The digital rectification of aerial photos in the System PIPS

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Abstract

This article describes the algorithm and the programme for the digital rectification of aerial photos carried out in the PIPS system created at the Reseach Institute of surveying and Mapping.

Digitized rectification,which corrects the errors caused by photo's attitude and relief,is done bloch by block ,and with two mathematic models.a simplest operation is adopted for saving the computer time,but the same result of calculation as good as strict resolution can be acheived.

The algorithm and the programme structure are so designed that a possibility is available to perform,according to bundle principle,the geometric rectification of new generation sattelet image which has an instantaneous exposure centre.(for example,the SPOT imsges)

As a result,a photomap and an orthophotomap,which are printed from the scanner T-201S,are given.

Programme organization

the digital rectification programme package wos developed with the support of the operatingsystem PRIMOS in the PIPS system(prime-based image processing system) at reseach Institute of surveying and Mapping.the tree structure wos adopted in programming and data organization,and the command procedure programme and running programme are loaded in the system command user file directory CMDNCØ as an external command for calling .therefore,the user can conveniently share them under his owner directory and process the digitized photo data when he is in the system.

Many users can share it simultaneously,and the security of programme package and data are guaranteed.

The design of programme package saw the special consideration on the rectification of scanner images with instantaneous exposure centres.so,all the data files and intermediate result files ,all the algorithm and programme shown in each block(except the block marked with thick line)can be equally used:therefore,this programme package can also be adapted for the rectification of scanner images by adding only a computational programme of scanner image orientation.

the structure of programme package is shown in diagram 1.

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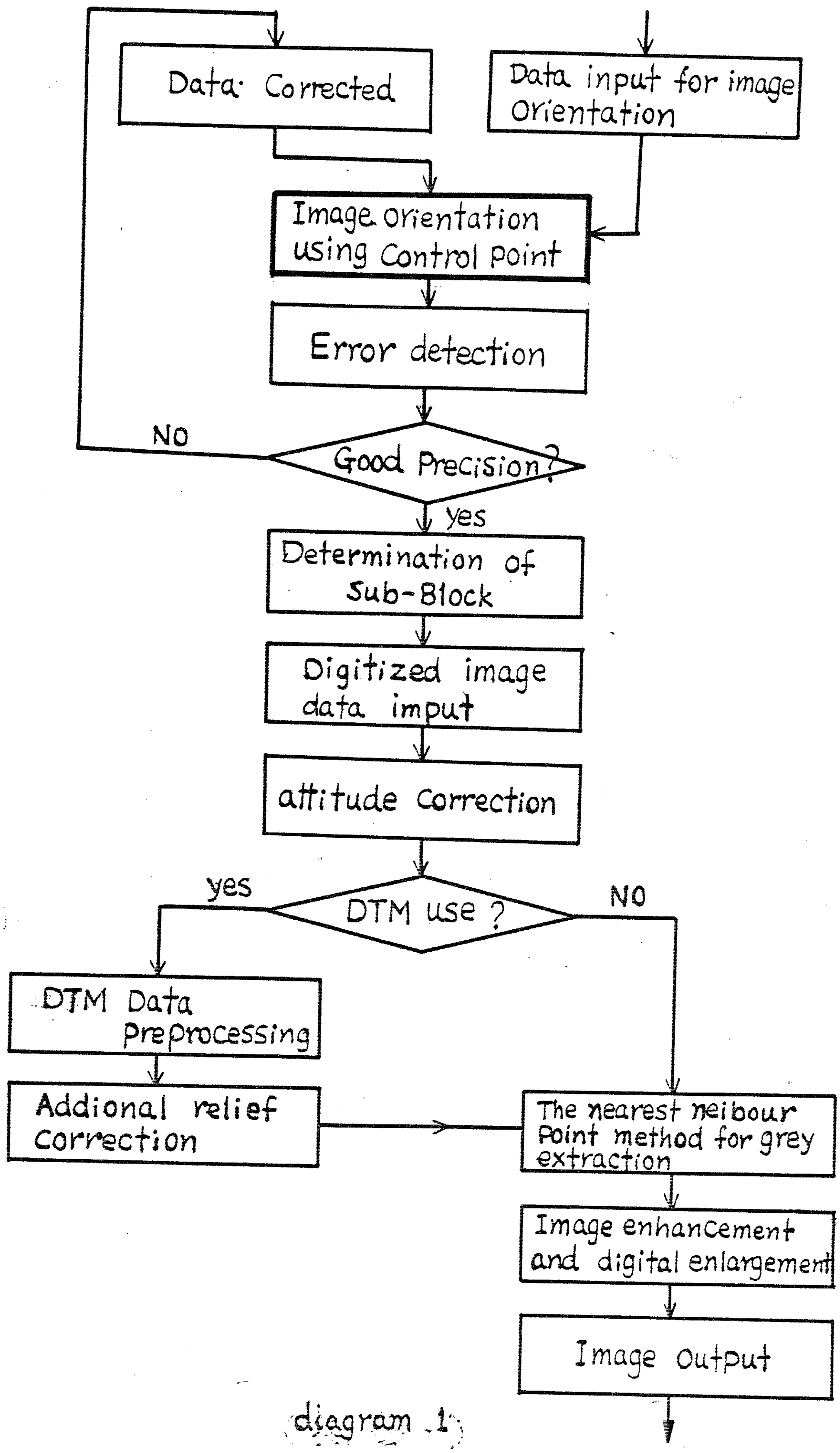


