ROMUALD KACZYŃSKI

TEST ON ORTHOPHOTO GENERATION
WITH DIFFERENT SOFTCOPY SYSTEMS

ABSTRACT: *The results of digital orthophoto generation with different output pixel size using three different softcopy photogrammetric workstations: ImageStation 6487 INTERGRAPH, PRI'SM/VPSTA of I'S, Softplotter of Vision International are presented.*

Aerial photographs taken by RC-10 Wild camera in the scale of approx.1:5800 in the Wieliczka hilly region in Poland were scanned on the PS1 PhotoScan ZEISS/INTERGRAPH flat bed scanner with aperture size 30 μm in IGiK.

DEM was generated semi-automatically using different software including MATCH-T.

Planimetric accuracy of digital orthophotos has been calculated on the basis of a set of check points measured on the analytical plotter Planicomp P-1 ZEISS in IGiK. Orthophotos in the scales 1:2 000 and 1:1 000 have been produced digitally with 0.3 m output pixel size with accuracy mp < 0.3 mm in the orthophotomap scale.

INTRODUCTION

A test has been carried out by the Institute of Geodesy and Cartography in Warsaw, Poland in the framework of a research project No 9 T12E 005 08 financed by the State Committee for Scientific Research in 1996. Test on the SoftPlotter has been performed by the Vision International Autometric in the USA. Tests on the Intergraph and International Imaging Systems (now DATRON Division) have been performed in Warsaw in IGiK.

Aerial photographs taken with Wild RC-10 camera in 1982 were used. Three digital photogrammetric workstations were used for generation of DEM and digital orthophotos using scanned aerial photographs. Original photographs have also been elaborated on an analytical plotter Planicomp P-1 ZEISS in IGiK.

1. PHOTOGRAPHIC MATERIALS

Black and white aerial photographs of the hilly Wieliczka region in Poland taken in 1982 in the scale of approx. 1:5 800 with RC-10 Wild camera (c_k = 154 mm) were used. These photographs have not been taken that time for orthophoto production. As many of these kind of photographs are available in Poland it was interesting to investigate them in order to use them for production of orthophoto digitally. New colour aerial photographs in the scale 1:26 000 with the RC-20 Leica camera are now taken on all territory of Poland in the framework of PHARE PL 9206 programme. These new photographs will be used also for production of digital orthophotomaps.

Aerial Triangulation was performed on an analytical plotter P-1 Planicomp ZEISS in the Photogrammetry Department in IGiK. PAT-MR software was used for the adjustment of Aerial Triangulation. Coordinates of the projection centres (X_0, Y_0, Z_0) have been used for comparison with results obtained by digital photogrammetry methods. Part of the Results of Absolute Orientation (AO) achieved on the P-1 Planicomp are shown in Table 1.

Table1. Results of AO performed on the P-1
Planicomp ZEISS

Photo No:	803	801	799
X_0	-90446.90	-89921.94	-89376.31
Y_0	22616.08	22612.17	22613.41
Z_0	1162.28	1168.10	1177.33
H [m]	882	888	888
Parallax points	8	10	10
Mean parallax [mm]	0.002	0.002	0.002
Max. parallax [mm]	0.004	0.004	0.004
RMSE x,y [m]	0.04	0.04	0.04
RMSE z [m]	0.10	0.03	0.03

2. SCANNING DIAPOSITIVES OF AERIAL PHOTOGRAPHS

Scanning of the B/W diapositives of aerial photographs were performed in IGiK with a precision flat-bed PS-1 PhotoScan ZEISS/INTERGRAPH scanner, model IS 6745.

Resolving power of these B/W diapositives is about 40 l/mm. MTF suggests to use aperture size 30 x 30 μm for scanning.

It is necessary to determine the maximum aperture size which can be used for digitising photography in order to limit the amount of digital data recorded.

A scanned photo needs to be in a useful format which also includes compression, tiling and overviews.

