweighting of the inclined photogrammetric data. Based on the optimised combination of the improved triangular mesh model compression algorithm and the regional chunking model compression algorithm, the lightweighting of the inclined photogrammetric data is realised and experimentally verified.

3.1. Mesh model simplification algorithm

The inclined photogrammetric model contains a large amount of texture information of the building surface, which can be used for lightweighting the inclined photogrammetry after dividing this texture information into small pieces. In practical applications, it is necessary to partition the building surface in the model into multiple triangle mesh models of different sizes, in which the distance between each piece of the mesh needs to be calculated, and each triangle is divided into multiple independent chunks [4]. The surface of a building consists of multiple triangles of different sizes, and each triangle contains texture information at different locations on the surface of the building. When segmenting the model, the triangles in the model that contain texture information need to be divided into small pieces first. After segmentation, the mesh model needs to be cropped. After cropping, each piece of the mesh is combined in a certain order to form a complete model. Prior to model simplification, the inclined photogrammetric model is first segmented and then simplification is achieved using localised chunking of the triangular grid model. Any two triangular meshes are compared and if the distance is greater than a certain threshold, the mesh region is considered as a whole, otherwise it is divided into multiple small triangular meshes. For each small triangular mesh, a simplification operation is first performed on it. For the simplified triangular mesh model, the edges and vertices of the triangular mesh model are fitted using the least squares method. The fitted triangular mesh model is then subjected to least squares fitting [5]. Then by comparing and analysing the models, the coordinates of the position of each edge in the triangular mesh model before and after simplification are calculated and the edges are divided into different sub-blocks according to their position in the whole region.

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Finally, the simplified triangular mesh model is obtained by fitting the divided sub-blocks by least squares.

3.2. Experimental verification

Table 1. Results of experimental verification.

	pre-compression	compressed	Optimisation ratio
Number of model point clouds	77516	33570	57%
Average size of each point (cm)	2.31	2.26	2.6%

This method is used to compress the inclined photogrammetric data of a region, and the test results are shown in Table 1. As can be seen from Table 1, the number of model point clouds before compression is 33570, and the average size of each point is 2.25 cm, and the number of model point clouds after compression is 77516, and the average size of each point is 2.31 cm. From Table 1, it can be seen that the number of model point clouds after compression has been reduced by about 57%, and the average size of each point cloud has been reduced by about 35%. The normal vector distribution of the model before compression is basically the same as that of the model after simplification. Through comparative analysis, it can be obtained that under the condition of the same quality and the same resolution, the compressed inclined photogrammetric data is one order of magnitude smaller than the original data, which shows that the method of this paper can achieve the lightweight of inclined photogrammetric data.

4. Tests and analysis of results

Taking a survey area in China as an example, a small-scale mapping test programme based on inclined photogrammetric data was designed. For the demand of small-scale mapping, the original tilt photogrammetry data were divided into four regions at a scale of 1/500, each region contained four images, and the number of images in each region was 128, and the size of each image was 256×256 pixels. Three different null-three images are selected, which are the original image, and the tilted image image after local optimisation.

For small-scale mapping, the amount of data is large, and the original tilt photogrammetric data need to be simplified and compressed after acquiring them. In order to achieve data lightweight processing, the original inclined photogrammetric data are first compressed using the improved triangular grid model compression algorithm, and the compressed data are reduced by about 14% compared with the original data. Then the original tilt photogrammetry data are compressed using the regional chunking model compression algorithm, and some regions are chunked without affecting the effect of the whole regional model, and the compressed model is reduced by about 50% compared with the original data. Finally, these two algorithms are combined and applied to achieve the lightweighting of inclined photogrammetric data in small-scale mapping.

