Experimental research of Double-Camera Low Altitude Photogrammetry

Hongcheng Liu
National Key Laboratory of Remote Sensing Information and Imagery Analysis,
Beijing Research Institute of Uranium Geology
Beijing,China
liuhckangl@gmail.com

Zongjian Lin
Research Center of Surveying and Mapping
Chinese Academy of Surveying and Mappin
Beijing,China
Lincasm@casm.com

***Abstract*-This paper focus on the design experimentation system of data processing in two camera image, for experimentation of relief stereo mapping and on image processing methods, which base on its composition and dual combination of wide angle digital camera design principles. Practice shows that flight efficiency can be doubled. At last, through experiments the Double Camera Low Altitude Photogrammetry System can achieve 1:1000 scale aerial photographic tasks. As a branch of remote sensing the UAV Borne Double Camera Law Altitude Photogrammetry develop greatly and have a spacious application foreground.**

Keywords-low altitude photogrammetr; wide-angle dual combined digital camera; self-calibration

I. INTRODUCTION

With the rapid development and informationization of economy and society, the demand of high resolution remote sensing image increase every day. How to get fundamental geography data rapidly is a primary problem of our state construction and informationization. As a result of the aviation remote sensing platform and sensor's limit, the aerial photogrammetry is gaining the small area, the big scale data aspect to have the cost to be high, the ratio difference, the elevation cannot achieve questions and so on. Has the low cost and mobile nimble and so on many merit low altitude unmanned aerial vehicle remote sensing can gain the high resolution remote sensing image rapidly in the small area region, is the national aviation remote sensing monitor system important supply, will be the aviation remote sensing future development direction. Owing to the restrietion of platform's volume and weight, UAV can only use single camera system with stable platform presently. Single digital camera's coverage and base-height ratio is small, which increase the interior and field workload, moreover, the elevation accuracy is rather low. So, using Multi-Format mosaic technology, increasing the format size has become a research focus recently.

II. THE PRINCIPLE OF WIDE-ANGLE AND LIGHT SMALL DUAL COMBINATION DESIGN

Wide-angle and light small dual combination is use two cameras in the means of inner obliqus to join.Figure 1illustrate the perfect way. The camera's lens to match together. But this way has difficuly at to deal with CCD connect and spectroscope to fix. Presently the aerial aerial camera use the method of outer obliqus to join in general.The case in point is DMC. UltraCamD use the two ways.In the way of outter obliqus, owing to every camera has different size, the camera has height displacement result in projection focal can't overlap.

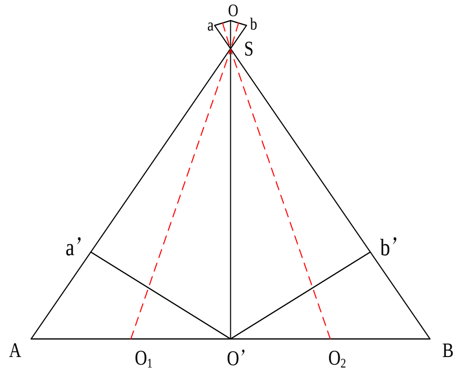

Figure 1. Perfect two canmera mosaic model

So, we can design the structure as So, we can design the structure asfigure2 illustrate. In this way, two camera to slope the same tumble angle ω, thus to make up the expand the view scope angle A1SA2 and to make up the overlap region B1SB2. We can conduct self-calibration with the help of the overlap region to confirm the origin distortion.

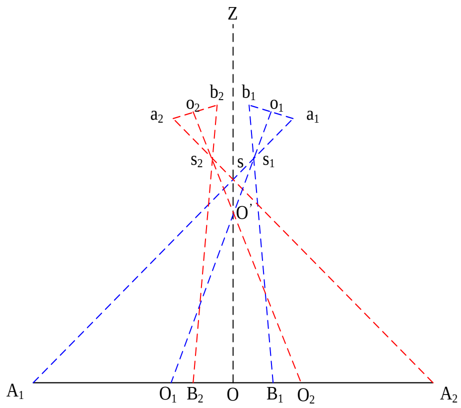

Figure 2. Field of view mosaic model with overlay

Actualy, wide-angle and light small dual combination of low-altitude aerial camera system design the structure which illustrate in Figure3. two camera fly along the airline to take a picture. The first camera to incline left ω angle, the second camera to incline right ω angle. In advance, accurate measure the two cameras themselves later photograph time by an oscilloscope. Consider the origin later photograph time in the synchronism control photograph structur.and the compensate later photograph time which inverse compute in accordance with the diatance of two camera in the fly dieection. We can design the the synchronism control photograph structure later time and can make the contemporary photograph probably in this way. The influence of the surplus time error can eliminate by the way of self-calibration in later.