JPEG (Joint Photographic Experts Group is a working group of IEC/ISO and CCITT) has developed an international standard for grey scale or colour still image compression. The level of quantisation can be changed by the operator who can specify the Q-factor (Quality or Quantisation factor). Q-factor is variable between 0 and 300. The compression ratio Q is selected on the basis of minimising visible distortion. Normally Q- factor of 25 is used for compression of B/W photo which is equivalent to 3-4 times compression.

Only ImageStation 6487 Intergraph has incorporated the JPEG software into JPEG image compression/decompression hardware board. The compressed image before being displayed on the monitor is on-the-fly decompressed by the JPEG. One B/W photo scanned on PS1 with aperture size 30 μm has a file size of about 60MB. With JPEG compression Q = 25 the image size is only about 20 MB. Due to JPEG the image file has smaller size so they transfer over the network faster.

The compressed images with Q = 25 were used with ImageStation 6487 Intergraph in order to generate DEM and orthophotos.

Uncompressed images converted to raw, untiled TIFF format were recorded on 8mm magnetic tape 2.3 GB with UNIX *tar* command and used for processing with the PRI²SM/VI²STA of I²S in IGiK and by Vision International in USA.

3. PROCESSING OF COMPRESSED IMAGES ON THE IMAGESTATION 6487 INTERGRAPH IN IGIK

After project set-up with all camera data the interior orientation (IO) is performed using ISDO or ISDM software. The IO process determines the relationship between the calibrated fiducial coordinates and the image pixel coordinates. An affine transformation computes the IO. Once the fiducials on the first photo have been measured all the fiducials on next photos in the strip can be measured automatically on the basis of image correlation techniques. Next step is Relative Orientation (RO) to remove *px* and *py* parallaxes at least at 6 Grüber points in the stereo pair. RO determines the relationship between two images. There is ability to measure in both mono and stereo modes at the

same time. Automatic point measurement using image correlation techniques is also available. Transformation is then computed using the coordinates of the same ground point in the left and right images. The results are shown as image residuals, py parallax, RMSE.

In Absolute Orientation (AO) full coordinates GCP's (planimetry or vertical only) or check points are measured. No. of GCP's , X, Y, Z are stored as ASCII file. Elements of exterior orientation for each photo are calculated. Single Photo Resection allows the user to determine the relationship between image coordinates and corresponding GCP's system. The output parameters with DEM can then be used to create orthophoto, perspective view, aspect, slope, shaded relief.

Then the photos must be resampled into the epipolar format. Along the epipolar lines $py = 0$. Epipolar resampling removes the effects of tilt, tip and swing and use any corrections such as earth curvature, lens distortion, atmospheric refraction. One model (two images) will then be stereo ready for 3D viewing and DTM collection. For 30 μm image resampling a stereo model to epipolar format takes about 15 minutes. The files produced are approx. 60 % of the size of the original scanned images. All further processing (excluding generation of orthoimages) will be performed on the epipolar images.

For 3D viewing, digitising and Feature Collection ISSD, MSFC, ISDC, ISMT modules are used.

DTM can be collected manually with ISDC or automatically with Match-T software (ISMT). On-line triangle and contour generation allows the user to view and manipulate in real time the contour over the collected area while still in the model. The Match-T software uses epipolar images, therefore the image matching problem is reduced from a two to one-dimensional task. Matching needs to be carried out along the horizontal direction of the base line only.

The Match-T on a 30 μm model will generate DTM at a user specified grid spacing in less than 40 minutes.

ISSD is a stereo raster image display software with 3-D cursor tracking and stereo vector superimposed using IMD stereoplotter. Stereo viewing system uses an infrared emitter and crystal glasses (Crystal Eyes system). The images seen stereoscopically are controlled by this system consisting of a remote signal emitter synchronised with the 120 Hz image flicker rate and a pair of crystal glasses that receive the signal. As the result the image pair appears as a single continuously displayed stereo image.

A pointing device hand-held controller (HHC) is used to move the cursor and to perform precision 3-D mensuration.

Vitec (VI-50) is raster processor which operates at about 300 millions operations per second. This device is used for stereo roaming and digitising as well as for resampling scanned images into epipolar format.

Real time image decompression/compression is done using JPEG hardware.

Grid spacing of 5 m was used to generate DTM using Image Station Match-T (ISMT) software. This file has been later used to generate orthophoto images using ISIR Software.