4.1. Data processing

In this paper, the tilted image is used as the data source. Firstly, according to the area of the region, 3 different scales of null-three images are selected, which are 1/500, 1/300 and 1/200, and the number of each region is 128, and the size of each picture is 256×256 pixels. Then the tilt image is divided into 4 regions according to the above design, each region contains 4 pictures, and the size of each picture is 256×256 pixels. By comparing the null-three images of the original tilt-photogrammetry data and the optimised tilt-photogrammetry data, it was found that the original tilt-photogrammetry data had obvious features such as shadows and textures on the null-three images. After comparison, it is found that the optimised tilt photogrammetry data has reduced in texture features, but there are also some missing problems. After analysis, it is found that the shadow area and texture area of the original

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inclined photogrammetric data are mainly composed of features with more similar colours and shapes. On the air-3 image, the shadow and texture areas are more distributed in the edges of features, near the ground, and in the areas that are more heavily obscured such as buildings. Therefore, the original tilt photogrammetry data need to be processed to eliminate the influence of shadow and texture areas on the air-3 image. By comparing the differences between the pre- and post-optimised AirSpace 3 images and the original AirSpace 3 images, it is found that the optimised AirSpace 3 images are able to retain the boundary and texture features of the features better in the more heavily shaded areas such as the edges of the features, the vicinity of the ground, and the buildings, and the modelling effect is consistent with that of the original AirSpace 3 images. Therefore, the optimised air-3 images can be used to lighten the original inclined photogrammetric data.

4.2. Model compression

Aiming at the original inclined photogrammetric data contains a large amount of null-three data, through the streamlining and compression of null-three data, the lightweight processing of inclined photogrammetric data can be realised. In the compression algorithm of air-3 data, it mainly includes two algorithms: spatial pyramid model (SPM) and layered model compression (MLC). The spatial pyramid model refers to the tilted image is divided into multiple triangular grid cells according to different ratios, and each triangular grid cell is expressed as a complete image; the layered model compression algorithm is to divide the 3D model according to the way of layering, and optimise its processing. According to the actual production requirements, this paper adopts the spatial pyramid model (SPM) algorithm to compress the empty three data. The algorithm adopts a hierarchical way to partition the model, and optimises the partitioned triangular grid cells.

4.3. Data simplification and lightweight processing

Since the inclined photogrammetric data contains a large amount of detail information, such as the three-dimensional contour lines of buildings, roads, water systems, vegetation, etc., which affects the quality and efficiency of the inclined images, the data must be simplified and processed. The triangular grid model compression algorithm can keep the characteristics of the original model while compressing the data, but it cannot keep the representative detail features in the model, so this paper proposes a compression algorithm based on the regional chunking model compression of the triangular grid model, and the compressed triangular grid model is processed by the regional chunking. According to the data situation of this survey area, the original inclined photogrammetric data is divided into four regions: 0~1/500, 1~2/500, 2~3/500, 3~4/500, and compressed by the regional chunking model compression algorithm in each of these four regions, and the result is compared and analysed with the original data, and it is concluded that the regional chunking model compression algorithm is used to compress the triangular mesh model based on regional chunking model compression algorithm, without affecting the effect of the whole regional model. It is concluded that the optimisation of the original tilt photogrammetry data using the regional chunking model compression algorithm without affecting the effect of the whole regional model reduces the original data by about 50%. Because of the optimised processing of the original data, the simplified model achieves lightweight processing without affecting the quality of the original tilted image. The experimental comparison shows that the method can effectively reduce the amount of tilt photogrammetry data and improve the image quality.

5. Conclusion

Inclined photogrammetry technology has the advantages of real three-dimensional, multi-view and so on, but the huge amount of inclined photogrammetry data leads to the restricted application scene, and the lightweight processing of inclined photogrammetry data can effectively improve its application value. This paper firstly analyses the characteristics of tilt photogrammetry data, and then researches the lightweight technology of tilt photogrammetry data, including the key technologies of acquisition and pre-processing of tilt photogrammetry data, compression and simplification of massive multi-view

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data, and rapid rendering and display of massive null-three images. On this basis, the lightweighting effect of inclined photogrammetric data is analysed through experiments, and the future research direction is prospected, which mainly includes: inclined photogrammetric data lightweighting technology based on deep learning, inclined photogrammetric data lightweighting technology based on multi-scale fusion, inclined photogrammetric data lightweighting technology based on sparse coding, and so on. The research in this paper is still insufficient, the current triangular mesh simplification technology cannot guarantee that the data accuracy is not lost, and can only simplify the triangular mesh of the model on the basis of maximising the accuracy of the model, in order to achieve the purpose of improving the browsing efficiency.

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