Figure 3. Two combined-camera system

III. THE SUMMARY OF THE EXPERIMENTATION

A. The general situation of the experimential region

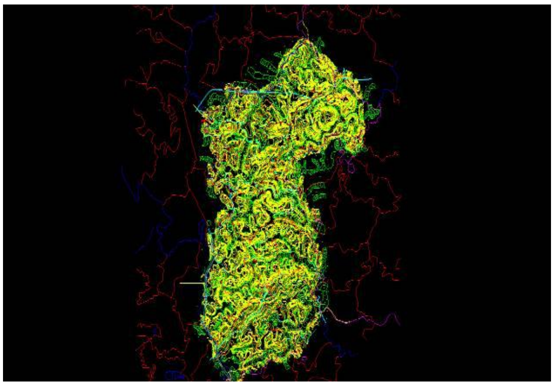

Figure 4. The relief map of experimential region

The experimential region is a mountainous region. The highest region is 323 miters. The lowest region is 323 miters. The terrain has the average slope about 6. Figure 4 is the relief map.Figure 5 is the map of contour line.

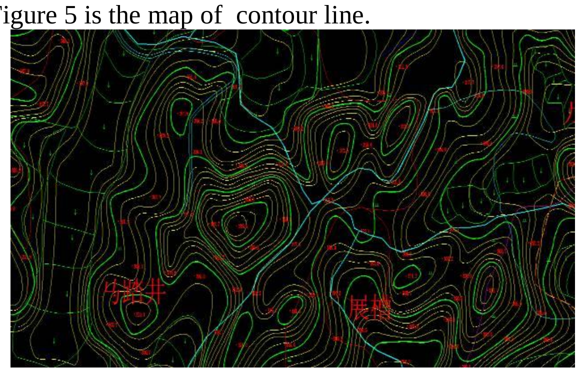

Figure 5. The map of contour line

B. The airline design of the experimential region

The experimental area about 15 kilometers. This flying height is 500 metres and gain 1006 images. The resolving power of image is 0.1 meters. Aireline design map for experiment is figure 6.

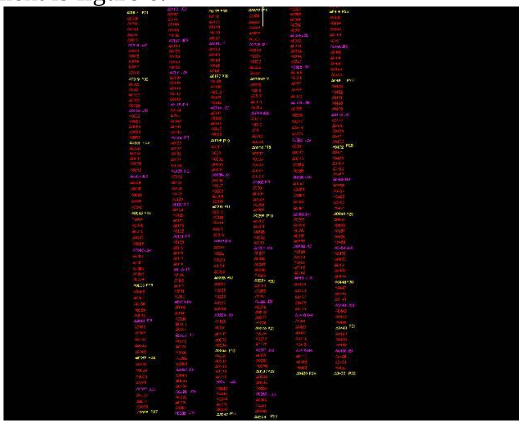

Figure 6. Aireline design map for experiment

C. Ground point measuring

Figure 7. Check Point Location

Figure 8. Control Point Location

We can choose the apparent feature in some images. The control point had better in the center of the image and the terrain is flat. In the interval of airelines maybe choose a aireline,in which choose the ground control point. In the interval of images maybe choose an image,in which choose the check point and the ground control point.Choose 32 ground control points and 51 check points in all in the region. Figure 6 is the Image control points layout picture.

IV. THE CALIBRATION AND MOSAIC OF TWO COMBINED-CAMERA

A. The calibration of Two combined-camera

Combined camera calibration is same as the general aerial photography camera calibration. Every camera use inner orientation and distortion correetion equation estimate camera parameters through to photograph the outdoor or indoor calibration field.

$$\left.\begin{aligned} x - x_0 + \Delta x &= -f\,\frac{a_1(X-X_s)+b_1(Y-Y_s)+c_1(Z-Z_s)}{a_2(X-X_s)+b_2(Y-Y_s)+c_2(Z-Z_s)} \\ y - y_0 + \Delta y &= -f\,\frac{a_3(X-X_s)+b_3(Y-Y_s)+c_3(Z-Z_s)}{a_2(X-X_s)+b_2(Y-Y_s)+c_2(Z-Z_s)} \end{aligned}\right\}$$

In which (x_0, y_0) is the internal orientation,f is the focal length, $\Delta x, \Delta y$ is the distortion。

$$\left.\begin{aligned} \Delta x &= (x-x_0)(k_1 r^2 + k_2 r^4) + \\ &\quad p_1[r^2 + 2(x-x_0)^2] + 2p_2(x-x_0)(y-y_0) \\ &\quad +\alpha(x-x_0) + \beta(y-y_0) \\ \Delta y &= (y-y_0)(k_1 r^2 + k_2 r^4) + p_2[r^2 + 2(y-y_0)^2] \\ &\quad +2p_1(x-x_0)(y-y_0) \end{aligned}\right\}$$

$$r = \sqrt{(x-x_0)^2 + (y-y_0)^2}$$

In which, r is the distance between image point and the center. k_0, k_1, k_2 is the radial distortion coefficient, p_1, p_2 is the tangential distortion coefficient.We can estimate the relative orientation parameter through Space resection,and then translate to combined camera calibration the coordinate system which use two-camera center projection line for virtual projection line. The calibration result illstruate in table 1.

