Method of extracting control points from GF-7 remote sensing image based on five-layer-fifteen-level tiles

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Abstract: In view of the traditional manual and semi-automatic methods can not quickly and effectively extract control points, this paper uses five-layer fifteen-level tiles (FLFLT) as reference images, and proposes an efficient and automatic method for automatic extraction control points of GF-7 image. Firstly, the remote sensing image and reference image are sampled down, and the remote sensing image is partitioned to improve the image processing efficiency. The Harris algorithm is used to extract the feature points of the remote sensing image and reference image, the normalized cross-correlation (NCC) algorithm is used for feature matching, and the Random Sampling Consistent (RANSAC) algorithm is used for gross error elimination. Finally, the least-square algorithm was used to fit the geometric transformation parameters, and the geometric transformation model was used to carry out geometric correction of GF-7 image, and the better correction results were achieved. Experimental results show that the proposed algorithm can extract control points quickly and effectively, and can be used for automatic extraction and geometric correction of high resolution satellite data.

1. Introduction

Aiming at the characteristics of large amount of multi-source remote sensing image data, high resolution and non-standardization of geographical location information, the former Institute of Remote Sensing and Digital Earth designed a five-layer-fifteen-level (FLFLT) remote sensing data organization model[1]. Based on this model, the research can quickly carry out the operational and mass processing of remote sensing image[2]. Compared with other spatial data management methods, this model can solve the problems of precision loss and unable to update locally[3]. Meanwhile, the redundancy information of each image based on this model is the lowest, which has obvious advantages in meeting the national scale standard[4].

GF-7 satellite has high spatial resolution, high time resolution, high spectral resolution, high positioning accuracy of the earth observation ability, the texture features are clear and the spectral information is rich for each image[5]. It has realized the 1:10,000 scale satellite stereoscopic mapping, and play an important role in territorial mapping, urban and rural construction, statistical investigation and so on[6]. Before the Gaofen-7 satellite images are put into use, geometric correction is needed to eliminate the geometric distortion caused by the satellite attitude, atmospheric influence, earth rotation and other complex environment in the imaging process[7]. To register GF-7 images, the original processing method with manual operation needs a lot of manpower and material resources, and due to the influence of human subjective factors, there will be different errors, which affects the production efficiency[8]. Therefore, finding a fast, high precision and automatic registration method of GF-7
image has a better application prospect[9].

In this paper, FLFLT were used as reference images to extract control points of GF-7 image[10-11]. The GF-7 image was segmented and the corner points were extracted by Harris algorithm[12]. Searching the best matching point as the control point between the GF-7 image and FLFLT[13]. Finally, The GF-7 image was calibrated by control points which the accuracy less than 1 pixel, and the corrected image was aligned well with the reference image[14-15].

2. Method

Fig.1 shows the process of extracting control points from GF-7 images based on FLFLT. Firstly, the GF-7 image and FLFLT were sampled down. Then, the GF-7 image was segmented into blocks, and Harris algorithm was used to extract a large number of corner points in each block images. The normalized cross correlation (NCC) algorithm was used to find the feature points on FLFLT. The RANSAC algorithm was used to eliminate gross errors and retain most of the better quality control points and then output them. The least square method was used to fit the geometric transformation parameters and the control points were used to correct the GF-7 image.

3. Experiment and Evaluation

3.1. Experimental data

(1) Remote sensing image

In this paper, we use a GF-7 multispectral image to extract control points which located in the southwest of Mudanjiang City, Heilongjiang Province, China. The basic image information is shown in Tab.1 and the product grade is 1A.

| Tab.1 Basic Information of GF-7 Satellite Image in Research Area |
|---------------------------------------------------------------|
| Collection Time | Center Lon/Lat | Size | Coverage Area |
| 2021-01-10       | 129.3°E/44.1°N | 8967*10032 | Mudanjiang, Heilongjiang, China |

(2) Reference image

FLFLT were used as reference images. The segmentation principle of FLFLT is as follows. The sphere surface of the earth with each block was filled with a 1000×1000 image. Each layer has three levels with a size proportion of 5:2.5:1, and the ratio between each layer is 10:1. The block size of the first layer are 50°×50°, 25°×25° and 10°×10° in sequence, the second layer are 5°×5°, 2.5°×2.5° and 1°×1°. And so on for the layers of 3, 4 and 5.
3.2. Experimental results and evaluation

