A New Spatial Interpolation Method of GCP Datum of Remote Sensing Images*

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Abstract: A new method, called dynamic space projection method that is suitable to remote sensing image,is adopted to encrypt GCP (ground control point) datum in this paper. The essence of this method is to encrypt enough GCP by using a few known GCP in order to realize the precise correction of remote sensing image. By making use of the method to the GCP datum encrypting and precise geometric correction of TM image and SPOT image, the precision of encrypted GCP is less than one pixel, the precision of precisely corrected image is less than two pixels.

Keywords: Spatial Interpolation, GCP Datum, Remote Sensing Image, Space Projection.

1.Introduction

A basic problem of geography is that according to the known characteristic of geography space to search after the unknown one. For example, in the process of remote sensing image precise processing or target precise positioning by using remote sensing image, the basic problem is to determine the geographic coordinates of unknown points by using the known ground control points(GCP).In the research of remote sensing image precise processing, the problems of precise geometric correction of images of the region, such as ocean, desert, depopulated and cloud covered, that is short of GCP are often encountered, traditional methods, such as polynomial and co-linear equation method, needs amount of GCP, so they can't able to solve this problem effectively.

In this paper, we attempt to put forward a new method, called dynamic space projection method that is suitable to remote sensing image, to deal with this problem. The dynamic space projection method model is that supposing a dynamic cylinder tangent to the surface of the earth instantaneously, as is show in figure 1, and denoting the image datum by the cylinder coordinate system, according to this geometric model, the mathematical model can be deduced. The model exactly simulate the physic

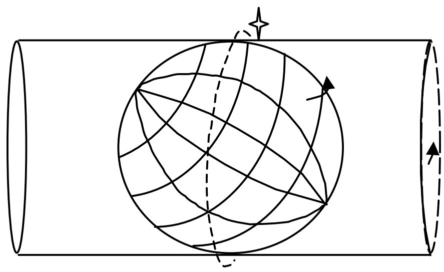

Fig.1. Geometric model of SOM

course of the satellite imaging, the swing of scan lens, movement of satellite, rotation of the earth and move forward of the track are considered together in the process of modeling, therefore, the model is the perfect one to describe the satellite image.

2、Mathematical formula of the space projection model and its linearization

According to the geometric model above, the formula of SOM can be deduced strictly. Taking the orientation of the flight of satellite as x axis, the intersection point of satellite orbit and equator as

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origin, to build the coordinate system by right-hand rule. Refer to paper [2] (J.P.Snyder, 1977), the formula of SOM is

$$X = a\int_0^{\lambda''} \frac{HJ - S^2}{(J^2 + S^2)^{1/2}} d\lambda - \frac{S}{F(J^2+S^2)^{1/2}} \ln tg\left(\frac{\pi}{4} + \frac{\phi''}{2}\right) \qquad (1)$$

$$Y = a\int_0^{\lambda''} \frac{S(H + J)}{(J^2 + S^2)^{1/2}} d\lambda + \frac{S}{F(J^2+S^2)^{1/2}} \ln tg\left(\frac{\pi}{4} + \frac{\phi''}{2}\right) \qquad (2)$$

3. The experimentation of the GCP encrypting

Adopting TM image to do GCP encrypting experiment by using the method of space projection, as is show in figure 2, the image size is 6466pixel× 5728line. Choosing 10 GCP to be control points and calculate points, shwing as table 1, where three points are calculate points, the others are check-up points.

Table 1.Table of GCP of TM image

No .	Pixel	Line	longitude	latitude
1	1697.0	184.0	113.176003	23.543786
2	2228.0	1698.0	113.260603	23.116206
3	3988.0	1496.0	113.778819	23.094656
4	2523.0	4140.0	113.234831	22.450397
5	416.0	5538.0	112.567192	22.164653
6	4392.0	269.0	113.953572	23.404797
7	5254.0	2839.0	114.080483	22.680464
8	421.0	2843.0	112.687178	22.886047
9	1492.0	156.0	113.118175	23.560178
10	442.0	1551.0	112.750819	23.231406

The appraisal method of the precision of encrypted GCP is as follows: The longitude and latitude of check-up points are calculated by formulas (1) — （2） ,then the new Gauss coordinates (x'_g, y'_g) can be calculated. Denoting the old Gauss coordinates by (x_g, y_g), unit is meter, then the corresponding geometric errors can be calculated by the following formula

$$Dx_g = x'_g - x_g,$$

$$Dy_g = y'_g - y_g,$$

$$Ds = \sqrt{(Dx_g)^2 + (Dy_g)^2};$$

where Dx_g, Dy_g, Ds are the absolute errors of x_g, y_g and distance orientation respectively ,

The average error can be calculated by

$$D = \sqrt{\sum_{i=0}^{7} (Ds_i)^2 \Big/ 7} \qquad (3)$$

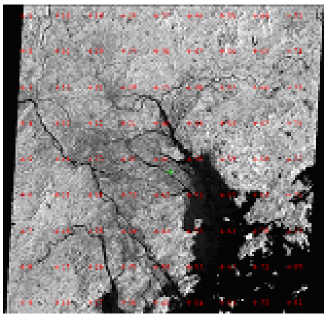

Fig.2. Original image

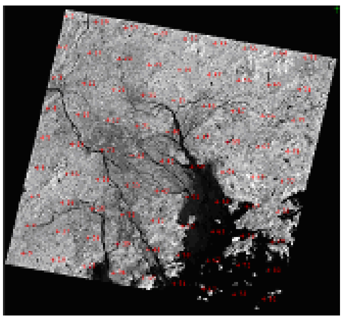

Fig.3. Rectified image

The average error of the encrypted GCP is 24.18m, equals to 0.81 pixel. Therefor, we can encrypt enough GCP for the image, for example, suppose a point's image coordinate is (2134,4521), the corresponding geographic coordinate can be calculated as follows

(longitude, latitude)

=(113.105647°,22.365211°)

So 81 GCP can be encrypted equably in the image, according to the 81 GCP, the image can be exactly rectify be using polynomial method, the rectified image is showing as figure 3, the precision is 1.48 pixel.

For another example, adopting SPOT image of Beijing area to do GCP encrypting experiment by using the method of space projection, as is show in figure 4, the image size is 6420pixel × 5999line. Choosing 15 GCP to be control points and calculate points similarly, where three points are calculate points, the others are check-up points.The average error of the encrypted GCP is 14.96m, equals to 1.496 pixels. Therefor, we can encrypt enough GCP for the image, for example, suppose a point’s image coordinate is (5068,3554), the corresponding geographic coordinate can be calculated as follows

(longitude, latitude)

=(116.621741°,39.680921°)

So 81 GCP can be encrypted equably in the image. According to the 81 GCP, the image can be exactly rectify be using polynomial method, the rectified image is showing as figure 5, the precision is 1.83 pixels.

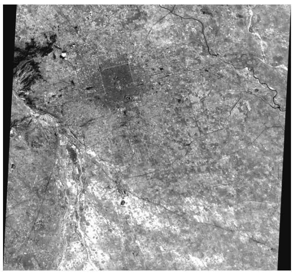

Fig.4. Original image

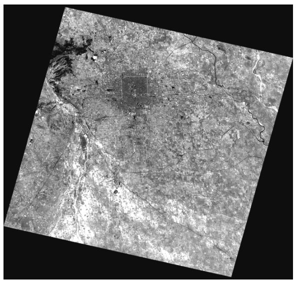

Fig.5. Rectified image

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