IMPROVEMENTS IN GROSS ERRORS DETECTION IN AERIALTRIANGULATION

João Bosco Lugnani
Edson Mitishita

Professor and Graduate Student at the
Universidade Federal do Paranã
Curitiba Pr. - Brasil -

Commission III

1. ABSTRACT

At the ISP Hamburg's Congress, 1980, it was decided that the Working Group III/3 would turn its attention first toward gross error dettection in the phototriangulation systems.

This work presents the results of investigation conducted by the authors in this area at the CPGCG- UFPR.

A set of procedures was developed and programmed. It was Implemmented and tested for off-line aerial triangulation. The results show improvements in processing time and in gross-error detection.

2. INTRODUCTION

The least squares estimation of parameters, generally used in phototriangulation, minimizing the quadratic form $V^TP\,V$, has also the property of distributing the effects of gross-errors of observations on the residuals.

The detection of blunders, gross-errors and outliers becomes a complicated task, especially when the number of such errors increases.

Several researches have done on the subject, by the cartographic community. Barda's method of snooping data, or some variant of it, were implemented for phototriangulation tests (Grü n, 1980; El- Hakim, 1981; Forstner, 1980). The efficiency of the detection increases, generally with the application of these approaches. A corresponding increase of processing cost accurs parallelly. Some computational savings can be obtained by the use of reliability models (Grün, 1980).

The reliability of the estimate parameters remains as a problem specially in cases when the number of blunders, gross-errors or outliers is large.

In this research a test was performed with a bundle block phototriangulation program, available at the CPGCG of the UFPR. The final results, after several runnings and removal of high residual observations, detected by the program, presented an acceptable precesion. the accuracy, however, was poor. the computed parameters presented high discrepancies from the known true values. The errors were intentionally introducted into the generated ficticious data, consequently these true values of parameters were known.

The external reliability of such computed parameters was neil

and the processing effort was very high, nevertheless the small residuals and acceptable inner precision indicate the opposite.

It is well known that the efficiency of statistical test increases when the number of gross errors decreases. In such cases the inner and external reliability become coherent.

This work presents a sequential screening of data aiming to minimize blunders and gross-errors on the data, for a bundle block adjustment. As a consequence, the external reliability increases and the processing effort is reduced.

3. PROCEDURES FOR GROSS ERROR DETECTION

The procedures used in this research screens the data sequentially, detecting blunders of photocoordinates first, in a planimetric linear transformation of adjacent photographs as it was done by El-Hakim (El-Hakim 1982).

The remaining blunders and gross erros of photocoordinates are dealled with in an analytical progressive strip formation. The collinearity equation is used to perform a relative orientation of each photo with respect to the previous one. Least squares adjustment is used to compute simultaneously the orientation parameters and the strip coordinates of points on the model. Positional constraint model, applied to the last points of the segment of strips formed, is used to introduce the scale into the new steriomodel. At any photograph newly added to the strip, the identification of gross-errors is done with the help of the variance-covariance matrix of computed parameters and with test on residuals.

Test fail causes interruption of the program for elimination of error and the adustment of that step is repeated. The error detection is somehow " on line " with this technique.

In every strip with three or more complete control points, the gross-errors of control are searched for, through a spacial similarity transformation adjustment with different sub-set of control to identify it. Variance,residuals, check points and personal judgement play important role at this step.

The data after this screening process is introduced in a bundle block adjustment program. The small number of gross errors, and even of outliers, present at the data, makes the inner and external reliability coherent, and reduces the amount of processing.

The technique was implemented and tested for a small block. The results are presented. Additional tests are being performed with different blocks and bundle programs.

4. TEST RESULTS

To test the presented approach, a three strips, twelve photos block, of ficticious data, was generated at the scale of 1:10000, with 153 mm focal length, 60% longitudinal and 20% lateral overlap. The block has 46 ground points, 8 of which are control points and 134 corresponding image points.

In order to test the algorithm, an available bundle block adjustment program was used twice. First with the data affected by blunders and gross errors intentionally introduced and later with the data screenned by the presented approach.

Table 1 shows points in image and object spaces with observed coordinates and with those coordinates affected by gross errors.

	PHOTOCOORDENATES				
Point	Precise observation			Observation with gross error	
	PH. Nº	X	Y	X	Y
642	1	86.133	38.458	86.233	38.358
669	2	91.533	-1.097	115.533	-1.097
669	4	-85.733	-1.742	-85.733	-1.702
622	7	89.909	-92.543	89.909	-92.593
627	9	0.699	-100.424	0.699	-117.424
636	10	2.231	-2.261	-2.301	-2.331
640	11	7.441	-1.361	7.380	-1.361
626	12	1.432	-1.247	1.402	-1.217
	CONTROL POINTS				
	Ground coord.			Ground Coord. with Gross errors	
	X	Y	Z	X	Y	Z
772	2550.000	6650.000	980.000	2549.000	6649.000	978.000
745	5050.000	2700.000	964.000	5050.000	2700.000	961.000

The results obtained by processing the block with the bundle block adjustment and the data affected by gross errors, is shown in table 2. Two points were properly eliminated and nine improperly removed by residual analysis.