diagram 1

The photos orientation

The transformations or inverse transformation are necessary for aerial photo orientaion:

digitized photo coordinate system $\overset{I}{\rightleftharpoons}$ image plane coordinate system $\overset{II}{\rightleftharpoons}$ theoretical image plane coordinate system

$\overset{III}{\rightleftharpoons}$ map coordinate system

Transformation I containes a translation and a rotation, transformation II is something like an affine transformation, and transformation III is a projection transformation :

$$x = -f\,\frac{A1(X-Xs)+B1(Y-Ys)+C1(Z-Zs)}{A3(X-Xs)+B3(Y-Ys)+C3(Z-Zs)}$$

$$y = -f\,\frac{A2(X-Xs)+B2(Y-Ys)+C2(Z-Zs)}{A3(X-Xs)+B3(Y-Ys)+C3(Z-Zs)} \qquad (1)$$

If there are more than three contril points,formula (1) can be linearized,andby using iteration and least square method the photo orientation parameters$\varphi,\omega,k,Xs,Ys,Zs$ can be approximated:thus the attitude and position of aerial photo in space can also be determined.a scanner image(for example SPOT image)can also be oriented adopting bundle theoreom,and the calculation procedure used is almost the same , that the orientation parameters in formula (1) should be a function of the time,and that the number of control point to be used in scanner image orientation should be more than that in aerial photo orientation(1).

After orientation,using the DTM data file which is assumed to be available,any point on the map would be mapped to conjugate one on the aerial photo.

Blockette grey extraction

The resulting output that we need is either a rectified photomap or an orthophotomap.the grey in a rectified image is extracted from aerial negtive using indirect method.for simplicity,we devide a sheet of rectangular photomap into several blocks,(or grids)then according to formula (1),these rectangular grids,relative to original plane (Z=Z0),are inversely transformated into the center projection grids of the photo(figure 2).as a result,the attitude errors of photo are eliminated,but it is not the time for an orthophotomap.it needs an additionnal point by point correction of height difference by means of DTM data for a rough terrain.

$$Dx = Kx\,h \qquad Dy = Ky\,h \tag{2}$$

In formula (2),the coefficients Kx,Ky is derived through derivation of Z from formula (1) :

