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Block-adjustment algorithm and Test for Three-line-array Image of high-resolution Remote sensing satellite

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Abstract: The geometric positioning process of high-resolution remote sensing satellite images was outlined. The necessity of block adjustment was analyzed. Combined with the imaging characteristics of line sensors, rigorous geometric model, satellite orbit model and interior O Rientation error model were researched on. Then The block math model of high-esolution remote Sensing satellite image was constructed. The elements of exterior orientation and interior orientation were using block solved method. ZY03 satellite images and ALOS PRISM images were tested in this way. The experiment demonstrated that the block adjustment method could improve the geometric accuracy of high-esolution E sensing satellite images.

Keywords: High resolution; remote sensing; line array; block adjustment; Satellite

with the continuous development of remote sensing technology and space technology , satellite photogrammetry Technology has become the focus of recent research and the heat of the Point . China to year 1 Month successfully launched resource third Test picture satellite . Resource No. Third satellite is our country's civil three-wire array stereo test [painted satellite , with a panchromatic camera and a multispectral camera on it two sensor . where , full-color Camera includes resolution about 2.1 m. under camera , The resolution is approximately 3. 6 m front and rear view of machine ; The resolution of a multispectral camera is approximately 5. 8 m[W].] Japan launches three-dimensional mapping satellite for 2006 Year ALOS (the Advance land observing satellite). ALOS satellite's Launch target is mainly for global stereo mapping , Environment monitoring and resource survey [3]. ALOS Satellite sensor pack Surround Stereo mapping sensor PRISM , near Infrared radiometer Avnir

and Synthetic aperture radar PALSAR .

After the satellite is launched , Is affected by external factors , such as launch Vibration , changes in temperature difference and acceleration after heaven , To make sensing The internal structure of the produces subtle changes . , to affect the satellite's inside azimuth element precision . in the satellite positioning process ,GPS Set prepare, The measurement error of the star-sensitive gyroscope device will also affect the final location result effect [4] . so , to get higher positioning fine degree , using Regional network adjustment method to solve internal and external azimuth element error Bad ,, to eliminate its impact on satellite positioning [5] . the first constructs A strict geometry model for the high resolution remote sensing Satellite line array sensor type , On the basis of this, the internal and external azimuth elements are calculated as a flat Difference

initial value ; By combining the actual flight conditions of the satellite , builds no the sameforeign-level model and internal azimuth model for testing .

1. mathematical Model

1.1 linear array sensor geometry

High Resolution remote sensing satellites carry GPS and star-sensitive screw , to record satellite flight position and posture . based on the number of auxiliary the location and posture of the satellite imaging moments , combines sensing Geometric information , to build resources third satellite imagery and ALOS PRISM Strict geometry model for images , Its general expression form [M]

where , (Xs , Ys , Zs) for a moment satellite location ; m is more than ruler coefficients ; and ECR for inertial geocentric coordinates to the Earth-solid core sit coordinate rotation matrix ; and E 0 C dy is the body coordinate system to the inertial core coordinate system rotation matrix ; and Batera for the sensor coordinate system to this body coordinate system rotation matrix ; PX and Py indicates that the image is on the previous a point in the sensor coordinate system in the pointing angle .

where , (X ,) A picture of a satellite image on a plane sitting like a coordinate values in coordinates ; (x 0 , y . is the coordinate value in the image plane of the primary point in the same position coordinates ; / is the camera main distance . binding (1) and style

(2) , Converts the rigorous geometric model of a satellite image to a traditional the collinear conditional equation for the (X-Xs) +i2I (Y-ys) +^3i (Z-zs)

x-x 0 ~-/ RlS (X-XS) +^23 (X-XS) +«33 (x-xs) '

-=-/ FII2 (x-xs) +^ (Y-ys) +^32 (Z-zs)

_-/ «13 (X-XS) +^23 (X-XS) +«33 (x-xs) •

(3)

where , represents the rotation matrix and the first I Row J elements of the column . rotate matrix R calculation formula is

W = (^RCC)_1. (4)

The foreign-corner element of any image point (P Flushes , K) to rotate matrices and calculations . foreign-line element (Xs, Ys,Zs) can be directly from GPS device measurement get .