Orthophoto generation is a process of removing the effects of tilt, relief, lens distortions from the perspective aerial photographs.

Image Station Image Rectifier (ISIR) or *rect_photo* software are used to generate orthoimage. The DTM is merged with other terrain information such as breaklines, spot highs to generate TIN or GRD file. A TIN file is a topologically triangulated network also called as a TIN or triangle file. A GRD file is a raster grid file that stores X, Y, Z values for regular spaced parts.

Three types of resampling techniques to generate orthophoto could be used: nearest neighbour, bilinear and cubic convolution. ISIR has capability to choose output pixel size in ground units, rotation of the output and coordinate system.

Image Station AutoOrtho software developed by TRIFID Corp. could be used for mosaics, tone matching the multiple orthophotos to produce single output composite image.

Once the orthophoto has been generated it can be displayed on the 27" two megapixel display, 24-bit true colour monitor using Image Station Imager (ISI-3) software. This software could be also used for enhancement, mosaicking and other digital image processing needs.

Output could be in digital form or/and as a hardcopy plot. Orthophoto hardcopy has been printed on a high precision Ink-Jet printer IRIS 3047 in IGiK.

Results of AO (coordinates of projection centres only) performed on the Image Station 6487 INTERGRAPH are shown in table 2.

Table 2. Results of AO on ImageStation 6487 INTERGRAPH

Photo No.	803	801	799
X_0	-90447.68	-89922.08	-89376.44
Y_0	22615.52	22612.36	22613.41
Z_0	1162.15	1168.05	1177.48
RMSE X,Y [m]	0.06	0.06	0.06

Contour lines spacing 1m have also been generated automatically from DEM and could be superimposed on an orthophoto map.

4. ELABORATION OF IMAGES
ON THE PRI²SM/VI²STA OF I²S/DATRON SYSTEM

PRI²SM 3.0 is a platform-independent solution. The Graphical User Interface is based on X Windows using the Motif window manager. PRI²SM 3.0 is a comprehensive digital compilation and map production system using aerial photography as well as SPOT and JERS satellite data. PRI²SM produces several products including DTMs (automatically or in stereo profile mode) orthoimages, standard map sheets using powerful automatic mosaicing capabilities, and various intermediate geo-referenced products according to mapping standards guidelines. Line maps are produced using the digital stereo superimposition interface to collect elevation and features into a variety of mapping and GIS packages. Image and line maps could be produced at large and small scales.

PRI²SM 3.0 is available in monoscopic and two stereoscopic versions. The stereoscopic system enables precision profiling for DTM capture and editing, feature extraction and compilation. Features are compiled (X,Y,Z data) into a variety of mapping and GIS packages. Collection of triangulated data, for both airborne and satellite platforms, is performed in either stereo or mono mode where points are measured and written into ASCII files. These files are then ingested into accompanying software packages for strip and block adjustment calculations.

Automatically generated DTMs are saved as ASCII (XYZ triplet format) files. Since the DTM is crucial in most photogrammetric and GIS applications, editing DTM files is given prime importance in PRI²SM, especially for automatically generated DTMs. DTMs are edited interactively in stereo mode with the imagery as a backdrop and the use of a digitising puck; or can be edited automatically using various types of filters. Once the DTM meets the projects accuracy and quality criteria, it can be offered as a final product or additional data sets can be derived, such as slope and aspect maps, contour maps, 3-D perspective views and orthorectified images. Multiple orthoimages can be merged into map sheets using automosaic functions.

Raw satellite digital images and scanned aerial photographs could be in the most popular image formats including BIL, TIFF, PostScript and BSQ.

DTMs in USGS or ASCII X,Y,Z format also ingested and connected to a project. Using the I²S image pipeline technology, PRI²SM is able to display and pan images of any size quickly without using large amounts of system resources (memory, swap space, etc.); allowing real-time image display and processing. Output orthoimages, DTMs and other corrected or rectified images are produced and tracked according to project parameters, along with quality control reports. Output datasets (raster, vector and text) are then archived on magnetic media and can be converted to other image formats for use in other integrated applications or hardcopy printing devices.