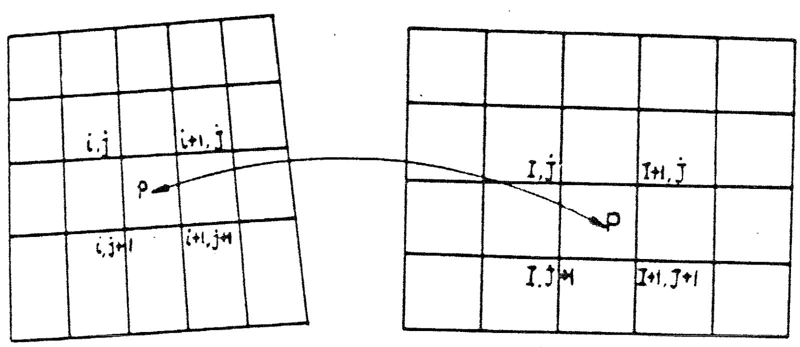
$$Kx = -\frac{(fC1 + xC3)}{A3X + B3Y + (C3(Z0 - Zs) - A3Xs - B3Ys)}.$$

$$Ky = -\frac{(fC2 + yC3)}{A3X + B3Y + (C3(Z0 - Zs) - A3Xs - B3Ys)} \tag{3}$$

The coordinates of perspective grid points in the photo and the relief correction coefficients Kx,Ky of the same points can be calculated at the same time by adopting formula (1),(3),so that,while the rectification is being performed with a bilinear transfomation grid by grid,the relief correction coefficients for any point can be interpolated according to the relief correction coefficients of the 4 grid points,and the additionnal height differance correction can be computed by using DTM data and the formula (2).

because of the blockette method adopted,the complicate projective transformation(formula(1)_(3))can be substituted by a simpler bilinear transformation without degradation of precision .For the program enables the calculation of pixels to be done all through the addition and subtraction method except for a single multiplication,the processing speed has been enhanced .

Grey extraction is based on the nearest neibourhood point method.



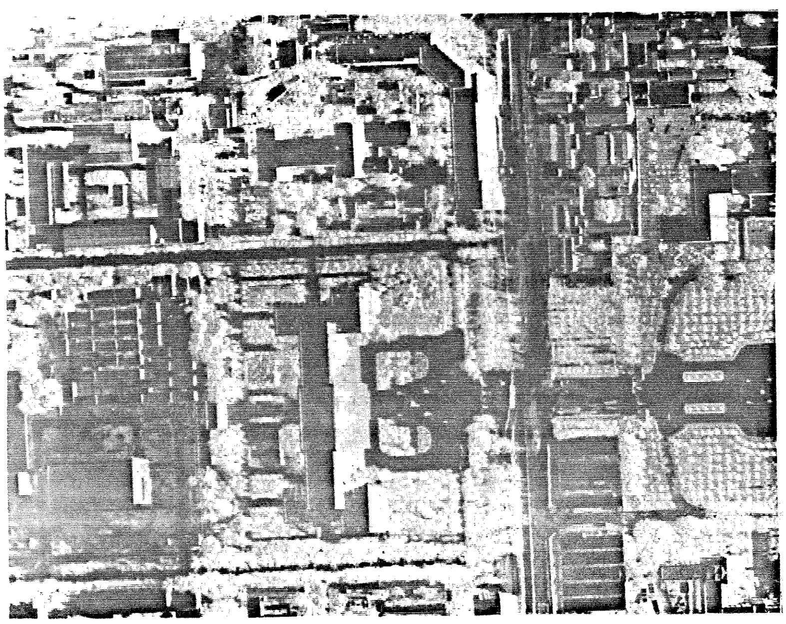
(figure 2)