1.2 Track Model

The satellite orbital model describes the satellite 's during flight position and posture Change . by establishing a satellite orbital model , can to fetch the foreign-bit element for each sample for a satellite Track model parameters . The advantage of the is that you can reduce the number of unknowns by The time the regional grid is out . builds on the orbital model

different , can generally be divided into lower-order polynomial models , segmented multiple Item model and orientation Slice model wait [M].

in satellite photogrammetry , can be based on actual flight conditions optimizes the trajectory model . currently on high resolution remote sensing satellite on- launchGPS device , Its measurement accuracy is often higher . as resources third satellite on dual-band GPS, after Precision fixed-rail processing , Its measurement precision reaches centimeter level . current high-resolution remote on satellite onboard star-sensitive gyroscope device , Its measurement precision is general to corner second level . under conditions of high satellite flight , from strict The build process for the lattice geometry model is known for the , angle Second level measurement precision has A significant effect on the final positioning result [1041] . because this , for better positioning accuracy , take appropriate modulo The type describes the change characteristics of the Posture .

Many scholars generally follow the selection of the orbital model directly model for aerial photogrammetry , with LPM Model , PPM modulo type or directional slice model for adjustment , not on track model refinement . here is an analysis of the high resolution three-wire array satellite measurements by the

special the point , finds strong dependencies between line elements and corner elements , The iteration is difficult to converge when the is in the solution .. due to current base of fixed rail this could be up to cm , The value of the line element is based on this feature As true value , building new track model , to Avoid a line element strong correlation between elements , to Achieve even if the A small number of control points can also obtain a stable solution . due to satellite flying relatively smooth in air , The can generally describe its attitude change characteristics by using a lower order polynomial model , is essentially a test The measurement data for the posture system is offset and drift error correction . The instantaneous foreign bit element can be represented as when The This [A]

X Si _ XS. 0 ;

Y St _ YS. 0 ;

. Zst _ Zs 0; (5)

Pt _ Po + + b P (* - *0);

_ « 0 + « ^ + (* - *0);

L Kt _ K 0 + (* - *0) •

where , (X S 0 , Y S 0 , Z S 0 , P 0 , 0 , K 0) = t 0 moment foreign bit element ; (, Y& , P , , is called , K ,) is * The foreign bit of the moment element ;(a ^ a ^ AJ offset correction for foreign-corner element ; (\, ", \) is the change in the drift correction of the foreign angular element

Rate .

1.3 Internal azimuth parameter model

camera system errors mainly include optical lens errors and CCD line array error . where optical lens errors mainly include camera lens distortion , The looks like the offset of the main point . CCD Line array error main package Surround meta dimension changes ,CCD scaling and CCD rotation change . according to this, The internal azimuth parameter model builds to [1344]

' Axs = Axp + (k1 [)] r2 + k 2 r4) x +

Pi (r2 + 2 x 2) + 2 P 2 x y + Sx ;

< 2 4 a - one (6)

Ays = Ay ^ + (kiR 2 + k[]2 r4) y + Pixy +

- 2 P 2 (r2 + 2 J 2) + ^ x .

where , Axs and Ays is the for any of the pixels in the image plane coordinate system system error Corrections ; Ax , and A ^ to sit like the main point on a plane like The offset value in the index ; k 1 and k 2 is a lens radial variable coefficient ; Pi and ^2 is the lens eccentricity distortion factor ; R for any image point to a like-ping Surface coordinate system origin from ;(x ,,) for any image point in the image level Surface coordinate system coordinates ; S is the scaling factor ; K is the rotation factor .

The internal azimuth parameter model takes into account the offset of a primary point , Lens Radial distortion , lens eccentric distortion , CCD Line Array scaling Effects of factors such as and rotation . but in actual adjustment , due to internal the parameters of the azimuth parameter model and the parameters of the orbital model are in the dependencies , The precision of the direct solution is often lower [1546] . to implement High adjustment precision , to build an inside azimuth parameter model with different parameters [] .

Many scholars in the adjustment generally follow the aerial photogrammetry directly The internal azimuth parameter model for the quantity . Consider each effect here because The child is built with the 8 The internal azimuth parameter model of the parameter . is based on this as the basis , constructs an internal azimuth parameter that contains the number of different parameters model , and use the actual data to model the internal azimuth parameters Line Validation Analysis , to seek for high-resolution three-wire array satellite transmission The internal azimuth parameter model of the sensor .

1.4 Area Network adjustment model

takes the orbital model parameters and additional model parameters as unknown number , Add formula (3) linearization , observing equation for regional network adjustment can be synthesized as

V = AX + by- l . (7)

where , V is the corrected number vector ; X is the orbital model parameter vector ; A the is the coefficient matrix of the parameter vectors of the orbital model ; Y is an attached model parameter vector ; B the is the coefficient matrix for additional model parameter vectors ; L is the observed vector . The corresponding formula is

bta btbJLy

Expressed as a new symbol

[Yy H :].

recognize 2

for easy calculation , to eliminate the number of point coordinate corrections X , is to the modifier equation to

(N - N2in ; ;Ni2) Y = (^2 - N2II.) . (i0)

will take advantage of the (io) solve Y Commodore (9) , to Find pending points coordinate corrections X. based on, update all unknown keep abreast into next iteration ,until precision meets requirements M .

