Evaluation of Computational Efficiency on Image-Block Cutting Area in Stitching Orthophoto

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Abstract

The feature of central projection will result the pixels offset for UAV aerial photos. This problem can be solved by way of correcting relief displacement of DEM that was constructed by dense point cloud. During the image processing procedure, the creation of dense point cloud spent the most time. By cutting the image into blocks to reduce the creating time of high dense point cloud is the main issue of this paper.

The coordinate difference between the whole area and the block cutting are another discussion. All in the whole area, 16 feature points were selected to be the check points. When image blocks were merging back, if the difference between two points is less than 1 pixel, the image-block cutting method will be considered workable. By cutting an image into blocks, it can be performed in parallel and distributed way. It can reduce the hardware requirement and make the difference of points matched. This is the contribution of the paper.

Key words: orthophoto, relief displacement, DEM

Introduction

Compared to traditional aerial photogrammetry, unmanned aerial vehicle (UAV) has the advantages of high mobility, easy operation and low construction cost. It has become an important tool for modern aerial photogrammetry.

But the images gathering by the UAV always suffer from the problems of image shift. This may be come from the low flying altitude, the coverage of the single image is small, the inclination displacement, and the relief displacement. For a wide range of image requirements, it will require to take multiple images and merging these images with adjustments and stitching technology.

Image stitching technology has two steps, one is geometric correction and the other is image merging. The purpose of geometric correction is to correct the tilt and displacement of the center projection. Image merging is done by matching characteristic points for stitching. The stitching process can be done by combining the overall images and making geometric correction after. It also can be done by correcting each single photo before merging them into a big one.

In recent years, the image processing has rapid development. Image feature identification and image projection geometry developed a lot of image matching correlation algorithms to do the feature extraction and matching.

Image stitching is the key step in generating orthophoto. There are many ways to improve the quality and efficiency of stitching. J. Yim, etc. [3] proposed by flying height, camera perspective and speed UAV flight planning, can improve the image stitching efficiency. H. Zhou etc. [4] by combining multi-lens into a camera matrix with SfM algorithm rearranged and stitched the photo with sparse point cloud, and finally merge the splicing images with multi-frequency mixed. N.M. Tarmizi et al. [5] pointed out that for large-scale orthophoto or digital elevation model (DEM) production process, if the photo were highly overlapped and was large scale, the operation process takes a lot of time and still cannot produce the results, it is appropriate to remove some photo for re-processing.

Orthophoto image creation is to project the original three-dimensional image into two-dimensional, and restore the corresponding position of three-dimension by multi-view stereo visual operation. After that it was generated by geometric correction and ortho-projection. It is a high-dimensional graphic operation. The operation process is not only time-consuming; the requirements of computing resources are also very expensive. That means that it needs high-level hardware to finish the work.

The method we proposed is that in the stage of dense point cloud generation, the photo is cut into blocks, and then it was processed separately. After each block was processed, they are merged back again. The purpose is to make the photo smaller and reduce the calculation threshold. The efficiency will be evaluated compared with the condition without cutting. The other issue we will focus on the difference between the re-merging and the original full photo.

Process and Method

This study was experimented in a university in Tainan, five control points were set up as shown in Figure 1. The flight carrier is DJI Phantom 3 Pro, the camera is 1 / 2.3 "CMOS, 12.4 million effective pixels, the picture size 4000x3000. Flight range is of 32.3 hectares, flight height of 100 meters, the front overlap rate of 80% overlap, side verlap 80%, the total number of 455 photos.

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Fig. 1 The experiment place and the positions of control points

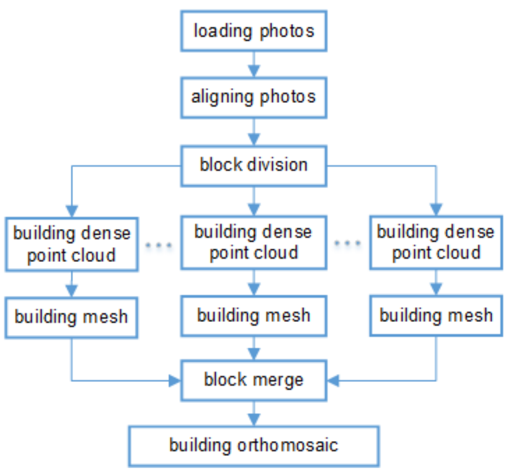

Fig. 2 Orthophoto image processing flow chart

Image processing was implemented by PC in computer classroom, hardware specifications are CPU i7-4790 and memory 16GB. The Display card is Intel HD Graphics 4600 that built in the motherboard. The PhotoScan software was used to produce the orthophoto image. The processing flowchart is shown in Figure 2.

