

COMPARISON OF SEMI - AUTOMATIC AND AUTOMATIC DIGITAL AERIAL TRIANGULATION

Romuald KACZYNSKI*, Jan ZIOBRO**

Institute of Geodesy and Cartography, Warsaw, Poland

*rom@igik.edu.pl

**ziobro@igik.edu.pl

Working Group III/2

KEY WORDS: Aerial triangulation, Automation, Accuracy

ABSTRACT

Two aerial blocks (93 and 56 photos) taken in different scales and of different qualities have been tested at the Institute of Geodesy and Cartography in Warsaw with two methods: semi-automatic with the use of ISDM INTERGRAPH and automatic with MATCH-AT Inpho. The results of comparison of two methods concerning their accuracy and usefulness in case of different quality of aerial photographs are presented.

1 INTRODUCTION

The comparison of results of Automatic Aerial triangulation with semi-automatic triangulation was the main task of the work. The comparison has been done on the basis of two blocks of aerial photographs taken without signalized GCP's. Independent check accuracy of aerial triangulation has been done. Also exterior orientation parameters have been compared. The usefulness of applying Automatic AT using duplicate diapositives with poor radiometric quality instead of originals of aerial photographs has been tested. Moreover, the study area was densely populated and covered by lush vegetation.

Two blocks have been used with natural GCP's identified with accuracy about 0.5 pixel and measured in the field. Aerial photographs have been scanned on PhotoScan PS-1 Zeiss/INTERGRAPH with pixel size 22.5 μm including photoalignment and compression by JPEG. Only Red band has been used for digital aerial triangulation.

2 DATA USED

Block No.1 consisted of town and residential area. As the LMK Zeiss camera was used - radiometric and geometric quality of the photographs were good. There were 17 natural, not signalized GCP's and 44 check points which have been identified and measured in the field with accuracy in X and Y - 9 cm, Z - 15 cm. The 93 photos were taken in 9 strips with end lap 60% and side lap 37 %. As the orthophoto maps of town were to be elaborated - LMK Zeiss camera with focal length 305 mm has been used.

Block No.2 was a part of a larger block, where photographs have been taken N-S/S-N in the framework of Phare project conducted in Poland in last few years. The strips have been taken in different times of the day. Duplicate diapositives that have been scanned were found to have radial deformation of up to 19 μm . Leica RC-20 camera has been used with focal length 152 mm and with end lap 60 % and side lap 30%. The block consisted of 56 photos taken in 4 strips. Block No.2 consisted of five towns and partly covered by forest. There were 16 natural GCP's and 16 checkpoints. Coordinates of all of these natural points have been identified in the field and measured by GPS technique with overall accuracy X, Y about - 45 cm and Z about - 30 cm.

All photographs have been scanned on the PS-1 PhotoScan Zeiss/INTERGRAPH with photoalignment, compression by JPEG (Q=25) and with pixel size 22.5 μm in Intergraph format. Only Red band was used for digital aerotriangulation. Description of the blocks is shown in Table 1.

Description	Block No.1	Block No.2
photo scale	1: 8 000	1: 27 000
No. of photos / strips	93 9	56 4
end lap/ side lap, %	60 / 37	60 / 30
camera focal length, mm	LMK 3000 305	RC 20 152
flying height, m	2700	4400
No. of control / check points	17 44	16 16
scanned material / channel	color, original red	color, duplicate red
pixel size, μm	22.5	22.5
terrain characteristics	city, partly open hilly	5 cities, partly forest, flat

Table 1. Aerial blocks data.

3 SEMI - AUTOMATIC AERIAL TRIANGULATION

Operator and automatic point transfer did point selection and measurements by digital image matching using ImageStation 6487 with ISDM INTERGRAPH software. In the each of the Gruber regions two tie points have been measured and transferred to all photos by correlation method. Natural points of good quality and contrast have been used as tie points. After measurements Least Square Matching (LSM) has transferred them to all overlapping photographs. About 26 tie points have been recorded for each photo.

Both blocks were adjusted with BINGO-F 4.0 software. Due to systematic deformation errors of duplicate diapositives block No.2 was adjusted with additional self-calibration parameters.

Data of semi-automatic aerial triangulation are shown in Table 2.

Description	Block No.1	Block No.2
No. of fiducials	8	4
mean σ_{int} , μm	4.3	5.3
No. of tie points per photo	26	26
total No. of tie points / connecting strips	630 350	366 175

Table 2. Data and parameters of semi-automatic aerial triangulation

4 AUTOMATIC AERIAL TRIANGULATION

Interior orientation parameters, GCP's and checkpoints data have been imported from semi-automatic measurements. Automatic Aerial Triangulation was performed on Image-Z with MATCH-AT Inpho version 2.0.0.6 software with following parameters:

- splitting factor - 4;
- number of tie points per area - 14;
- matching strategy - most accurate.

Two first parameters and a priori standard deviation of photo coordinates measurement have been roughly calculated. Both blocks have been then elaborated without any intervention of the operator. Block No.2 has been adjusted with self-calibration parameters with BINGO-F software. The data are shown in Table 3.

Description	Block No.1	Block No.2
parameters of AAT	most accurate splitting factor = 4 No. of tie points per area = 14 selfcalibration = no	most accurate splitting factor = 4 No. of tie points per area = 14 selfcalibration = yes
total No. of tie points	5616	3955
No. of tie points per photo	190	209
No. of clusters of tie points total / connecting strips	522 / 230	347 / 108
No. of suspect areas	1	8

Table 3. Parameters of AAT

From table 3 can be seen that there is only one suspect area in block No.1 and 8 in block No.2.

