Rectification Algorithm for Linear Pushbroom Image of UAV

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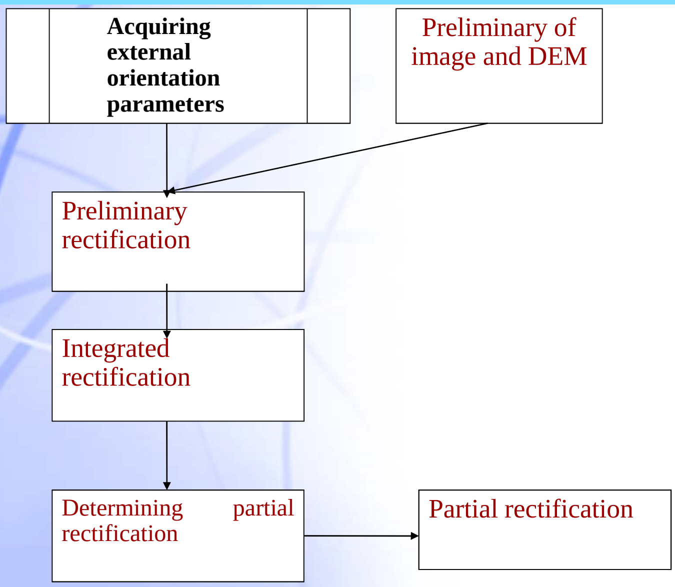
INTRODUCTION

In recent years, unmanned aerial vehicle (UAV) has become a strong supplement and an important complement for satellite and manned aerial remote sensing, because UAV has the ability to cover a large area, flight at higher altitude than before, and be not restricted to traveling on the dangerous place.

On the UVA, one of sensors is the multi-channel push broom sensor. Each linear array of the sensor consists of 6000 pixel array of CCDs which include blue, green, red and IR bands. The linear array can cover a stripe with approximately 6 Km on the ground. The motions (roll, pitch, yaw, etc) of the UVA platform are influenced by the relatively low-altitude flying so that have the attitude changed which are terrible to produce severe distortion of image.

a three-step rectification method is developed by mean of the DEM and GCPs (ground control points) of study area, as well as data of the positioning instruments (GPS, INS) on the UVA platform.

METHODOLOGY



Preliminary rectification

$$X' = X_S(l) + (Z_0 - Z_S(l))\frac{a_1(l)x - a_3(l)f}{c_1(l)x - c_3(l)f}$$

$$Y' = Y_S(l) + (Z_0 - Z_S(l))\frac{b_1(l)x - b_3(l)f}{c_1(l)x - c_3(l)f}$$

The external orientation parameters (position, attitude, six for each image line) of each linear array are calculated with data provided by the positioning instruments (GPS, INS), and then, the collinearity equation for multi-lens sensors is adopted with combining with the DEM data, finally, the original image can be rectified to level one (L1) image, 6000X6000 pixels in size approximately, which meets the requirements for accepted visibility.

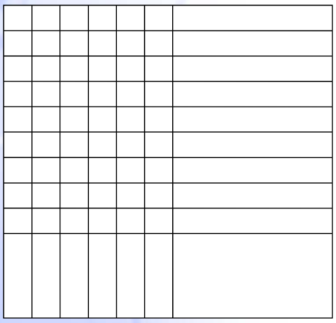
Integrated rectification

the sensor geometry is modeled with enhanced polynomials because this kind of functions is very flexible and can be adapted to different flight conditions. In this step, it is necessary that a reference image is used and several GCPs are selected in order to produce Level two (L2) image.

$$x = a_0 + a_1X + a_2Y + a_3Z + a_4XY + a_5YZ + a_6ZX + a_7X^2 + a_8Y^2 + a_9Z^2 (+ a_{10}XY^2$$
$$+ a_{11}XZ^2 + a_{12}XYZ + a_{13}X^2Y + a_{15}X^2Z + a_{16}X^3 + a_{17}YZ^2 + a_{18}Y^2Z + a_{19}Z^3)$$
$$y = b_0 + b_1X + b_2Y + b_3Z + b_4XY + b_5YZ + b_6ZX + b_7X^2 + b_8Y^2 + b_9Z^2 (+ b_{10}XY^2$$
$$+ b_{11}XZ^2 + b_{12}XYZ + b_{13}X^2Y + b_{15}X^2Z + b_{16}X^3 + b_{17}YZ^2 + b_{18}Y^2Z + b_{19}Z^3)$$

Partial rectification

- **The image is divided by 20 x 20 grids, which 300 x 300 pixels are included in each grid**



Firstly, the dense GCPs are matched to L2 image, which display and calculate whether exist the partial distortions or not.

Secondly, to segment the whole L2 image to neighboring partial images, Delaunay triangle transformation algorithm, a scheme of disassembling the entire image into multi-triangles to form a network, is introduced, and the GCPs are used as the vertexes of the triangle in the network.

The partial rectification impulation

(1) 1- 3 GCPs are selected by manual in order to acquire X’ and Y’ coordinates of the image;

(2) obtain the actual coordinateds of X, Y and Z;

(3) calculating the difference of the X, Y and Z by the fomula:

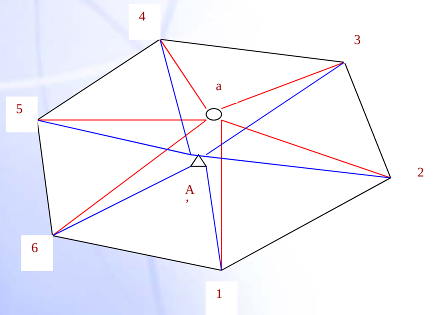
$$\Delta X = X' - X,\ \Delta Y = Y' - Y$$

(4)If $\Delta S - \sqrt{\Delta X^2 - \Delta Y^2} > T$ the GCP is marked as pending rectification, otherwise, the GCP is corrected.

(5)Extracting all of the corrected points and the pending rectificated points, building TIN by the Delauney Triangulation or Angle Judgement.

(6) Determining the pixels which belong to some triangulation and then, the image is divided to several triangulations by the pixels.

In each triangle, the partial image pixels are corrected using the geometrical stretch method and meanwhile, the adjacency of each triangle must keep the coherence. After the pending point of ”a” is rectified to the corrction point of ”A”, the partial rectification of the image is implemented.



CONCLUSION

Many experiments have been carried out in different conditions and areas using the method mentioned above. The results that present the three step rectification are feasible and effective.