A total of 115,740 control points were extracted, and 4499 points were matched by NCC. There are 400 points after the gross error was proposed, and the median error was 2.10692. There are many control points.
points automatically extracted with different errors, so not all of them they are suitable for saving as control points. In this paper, the control points are sorted from small to large by errors. We select 30 control points whose errors are less than 1 pixel for geometric correction showed in Tab.2. Column 1 is the point number. Column 2 and 3 are the row number and column number, which correspond to the pixel positions of the control points on GF-7 image. Column 4 and 5 are longitude and latitude, which correspond to the geographical positions of control points. The final column is the error size, which represents the error of the control point relative to the reference tiles.

| Point NO. | Row      | Column   | Lon./°   | Lat./°   | Error/pixel |
|-----------|----------|----------|----------|----------|-------------|
| 1         | 19812.49153 | 7881.971271 | 129.405924 | 44.164808 | 0.095977    |
| 2         | 14970.92959 | 14609.98244 | 129.348487 | 44.1276  | 0.12185     |
| 3         | 18103.17515 | 9679.840285 | 129.386953 | 44.158081 | 0.166885    |
| 4         | 871.564006 | 26760.97802 | 129.198333 | 44.06148 | 0.207614    |
| 5         | 14508.7364 | 11097.98156 | 129.352447 | 44.153168 | 0.215121    |
| 6         | 2989.442538 | 9204.82009  | 129.346444 | 44.182897 | 0.238083    |
| 7         | 1859.351  | 8179.52009  | 129.393995 | 44.168132 | 0.264779    |
| 8         | 7849.286227 | 18012.64313  | 129.278786 | 44.113595 | 0.34007     |
| 9         | 14198.02808 | 12456.16453  | 129.346668 | 44.143959 | 0.371591    |
| 10        | 7380.287799 | 22420.49814  | 129.264722 | 44.083052 | 0.388       |
| 11        | 18969.42116 | 12106.63661  | 129.388955 | 44.139675 | 0.462069    |
| 12        | 15653.90769 | 12883.31941  | 129.358376 | 44.138893 | 0.493462    |
| 13        | 13834.03287 | 6892.816415  | 129.356144 | 44.183929 | 0.519549    |
| 14        | 9475.717082 | 21250.81032  | 129.285622 | 44.088354 | 0.519608    |
| 15        | 9448.028617 | 3158.563643  | 129.326416 | 44.216635 | 0.531089    |
| 16        | 7183.400455 | 6631.514837  | 129.298827 | 44.195212 | 0.546421    |
| 17        | 9129.770848 | 18192.32534  | 129.289566 | 44.110525 | 0.558663    |
| 18        | 9646.966722 | 6016.102849  | 129.321672 | 44.196063 | 0.580938    |
| 19        | 15769.4814 | 11945.08748  | 129.361484 | 44.145375 | 0.587701    |
| 20        | 7022.460598 | 18199.16494  | 129.271172 | 44.113447 | 0.618811    |
| 21        | 13363.63468 | 20384.42219  | 129.321381 | 44.088973 | 0.658644    |
| 22        | 2014.944687 | 8816.226051  | 129.248872 | 44.18703  | 0.684577    |
| 23        | 10241.22467 | 21790.16924  | 129.291066 | 44.083423 | 0.772282    |
| 24        | 4443.09177 | 12269.78124  | 129.262161 | 44.159106 | 0.773874    |
| 25        | 13674.99179 | 23387.79708  | 129.317248 | 44.067282 | 0.788268    |
| 26        | 16127.9613 | 19834.91744  | 129.346672 | 44.088937 | 0.87895     |
| 27        | 13606.52085 | 17928.42113  | 129.329052 | 44.106045 | 0.911498    |
| 28        | 7371.631049 | 14699.07882  | 129.282149 | 44.137767 | 0.932171    |
| 29        | 21124.77247 | 13533.56419  | 129.404478 | 44.126483 | 0.938443    |
| 30        | 20668.18862 | 17781.71259  | 129.390818 | 44.097042 | 0.998493    |

The control points in Tab.2 are used to carry out geometric correction for GF-7 image based on the quadratic polynomial model. Fig.3(a) is the overall checkerboard map of the corrected GF-7 image and the FLFLT. Fig.3(b) is the checkerboard map of the local area I~IV. Compared with Fig.2, the GF-7 image and the edge features of area I~IV are well aligned.
4. Conclusion
In this paper, the control points of GF-7 image are extracted automatically through the research of corner point extraction algorithm. The errors of extracted control points are different, so it is not ideal to use all of them for geometric correction. Therefore, the errors of extracted control points are sorted, and the small error control points are selected as the final control points. Finally, checkerboard maps are used for analyse the corrected GF-7 image and FLFLT, the method has a good effect on the experimental data. However, sorting the control points may make them distribute uneven, further research will be carried out in the future.

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