A minimum of one tie point has been fully transferred for 85 % of clusters connecting strips in block No.1 and for 71% of clusters in block No 2.

About 40% of tie points connecting strips have been eliminated during block adjustment with blunder elimination in block No 1 and 30 % in block No.2.

5 RESULTS

Results of block adjustment are shown in Table 4. Accuracy of photo coordinates in AAT as compared with semi-automatic AT is 10 % lower for block No.1 and 24% lower for block No.2. Lower accuracy in the block No.2 is probably due to long strips acquired in different times and not complete removal of radial deformations by the additional self- calibration parameters.

Independent accuracy check of two blocks was done using well-distributed checkpoints. Results achieved in semi-automatic and automatic aerial triangulation are similar.

Accuracy of exterior orientation parameters calculated by AAT are about 25% better for block No.1 and 15% for block No.2 than that calculated by semi-automatic method.

RMS of differences of exterior orientation parameters achieved by the two methods is shown in line 9 Table 4. For block No.1 they are 77 % higher than could be expected from mean standard deviations of exterior orientation parameters for both methods (shown in line 8). The reason is that block No.1 is not regular (from 7 to 14 photos in strip) and the maximum differences appear for the ten photos on the edge of the block. Maximum differences do not exceed 2.1 m for coordinates X_o, Y_o, Z_o and 54 mgon for ω, ϕ, κ .

RMS of differences of exterior orientation parameters for block No.2 are about 30% higher then expected.

Description		Block No.1		Block No.2		
		ISDM	MATCH-AT	ISDM	MATCH-AT	
1	photo scale focal length number of photos	1 : 8 000 305 mm 93		1 : 27 000 152 mm 56		
		4.9 / 0.22	5.4 / 0.24	5.8 / 0.26	7.2 / 0.32	
2	std. dev. of photo coord., μm / pixel	4.9 / 0.22	5.4 / 0.24	5.8 / 0.26	7.2 / 0.32	
3	No. of control / check points	17 44		16 (14 XYZ, 2 Z) 16 (15 XYZ, 1 Z)		
4	a priori std. dev. control & check X,Y,Z, cm	9, 9, 15		45, 45, 30		
5	RMS control X,Y,Z, cm	9, 10, 14	12, 13, 8	40, 32, 17	42, 41, 22	
6	RMS check X,Y,Z, cm	15, 11, 19	17, 15, 27	52, 40, 36	54, 45, 77	
7	mean / max. std. dev. of objects points X,Y,Z, cm	5, 5, 19	5, 5, 19	26, 24, 36	26, 24, 42	
		12, 15, 46	10, 11, 34	57, 50, 72	46, 46, 66	
8	mean / max. std. dev. of ext. orient.	X _o ,Y _o ,Z _o , cm	31, 33, 15	19, 26, 13	43, 39, 28	39, 30, 26
			59, 49, 34	36, 39, 24	65, 67, 43	54, 54, 36
	ω , ϕ , κ , mgon	8.1, 7.6, 1.7	6.5, 4.7, 1.1	4.6, 5.0, 2.2	3.3, 4.7, 1.6	
11.7, 15.0, 3.8		9.9, 8.7, 2.0	8.4, 6.9, 4.2	7.2, 6.3 2.9		
9	RMS differ. of ext. orient.	X _o ,Y _o ,Z _o , cm	64, 80, 34		74, 45, 36	
			ω , ϕ , κ , mgon		19.7, 16.3, 2.8	

Table 4. Results of blocks adjustment

6 CONCLUSIONS

Point accuracy matching ranging from 0.22 to 0.32 pixel size has been achieved in both aerial triangulation methods. It is similar to the theoretical values possible to obtain by analytical aerial triangulation method. The results of semi-automatic and automatic AT are similar. Lower than expected accuracy of exterior orientation parameters in AAT is due to higher value of standard deviation of measurements of photo coordinates in AAT.

Lower quality of aerial photographs in block No.2 has adversely influenced the achieved accuracy, but still it was possible to run MATCH-AT.

MATCH-AT is a powerful automatic digital aerial triangulation tool. It generates many additional tie points that strengthen the geometry of the block.

ACKNOWLEDGEMENTS

This project (conducted in the years 1999/2000) has been funded by the Polish Committee for Scientific Research (Grant No: 9T12E 01417).

REFERENCES

- Ackermann F., 1996. Some Considerations about Automatic Digital Aerial Triangulation. OEEPE Official Publication, No.33, pp.157-164.
- Heipke C., Eder K.,1998. Performance of tie extraction in automatic aerial triangulation. OEEPE Official Publication, No. 35, pp. 127-185.
- Heipke C., 1998. Automatic aerial triangulation: results of the OEEPE-ISPRS test and current developments. Photogrammetric Week'99, D. Fritsch, R. Spieller (Eds.), Wichmann, Karlsruhe, pp.177-191.
- Kersten T., 1999. Digital Aerial Triangulation in Production – Experiences with Block Switzerland. Photogrammetric Week'99, D. Fritsch, R. Spieller (Eds.), Wichmann, Karlsruhe, pp.193-204.
- Madani M., 1999. Operation and Performance of an Integrated Automatic Aerial triangulation System. Proceedings of the OEEPE Workshop on Automation in Digital Photogrammetric Production, Paris, June 21-24.
- Urset A., Maalen-Johansen, 1999. Automatic Triangulation in Nordic Terrain - Experiences and Challenges with MATCH-AT. Proceedings of the OEEPE Workshop on Automation in Digital Photogrammetric Production, Paris, June 21-24.