2. Experiment and Analysis

2.1 experimental Data

using the resource third satellite and ALOS A satellite image as a Experiment Data .

The main coverage area of the resource third satellite image is Hebei Ann Flat area . The topography of the Anping area in Hebei province is mainly hilly , Terrain Downs are smaller . The main features of this area are rivers , House and farmland, etc. . ALOS main coverage area for satellite images is wide East Shantou . Shantou mainly for urban areas , buildings more . The measurement methods for the control points are manual measurements. Manual measurement accuracy about I pixel . due to image resolution , partially laid control points on farmland and road corners are difficult to find on image no . Remove the difficulty of a different control point after the, finally getan flat Area Control Point and Shantou Control Point . such as Chart i shows . Control point access to field GPS measurement , precision is decimeter level . All experiments are in self-developed software SAT Next Finish . Software development platform for VC+ +6.0.

2.2 Regional Network adjustment Experiment

to get an ideal adjustment precision , Select different Rails channel model and internal azimuth parameter model for regional Network adjustment experiment . azimuth parameter model to (A ^, A ^, ki , k 2, I , 2, S , ^ , use different orbital models for regional network adjustment experiments , Solid test results such as tables 1 shows .

The orbital model of the resource third satellite is a pose first-order , ALOS PRISM When the orbital model of is a posture constant , Build different internal The azimuth parameter model for regional Network adjustment experiment , experiment results like table 2 : .

consists of the table 1 knows , Resource No. Third satellite image adjustment using the pose State First-order orbital model , Precision more ideal . ALOS PRISM when the orbital model of the attitude constants is used when the image is flat , Precision is ideal .

consists of the table 2 Know , uses different additional parameter models , Adjustment With different precision . an increase in the number of additional parameter model parameters is not a will improve Precision . parameter number is too low , adjustment precision is also relative poor . This indicates that in order to describe changes in the inner azimuth element , on The appropriate additional parameter model .

because the internal structure of different satellite sensors is different , in flat You also need to select a

different internal azimuth parameter model when is poor . from table 2 to know , Select an additional parameter model (A ^ , A ^ , I , 2, S , and to Resource # Third satellite images when the adjustment accuracy is relatively reasonablewant ; Select additional parameter model (AVA ^Swhen) ALOS PRISM Image adjustment accuracy is already ideal . adjustment after error no Distribution Chart 2 is shown in . where the thin line arrows indicate elevation errors bad ; the thick-line arrows represent plane errors . the top and bottom of the arrow direction are "" positive or negative .

The is tested by the above orbital model and the internal azimuth parameter model to know for different high-resolution three-wire array satellites , Adjustment Use the orbital model of the attitude constants constructed in the article , in a handful of controls Make- point conditions , to achieve better accuracy .

But the selection of the internal azimuth parameter model should be based on different high resolution Rate three-wire array satellite sensor features , Building different inner orientations parameter Model . This may be different from the structural features and design principles of the high-resolution three-wire array satellite sensing . specific selection options to learn from the selection method , to achieve the ideal Adjustment Results .

3. closing

rigorous geometric model of a high-resolution remote sensing satellite sensor build off , Error factors affecting positioning results divide analyze , and build different orbital model and internal azimuth parameter model to perform a regional network adjustment experiment . experiment shows , different satellite sensors adjustment , due to sensor construction and on-board star-sensitive gyroscope have different precision , So in the orbital model and additional parameter model The selection of is not necessarily the same . selection of models with Adjustment both the considering the impact of error from all aspects , and avoid each error factor Strong correlation between, . the tradeoff between and Trade-offs is its difficulty .

for common PPM Model , LPM model and orientation slice model improved , for high-resolution three-wire array satellite Track model . When considering the internal azimuth parameter model , no direct The introduces a common internal azimuth parameter model containing 8 to. poor . instead of the level of precision after the adjustment , to include not Filter The internal azimuth parameter model with the number of parameters , thereby most finally select the appropriate internal azimuth parameter model , Got a bit of a better The adjustment precision you want .

Select the appropriate orbital model and additional parameter model adjustment after , Resource third satellite images have a plane precision of approximately 0.6 GSD ,elevation accuracy is better than 0. 5 GSD; ALOS PRISM image flat The precision is approximately 0.9 GSD , elevation accuracy is better than 0.8 GSD . Construction and selection of the track model and the internal azimuth parameter model in the text method , for other high-resolution remote sensing satellite sensors Regional Network The adjustment solution provides references and references to .

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