Experiment and result

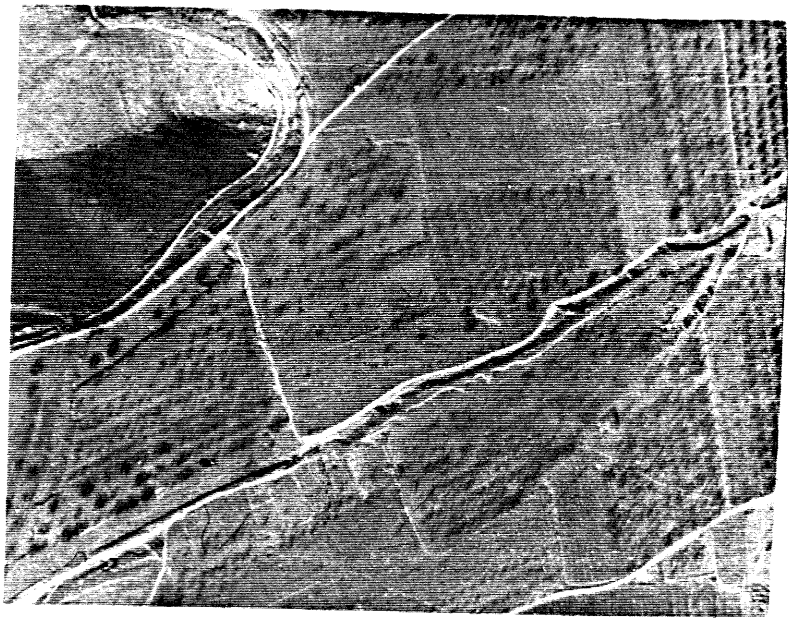
As a result of the digital rectification experiment on air photos two sheets of photomap have been tured out.for the photomap one,the scale of the photo used is 1:12000,Fk=152.89 mm,and the scale of the photomap produced is 1:1000.the orientation accuracy(MSE) wos 0.1mm on photo(using 20 check points) .the digitalization wos carried out on a pds digital microdensitometer,with sampling interval being 25μ.the digitalization for 4M data wos finished in 30 minutes.about one hour wos expended in doing digital rectification and grey extraction.because of the flat area no DTM data wos used.

For the second one,the scale of the photo that wos used is about 1:18000,Fk=98.62mm,and the scale of rectification orthophotomap is 1:1000.the orientation accuracy(MSE)wos 0.1mm on photo.(using 6 check points)with sampling interval being 12.5μ ,scanner digitalization of 16M data wos finished in 60 minutes .there are about 70m of height difference in the map,the DTM data acquired from the mannual digitalization of existing topographic maps wos used in digital rectification for getting an orthophotomap.about 200 minutes wos expended on blockette rectification and grey extraction..

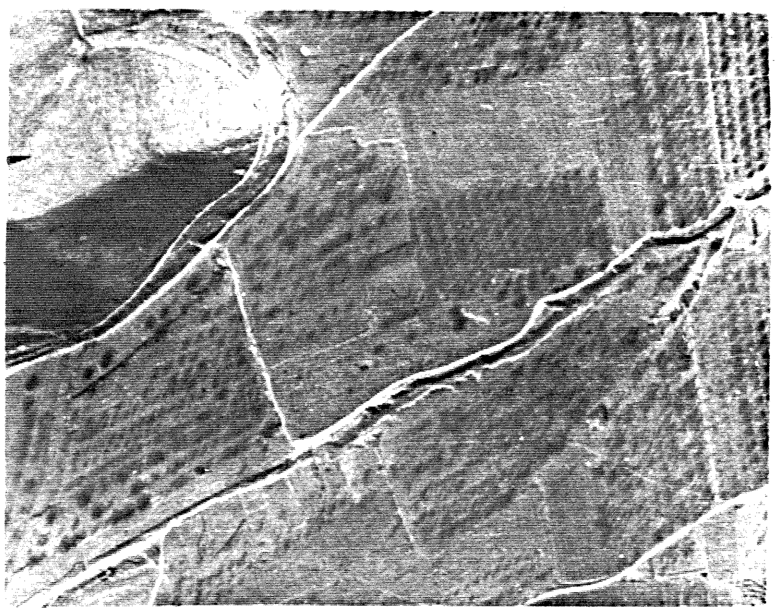
Rectified image output wos done on a T-201S scanner which is made in CHINA..



(figure 3) first sheet of photomap



(figure 4) second sheet of photomap



(figure 5) a sheet of orthophotomap

Conclusion:

1)a flatbed digital microdensitometer should be used to ensure the high resolution and high precision.To output a rectified photomap it is better to use a scanner of a large format (the scanner T-201s made in China has a format 55-50cm^2),and with an image resolution no less than 10pl/mm.

2)Obviously the digital rectification with comouter has a great potential and flexibility.such a programme package can process not only aerial photos but also any kind of scanner images with instantaneous exposure centres.For the practical application of digital rectification,the speed of processing must be raised.One of the solutions to this problem is possibly the application of special parallel microprocessor.

Refference:yang ming Hui, ren we chun :"the geometric rectification of a scanner image with instantaneous exposure centre".