In order to understand the efficiency difference between the full region and the block-cutting, the following steps were taken by sequence. First, the entire area of the aerial photography photos are all loaded into the personal computer. Second, the photo alignment program was applied to the photo. The purpose of this step is to calculate the camera position when shooting. Third, the dense point cloud for the whole area and block cutting were generated. The generation time for the whole area dense point cloud will be used as a benchmark.

Block cutting method is divided the whole region into 5 kinds of equal blocks by 2, 4, 8, 16 and32. After cutting, the blocks are called 2-blocks, 4-blocks, 8-blocks, 16-blocks, and 32-blocks. In order to make the blocks in the subsequent stitching process to automatically match and stitching, the overlap rate between adjacent blocks is 20%. The photo of each block was fed into computers with the same specifications. The dense point cloud generation and grid generation were computed in parallel and time spent in each computer was recorded. After that, all the blocks were merging and stitching in the form of grids by grids. Finally, the orthophoto was created.

In the process of creating orthophoto, the time spent to generate dense point cloud by way of the whole area is the largest. The time required for grid generation and block merging can be negligible compared with the overall processing time. The time spent for image alignment and generation of dense point cloud is almost fixed. The analysis of time spent by block cutting to generate dense point is one the key points of this experimental. And then, the position difference between the whole photo and the blocks combination will be discussed. The point coordinates in whole photo can be constrained because of the deployment of control points. Rather in the blocks combination, each block didn't have enough control points to constrain the point coordinates, so that the whole image orthophoto is chosen as a benchmark for comparisons. In order to check if the block combination orthophoto are distorted by extrusion, expansion or screwy that causes the difference in photo, the coordinates difference will be recorded by 2,4,8,16 and 32 blocks respectively. The 16 feature points in the whole photo were marked as A, B, C, ... to P. Compared to the 16 feature points in the same position, these check points will respectively be marked as A', B', C' ... to P', the result of differences is shown in Figure 3.

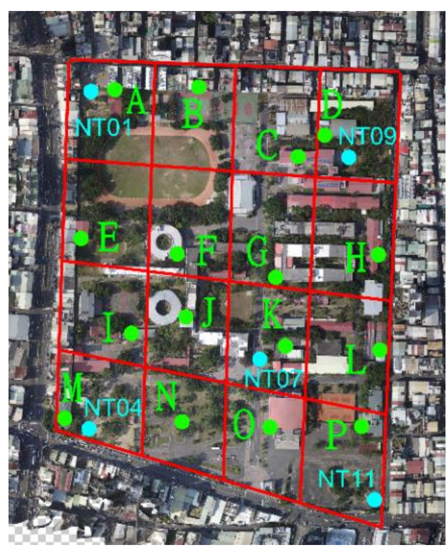

Fig. 3 The distribution of check points.

Results

In the experiment of image-blocking, UAV aerial photography is influenced by the wind and wind direction. The film shooting distance is not always the same and the number of photo that each blocks covered is not consistent either. The generating times for every dense point cloud is also different, as shown in Figure 4. The time and the number of photos were recorded on average.

It takes 8,427 seconds to generate the density point cloud for the whole image. This is accounting for 59.4% of the total processing time 14,176 seconds. The generating time for 2-blocks, 4-blcoks, 8-blocks, 16-blocks and 32-blocks are 5,249 seconds, 3,632 seconds, 2,349 seconds, 1,522 seconds and 653 seconds respectively. The total processing time are reduced to 11,058 seconds, 9,421 seconds, 8,172 seconds, 7,344 seconds and 6,478 seconds, as shown in Figure.5

From the experimental results above, it also can be found out that the generating time for dense point cloud is relative to the number of photo that each block contains. The average generating time of density point cloud for each image is about 20 seconds by image-cutting into 2-blocks, 4-blocks, 8-blocks, 16-blocks and 32-blocks respectively, as shown in Figure.6.