The PRI²SM software can also ingest DTM files and control point files for use in orthophoto generation. Interior, relative and absolute orientation of scanned aerial photos are performed in stereoscopic mode or in monoscopic mode. Camera data such as fiducial locations, focal length and camera descriptors are entered into a project menu and stored in the database for each project. Flightline descriptions, output orthomap projections and other project information are entered into a database form and stored for each project. These data can be easily viewed and edited. Using ground control points, the image model is resolved to high precision allowing automatic DTM generation and orthorectification to subpixel accuracies. A RMSE of the model transform is reported after each control point is added. Once the model transformation is derived, the DTM is ingested or created manually in stereo profile mode or automatically. Elevation postings are collected at the grid resolution specified in the project definition. After editing the DTM and gridding it to the proper resolution, the orthoimage is produced according to the project parameters. Using check points, an assessment of the precision of the output map can be quantified, performed in the Quality Check (QC) function. The QC verification step measures the errors in the image map projection against the defined check points. Error vector (which are displayed on the image) values are reported for each check point and a RMSE value is reported for an overall quality determinator.

Aerial Triangulation Collection System and AT adjustment is also available in the PRI²SM software.

Image map sheets are defined according to output scale, map projection and coverage. The inputs to the orthorectification process are the image model, raw imagery and DTM. The output from the ortho process is an image map meeting the map sheet specifications, i.e., scale, map projection and map extent. Additional functions include automatic mosaicing of multiple ortho-images into the mapsheet, and user-friendly creation of map surround information such as scale bars, multiple coordinate grids and/or tic marks. Titles, notes, logos, legends, and other GIS or graphic layers overlaid on the imagery.

PRI²SM is designed to accommodate other stereo viewing satellite systems as they become available, and new satellite modelling algorithms can be easily integrated into the Open PRI²SM system.

The PRI²SM system is complemented by VI²STA™, I²S' advanced, state-of-the-art Remote Sensing Software package for subsequent image analysis. Once imagery is rectified, the whole suite of powerful image processing applications can be performed, including image enhancements, filtering in spatial and Fourier domains, change detection, classification, creation and revision of map and GIS coverages and databases. PRI²SM and VI²STA™, exchange raster and vector data with a variety of GIS and mapping packages, resulting in a total solution for demanding modern mapping applications.

The A0 results achieved on the PRI²SM mono system installed on the Sun Sparc 20 SX in IGiK are shown in table 3.

Table 3. Result of A0 on PRI²SM I²S

Photo No.	803	801	799
X_0	-90447.14	-89922.05	-89376.82
Y_0	22616.15	22612.40	22612.66
Z_0	1162.27	1168.07	1177.68
RMSE x [m]	0.08	0.06	0.10
RMSE y [m]	0.09	0.10	0.10
MMSE z [m]	0.17	0.20	0.20

5. ELABORATION OF THE IMAGES ON THE SOFTPLOTTER BY VISION INTERNATIONAL AUTOMETRIC IN THE USA

The SoftPlotter is a Softcopy Photogrammetric Workstation system developed by the Vision International, a division of Autometric Inc. in the USA in 1994 and works on all Silicon Graphics computers. The SoftPlotter product comes with ERDAS IMAGINE software, Plus 3 TERRAMODEL Contour software and - optionally - with MicroStation Bentley Systems.

The results of Absolute Orientation performed on the SoftPlotter are shown in the table 4.

Table 4. Results of AO performed on the SoftPlotter

Photo No.	803	801
X_0	-90447.73	-89922.56
Y_0	22615.42	22611.74
Z_0	1162.05	1168.24
RMSE x [m]	0.03	0.03
RMSR y [m]	0.03	0.03
RMSE z [m]	0.02	0.02

6. ANALYSIS OF AO RESULTS

The comparisons of all AO results achieved on different systems were performed with the use of data achieved on the P-1 Planicomp ZEISS which have been taken as the true values.

RMSE (in meters) of the coordinates of the projection centres achieved on three different digital photogrammetric workstations for each photo are shown in tables 5-7.