TABLE I. TWO-CAMERA SYSTEM CALIBRATION RESULT

	Front Camera	Back Camera	VirtualCamer
Focal Length	3795.0126	3792.7652	3800
Image Width	5616	5616	9856
Image Height	3744	3744	3648
A1	7.89491E-09	7.91905E-09	0
A2	-5.35E-16	-5.32E-16	0
P1	1.5366E-07	-1.101E-08	0
P2	-3.52809E-08	-9.16327E-08	0
C1	-0.000281277	0.000337663	0
C2	0.00015474	-9.02062E-05	0

B. The mosaic of Two combined-camera

If elements of relative orientation has no error through analysis the overlay region and two camera exposure synchronously, the overlap region would be match together perfectly. But due to these two errors exist, the overlap region would be not match together. We can search out the parallax and vertical parallax cause by two images are not overlay in the characteristic through image matching. Then, we can estimate the remaining error by means of least squares correlation.

$$\begin{cases} \Delta x = \Delta b_x + \dfrac{x}{H}\Delta b_z + H(1+\dfrac{x^2}{H^2})\Delta\varphi + \dfrac{xy}{H}\Delta\omega - y\Delta\kappa \\ \Delta y = \Delta b_y + \dfrac{y}{H}\Delta b_z + \dfrac{xy}{H}\Delta\varphi + H(1+\dfrac{y^2}{H})\Delta\omega + x\Delta\kappa \end{cases}$$

Figure 9. Two- Camera Image and Virtual Image

Where x and y is known as the coordinate in which the origin coordinate is the principal point of photograph in the virtual image.H is the distance which between projection plane and projection center. Generally speaking，H maybe defined as $H = \frac{1}{2}(f_1 + f_2)$ .In which f_1 , f_2 is the focal length. Δb_x , Δb_y , Δb_z , $\Delta\varphi$, $\Delta\omega$, $\Delta\kappa$ is the remaining error of relative orientation and approximate value. We can eliminate paralla.The virtual image and photo are shown in Figure 9.

V. THE PROGESS OF AIR TRIANGULATION

A. Feature extraction in stereo photopair

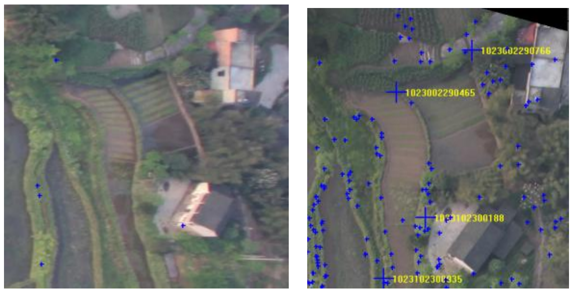

Figure 10. Feature extraction in stereo photopair

In the edge of the image, there are many deformations, as shown in figure 10, the corresponding image points has many difference in the stereo photopair. So, we must be as less as possible to extract the feature point in these region.

B. The error of relative orientation progess

We can estimate relative orientation parameters and extract the feature points in the relative orientation progess. Then , we can estimate the mean square error through block adjustment he result as shown in Table 2.

C. Region adjustment

We can choose the standard airline that fly height is stable from all aielines, then control other airelines in proper order use the control point in the among aireline model. At last estimate the MSE of the join point in the region adjustment process. The result of the coordinate MSE is 0.137, 0.214, 0.418.

D. Use GCP for absolute orientation

We can adjust the four ground control points be distributed over the region to the accurate location , then shear the image which other control point exist.which illstrute in Figure 11.At last estimate the coordinate MSE of the GCP is 0.143, 0.305, 0.495.

Figure 11. The Adjustion of the GCP

VI. CONCLUSION

Through experiments the paper proved that, wide-angle and light small dual combination of low-altitude aerial camera system can achieve 1:1000 scale aerial Photographic tasks.Due to the width parallel the flying direction, base-height ratio is short and the height precision is low. So, we can attempt the height parallel the flying direction, enhance the base-height ratio so that improve the height precision.

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