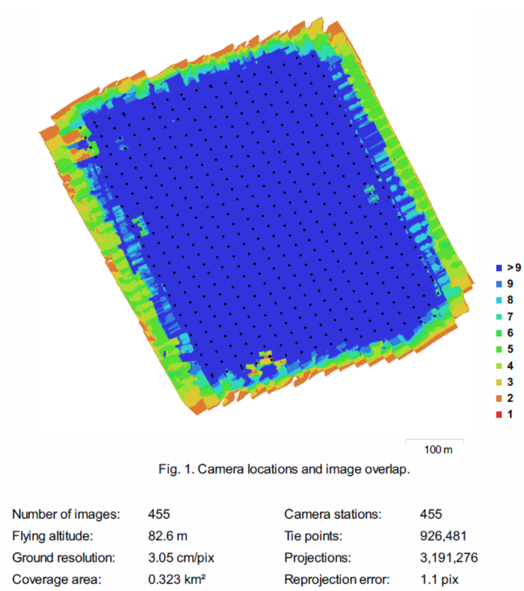

Fig. 4 The generator report on whole area

As to the precision of point accuracy compared by the whole image and merged image, the results generated by PhotoScan show that the ground resolution of the whole orthophoto image is 3.05 cm/pix, the relief displacement is 1.1 pix, horizontal error of control points is 3.21cm. The ground resolution for 2-blocks, 4-blocks, 8-blocks, 16-blocks and 32-blocks are 3.05 cm/pixel, 3.06 cm/pixel, 3.07 cm/pixel, 3.06 cm/pixel and 3.05 cm/pixel. Their differences are very small. The relief displacements are 1.13 pixel, 1.17 pixel, 1.22 pixel, 1.23 pixel and 1.22 pixel respectively, as shown in Table.1

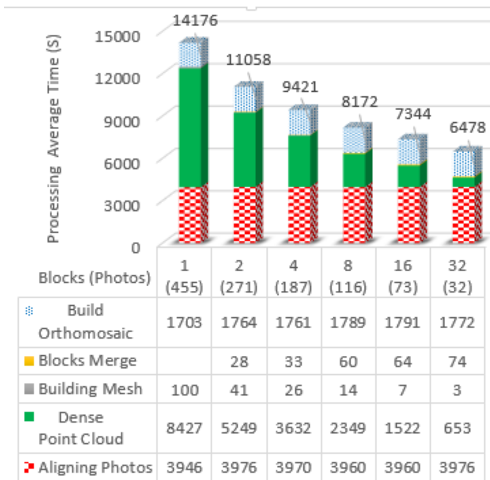

Fig. 5 The whole area and block cutting operation time comparison table

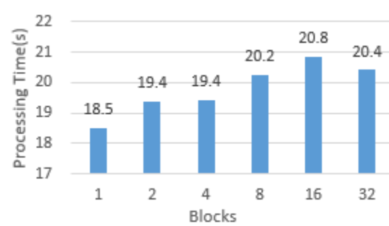

Fig. 6 Unit photo in each block dense point cloud generate average time

Table 1 Report on floor resolution and projection error of each block

Blocks	GSD (cm/pixel)	Reprojection error (pixel)
1	3.05	1.1
2	3.05	1.13
4	3.06	1.17
8	3.07	1.22
16	3.06	1.23
32	3.05	1.22

In the experiment of coordinate differences for the 16 check points, all the differences are less than 1 pixel (3cm), as shown in Fig.7(a)(b).

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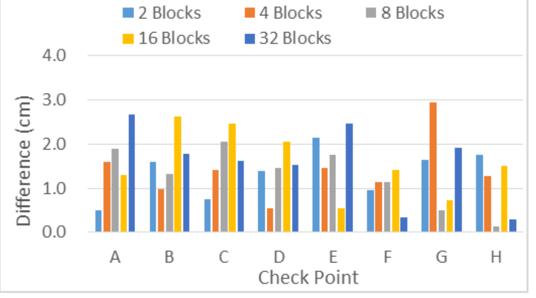

Fig. 7.(a) The difference between the check points A ~ H and the whole area

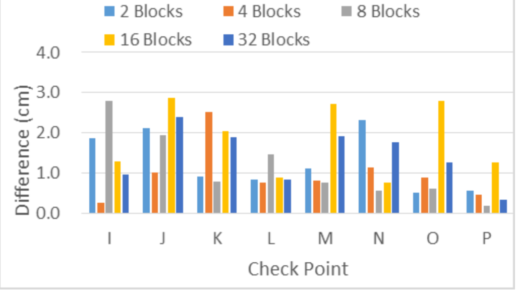

Fig. 7.(b) The difference between the check points I ~ P and the whole area

Conclusion

For a wide range of orthophoto processing, images with cutting blocks have the advantages of parallel and distributed processing. It can improve the efficiency of processing. And because the pixels size is also become smaller, the computer hardware specification requirements will be also reduced in many ways. This will has the characteristics of cloud processing.

Secondly, as to the difference of the coordinates of the check point, the whole area has the control point to make the pixel position error be restricted. By way of the block cutting and then merging back, in the condition of sub-blocks without control points, the difference between the coordinates of check point is still less than the ground resolution of 1pixel. The feasibility of this method was verified.

In this experiment, UAV aerial images were used with check points overlapping. This lacks of field distance measurement and fails in the accuracy of the distance. It can be improved for future experiments.

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