Table 5. Residuals of AO parameters on IS 6487

Photo No.	803	801	799
ΔX_0 [m]	0.78	0.14	0.13
ΔY_0 [m]	0.56	-0.19	0.00
ΔZ_0 [m]	0.13	0.05	0.15

Table 6. Residuals of AO parameters on PRI^2SMI^2S

Photo No.	803	801	799
ΔX_0 [m]	0.24	-0.09	-0.51
ΔY_0 [m]	-0.07	-0.23	0.75
ΔZ_0 [m]	0.01	0.03	-0.35

Taking into account RMSE of AT performed on the P-1 Planicomp for photos 803 and 801 one can see that residuals obtained on the ImageStation 6487 and PRI^2SM could be accepted. Residuals on SoftPlotter are bigger but they still could be accepted.

Photo No. 803 elaborated on IS 6487 has bigger residuals but also has the biggest RMSE elaborated on P-1.

Table 7. Residuals of AO parameters on SoftPlotter

Photo No.	803	801
ΔX_0 [m]	-0.83	0.62
ΔY_0 [m]	0.66	0.43
ΔZ_0 [m]	0.23	-0.14

7. GENERATION OF ORTHOPHOTOS
AND ACCURACY ANALYSIS

Orthophoto images have been generated on the three workstations using raw scanned aerial photos and generated independently DEMs. Digital orthophotos have been checked using check points. Coordinates of check points have been measured on the Planicomp P-1 ZEISS. The results of planimetric accuracy of the orthophotos are shown in table 8.

Planimetric accuracy depends on DEM and on the output pixel size specified during generation of the orthophoto images. Optimum output pixel size is 0.3 m for these old photographs (scanned with aperture size 30 μm which in the scale of aerial photography approx. 1:5 800 is equal to 17 cm in terrain).

In literature is given that with adequate GCP's a 1.5 pixel output accuracy of the original imagery could be achieved. This is for the entire process included interior and absolute orientation, DEM generation and orthophoto rectification.

The old original B/W photos in scale of 1:5 800 were scanned with 30μm pixel size which is equivalent to 0.17 m in terrain. Therefore expected output accuracy of orthophoto could be 1.5 x 0.17 m = 0.27 m.

This accuracy is met only for SoftPlotter which probably was due to better DEM generated by the Autometric in USA as it was done by the IGiK in Warsaw.

Taking into account that map accuracy standards requires planimetric accuracy mp < ± 0.3 mm in the map scale, and orthophoto needs a resolution of 3-8 pixels/mm at display scale, the output orthophoto can be produced in the scale of 1:2 000 using 0.30 m output pixel size.

Table 8. Planimetric accuracy of orthophotos

Workstation	generated orthophoto output pixel size	No. of check points	RMSE		
			on the ground (in meter) X Y	at ortho scale (in pixels) X Y	in pixels of scanned photo
INTERGRAPH IS 6487	0.20 m	31	0.51 0.54	2.5 2.7	3.1
I²S PRI²SM	0.40 m	42	0.47 0.37	1.2 0.9	2.5
I²S PRI²SM	0.30 m	18	0.35 0.38	1.2 1.3	2.1
I²S PRI²SM	0.50 m	16	0.65 0.66	1.3 1.3	3.8
SoftPlotter	0.30 m	17	0.23 0.27	0.8 0.9	1.5

8. CONCLUSIONS

Aperture size of 30 µm for scanning of the B/W old aerial photographs taken by the WILD RC-10 camera has been used.

DTM which have been generated on three different workstations with the correlation methods were used for generation of orthophotos. Orthophotographs were generated digitally with different output pixel sizes (from 0.2 to 0.5 m). Output pixel sizes 0.3 m and 0.4 m allow to produce orthophotographs with accuracy mp < 0.3 mm in the map scale of 1:2 000 and mp < 0.5 mm in the map scale of 1:1 000. Output pixel sizes 0.2 m and 0.5 m gives worse results for these photographs (scanned with aperture size 30 µm).

The systems ImageStation 6487, SoftPlotter and PRI²SM can be used for producing high accuracy and high quality digital orthophotomaps even using as input old photographs taken by a camera WILD RC-10.