As a consequence of this eneficient gross error detection, after eight execution of the program, the residuals at photo scale were acceptable (smaller than 0.020 mm), but the discrepancies with respect to the true values were too high. Table 3 shows a sample of this discrepancies.

Table 2. Shows points identified by the residual analysis through the bundle block adjustment program.

	11 ELIMINATED POINTS										
Point Nº	636	620	612	663	624	613	637	664	621	625	669
Photo Nº	9,10 11	5,6,7 9,10,11	1,2,3 5,6,7	1,2 3	9,10 11	2,3,4 6,7,8	2,3 4	2,3 4	6,7,8 10,11,12	10,11 12	3 4
Elimin.	right	wrong	wrong	wrong	wrong	wrong	wrong	wrong	wrong	wrong	right

Table 3. A sample of the discrepancies betwen estimate and true coordinates (data without screening)

Point Nº	DISCREPANCY		
	X(m)	Y(m)	Z(m)
610	1.128	0.195	0.458
615	0.231	0.183	3.659
628	0.002	0.035	0.787
630	0.001	0.036	0.197
633	0.793	0.273	16.431
634	0.334	0.492	2.643
641	1.058	0.023	0.553
642	0.742	1.627	20.494
667	0.683	0.141	0.328
668	0.201	0.272	18.615

The sequential screening of the data was then performed as proposed in the previous section. All those eight points with gross errors in their photocoordinates were identified and removed. Two points were improperly removed also.

The two control points with gross errors were also detected and removed. The detection of gross errors was not sharp enough to eliminate the error always only from the specific photo. In several cases the point was eliminated from one or two more photographs bisides the one with gross error. Table 4 shows the identified and eliminated points and the photo number from which they were eliminated.

Table 4. Shows the point number and photo number of points with gross errors by the sequential detection algorithm.

REMOVED POINTS			
Properly		Improperly	
Point Nº	Photo Nº	Point Nº	Photo Nº
642	1	634	6,7
669	2,3,4	644	5,6
622	7,8		
636	9,10,11		
640	10,11,12		
626	11,12		
627	9,10		

The obtained data was introduced into the bundle block adjustment program. The estimated parameters, after one run, presented discrepancies from the true values, as shown in table 5.
There is an agreement betwen inner and external reliability.

Table 5. Sample of discrepancies betwen true coordinates and those estimated through bundle adjustment of screenned data.

	FINAL DISCREPANCIES		
Point Nº	X(m)	Y(m)	Z(m)
610	0.031	0.033	0.151
615	0.015	0.089	0.188
628	0.016	0.084	0.141
630	0.041	0.044	0.027
633	0.004	0.022	0.060
634	0.174	0.042	0.298
641	0.041	0.100	0.259
642	0.095	0.061	0.028
667	0.087	0.058	0.172
668	0.025	0.006	0.062

5. CONCLUSIONS

The expected improvement on identification of gross erros by the presented algorithm and the corresponding benefits on the reliability were verified by the test.

The computational affort is reduced, once the preprossing programs are very small.

More tests are required and are being conducted, with different blocks and different programs, to verify, more precisely, the extent of benefit from the application of this sequential procedure of error detection.

Data snooping test should be introduced in the available bundle block programs to take into consideration redundancy of observation and the geometric configuration effects on the statistical analysis.

6. REFERENCES

(1) El-Hakim,S.F. " Data snooping with weighted observations ". Presented paper. ISP Commission III Simposium. Helsinki, 1982.

(2) El-Hakim,S.F. " A step-by-step strategy for gross-error detection ". Present paper, ISP Commission III Simposium. Helsinki, 1982

(3) El-Hakim,S.F. " A pratical study of gross-error detection in bundle adjustment ". The canadian Surveyor, vol 35,Nº 4. 1981.

(4) Forstner, W. " The theoretical reliability of photogrammetric coordinates ". Paper presented at the 14th ISP Congress. International Archives of Photogrammetry. Vol XXIII, part b3, Hamburg, 1980

(5) Grün, A. " Internal reliability models for aerial bundle systems ". Paper presented at the 14th ISP Congress. International Archives of Photogrammetry. Vol XXIII, part b3. Hamburg, 1980.