RESEARCH ON POSITIONING AND ORTHO-RECTIFICATION OF SINGLE HIGH-RESOLUTION IMAGE BASED ON GENERAL SENSOR MODEL

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Abstract: High-resolution images, commonly including SPOT, IKONOS, QuickBird and so on, are all obtained by a push-broom sensor consisting of a linear CCD array. For these images, the traditional method of positioning and ortho-rectification based on collinear equation is rigorous in theory, but the advantages are inconspicuous. Meanwhile, because of the advantages including independence of sensor, independence of coordinate system, and good real-time performance, the general sensor model is in well accordance with the trend of diversity of sensors. So, this paper researches on positioning and ortho-rectification of single high-resolution image based on general sensor model.

1. Introduction to general sensor model

Commonly, the general sensor models include polynomial model, direct linear transformation model and rational function model.

Polynomial model is marked by its simply form and low requirements for the number of GCPs. And it is the most commonly used model in actual practice. Polynomial model is provided by nearly all remote sensing image processing systems as a positioning model. Traditional polynomial model includes 2D-polynomial and 3D-polynomial.

Direct Linear Transformation (DLT) model is widely used in close-range photography and is leaded into positioning of high-resolution image along with the emergence of push-broom sensor consisting of a linear CCD array. Traditional DLT includes Generic DLT (GDLT), Self-calibration DLT (SDLT) and Extension DLT (EDLT).

Rational Function Model (RFM), and its coefficients are provided in corresponding RPC file.

2. Positioning of Single High-Resolution Image Based on General Sensor Model

Coordinate in image space and coordinate in object space can be gained through positioning using the direct form and indirect form of general sensor model. These processes are called image space positioning and object space positioning respectively. The flow of image space positioning can be described as follows:

(1) Solving coefficients for direct model

(2) Positioning using selected direct model

(3) Assessment of positioning accuracy
Statistical value of certain index (i.e. RMSE) is computed to assess positioning accuracy.

The flow of object image positioning can be described as follows:
(1) Solving coefficients for indirect model
(2) Solving the initial value of plan coordinate in object space
(3) Solving 3D coordinate in object space iteratively
(4) Assessment of positioning accuracy

3. Ortho-Rectification of Single Image Based on General Sensor Model

Image space positioning and object space positioning are the basis of indirect solution and direct solution of ortho-rectification. Because iteration is needed and pixels of ortho-image are irregularly distributed when using direct solution, indirect solution is more frequently used in practice. As an alternative solution, it's necessary to have research on direct solution.

3.1 Direct Solution

The basic idea of direct solution is to solve the coordinate in selected ground coordinate system for each pixel in original image. It includes the following steps:
(1) Solving the 3D-coordinate in object space for each pixel in original image based on object space positioning iteratively;
(2) Solving corresponding pixel coordinate in ortho-image;
(3) Gray assignment based on gray overlay.

3.2 Indirect Solution

The basic thought of indirect solution is to solve the coordinate in original image for each pixel in ortho-image. It includes the following steps:
(1) Solving the ground coordinate for each pixel in orhto-image;
(2) Solving pixel's coordinate in original image for each pixel in ortho-image based on image space positioning;
(3) Gray interpolation for these non-integer pixels;
(4) Gray assignment for pixels in ortho-image.

4. Experiments and Analysis

A sub-image of an IKONOS Reference image of Liaoning Province is chosen to validate the algorithm. 13 irregularly distributed GPS GCPs are collected. A DLG product with a scale of 1/10000 is used as DEM.

4.1 Experiments of Positioning of Single Image

Several comparatively well-distributed GCPs are selected to solve the coefficients of general sensor model using least-squares method. Other GCPs are used as check points. From the image space positioning results of First order 3D-Polynomial (FTP), Second order 3D-Polynomial (STP), DLT, SDLT, EDLT and RFM, it is obvious that the best positioning accuracy of sub-pixel is obtained using RFM, while the positioning accuracy of STP is worst. That's because region covered by a single IKONOS image is

comparatively small, STP can’t fit the image deformation well.

4.2 Experiments of Ortho-rectification of Single Image

Based on the theoretical and experimental researches on positioning using different general sensor models, experiments of ortho-rectification of single image using blocking rectification with the support of DEM are carried out. Ortho-image and cognominal TFW file are acquired. one ortho-image is obtained by indirect solution using RFM and registered DRG in ArcGIS; the other ortho-image is obtained by direct solution using RFM.

As seen from the experimental results, registered DRG tallies closely with the ortho-image obtained by indirect solution. There is no obvious flaw existing in the ortho-image obtained by direct solution and it’s gray information is consecutive and integrated. The shape and size of ground object in these two ortho-images have no visible difference.

5. Conclusions

(1) In the process of positioning and ortho-rectification of single image, satisfying accuracy can be gained when general sensor model that can fit image deformation well is selected. In practice, check points should be used in a sub-image to validate models and the model with best accuracy should be chosen;

(2) In the process of error compensation for positioning using RFM, transformation using 1 GCP which is selected through cross-validation can obtain satisfying positioning accuracy;

(3) Gray overlay can solve the problem of gray interpolation in direct solution effectively and help get reasonable and practicable ortho-image.