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ROMUALD KACZYŃSKI

OPRACOWANIE ORTOFOTOMAPY METODĄ FOTOGRAMETRII CYFROWEJ NA RÓŻNYCH SYSTEMACH

Streszczenie

W artykule zamieszczono wyniki testu trzech cyfrowych autografów (stacji) fotogrametrycznych, a mianowicie: ImageStation 6487 INTERGRAPH, PRI²SM/VI²STA firmy I²S/DATRON i SoftPlotter firmy Vision International.

Celem testu było określenie dokładności generowania NMT i ortofotografii na w/w stacjach.

Materiałem źródłowym były zdjęcia lotnicze czarno-białe rejonu Wieliczki wykonane w 1982r. w skali 1:5 800 kamerą RC-10 WILD o

$f_k = 154$ mm. Diapozytywy tych zdjęć wykorzystano do aerotriangulacji na autografie analitycznym P-1 Planicomp ZEISS.

Wyznaczone metodą analityczną elementy orientacji zewnętrznej zdjęć zamieszczono w tablicy 1.

Diapozytywy zostały zamienione na postać cyfrową za pomocą skanera do zdjęć lotniczych PS-1 PhotoScan zainstalowanego w IGiK. Użyto apertury do skanowania 30 x30 μm.

Na stacji roboczej ImageStation 6487 w IGiK przeprowadzono kompresję plików obrazowych (Q = 25) korzystając z JPEG, oraz metodą cyfrową orientację wewnętrzną, wzajemną modelu i bezwzględną oraz wcięcie wstecz pojedynczego zdjęcia. Wyniki orientacji bezwzględnej zdjęć zamieszczono w tablicy 2.

W celu wygenerowania NMT za pomocą oprogramowania MATCH-T utworzono tzw. "overviews", czyli zestaw pomniejszonych podobrazów oraz obrazy epipolarne, tj. takie, dla których w liniach obrazu paralaksa poprzeczna py = 0.

Korzystając z oprogramowania ISIR wygenerowano ortofotografie cyfrowe.

Podobnie przeprowadzono orientację wewnętrzną i wcięcie wstecz pojedynczego zdjęcia na podstawie dostępnych fotopunktów (wyznaczonych metodą aerotriangulacji na P-1) na stacji fotogrametrycznej PRI²SM/VI²STA w IGiK.

Wyniki obliczenia metodą cyfrową elementów orientacji zewnętrznej zdjęć zamieszczono w tablicy 3.

NMT wygenerowano na podstawie utworzonych obrazów epipolarnych metodą korelacji. Korzystając z oprogramowania PRI²SM i VI²STA wygenerowano ortofotografie.

Firma Vision International w USA opracowała te same dane cyfrowe na systemie SoftPlotter. Rezultaty wyznaczenia elementów orientacji zewnętrznej stereogramu 803-801 metodą cyfrową zamieszczono w tablicy 4.

Przyjmując wyznaczone elementy orientacji zewnętrznej na autografie analitycznym P-1 Planicomp za bezbłędne, określono błędy wyznaczenia ich metodą fotogrametrii cyfrowej na trzech stacjach. Wyniki zamieszczono w tablicach 5, 6 i 7. Największe błędy wyznaczenia środków rzutów otrzymano dla SoftPlottera, a najmniejsze dla PRI²SM/VI²STA.

W tablicy 8 zamieszczono wyniki analizy wygenerowanych ortofotografii z pikselami o wymiarach 0.20 m, 0.30 m, 0.40 m i 0.50 m na różnych stacjach. Na dokładność generowanej ortofotografii mają wpływ wszystkie czynniki w procesie opracowania cyfrowego obrazów, a mianowicie:

- przeprowadzenie orientacji wewnętrznej;
- przeprowadzenie orientacji wzajemnej modelu;
- przeprowadzenie orientacji bezwzględnej modelu lub pojedynczego zdjęcia;
- utworzenie obrazów epipolarnych;
- generowanie NMT (i jego edycja);
- wielkość piksela generowanej ortofotografii.

Największy wpływ na dokładność ortofotografii ma wygenerowany NMT.

Dokładność planimetryczną ortofotografii sprawdzono na podstawie fotopunktów sytuacyjnych, których współrzędne wyznaczono podczas aerotriangulacji na P-1 Planicomp.

Z literatury wiadomo, że zdjęcia lotnicze wykonane kamerami fotogrametrycznymi z eliminacją rozmazu obrazu (FMC) pozwalają na otrzymanie ortofotografii z dokładnością rzędu 1.5 piksela skanowanego zdjęcia, tj. dla opracowywanych zdjęć około 0.27 m. Dokładność taką otrzymano jedynie dla SoftPlottera, a bliska jej dla PRI²SM (dla wielkości piksela w ortofotografii 0.3 m). Spowodowane to zostało tym, że NMT utworzony w IGiK na stacjach roboczych ImageStation i PRI²SM/VI²STA nie był edytowany, a co miało miejsce w przypadku SoftPlottera. Należy również zaznaczyć, że kamera RC-10 WILD nie posiada ladownika z FMC.

Biorąc pod uwagę, że ortofotomapy powinny charakteryzować się błędem położenia szczegółów mp < ±0.3 mm w skali opracowanej ortofotomapy, stare zdjęcia lotnicze wykonane kamerą RC-10 WILD mogą być użyte do opracowań cyfrowych na w/w trzech systemach.

W tym przypadku możliwe jest wykonanie ortofotomapy cyfrowej w skali 1:2 000 z pikselem 0.2 m-0.4 m, tj. np. od 0.1 do 0.2 mm w skali mapy.

РОМУАЛЬД КАЧИНЬСКИ

РАЗРАБОТКА ОРТОФОТОКАРТЫ МЕТОДОМ ЦИФРОВОЙ ФОТОГРАММЕТРИИ НА РАЗНЫХ СИСТЕМАХ

Р е з ю м е

В статье помещены результаты тестирования трёх цифровых фотограмметрических автографов /станций/, а именно ImageStation 6487

INTERGRAPH, PRI^2SM/VI^2STA фирмы $I^2S/DATRON$ и SoftPlotter фирмы Vision International.

Целью тестирования было определение точности генерирования NMT/Цифровой модели местности/ и ортофотографии на вышеупомянутых станциях.

Исходным материалом были чёрно-белые аэроснимки района Велички, выполненные в 1982 г. в масштабе 1:5 800 камерой RC-10 WILD с $f_k = 154$ мм. Диапозитивы этих снимков были использованы для аэротриангуляции на аналитическом автографе Р-1 Planicomp ZEISS.

Определённые аналитическим методом элементы внешнего ориентирования снимков помещены в таблице 1.

Диапозитивы были заменены в цифровой вид с помощью сканера для аэроснимков PS-1 PhotoScan, установленного в ИГиК. Была использована апертура для сканирования 30 x 30 µд.

На рабочей станции ImageStation 6487 в ИГиК была проведена компрессия массивов изображений /Q = 25/ с использованием JPEG, цифровым методом внутренняя ориентировка, взаимная и абсолютная ориентировка модели, а также обратная засечка единичного снимка. Результаты абсолютной ориентировки снимков помещены в таблице 2.

С целью генерирования NMT с помощью программного обеспечения MATCH-N создано так называемый „overviews", т.е. набор уменьшенных подизображений и эпиполярные изображения, т.е. такие, для которых в линиях изображения поперечный параллакс ру= 0.

Используя программное обеспечение ISIR выгенерировано цифровые ортофотографии.

Подобным способом была проведена внешняя ориентировка и обратная засечка единичного снимка на основе доступных опознаков /определённых методом аэротриангуляции на Р-1/ на фотограмметрической станции PRI^2SM/VI^2STA в ИГиК.

Результаты вычисления цифровым методом элементов внешней ориентировки снимков помещены в таблице 3.

NMT генерировано на основе созданных эпиполярных снимков методом корреляции. Используя программное обеспечение PRI^2SM и VI^2STA выгенерировано ортофотографии.

Фирма Vision International в США обработала те самые цифровые данные на системе SoftPlotter. Результаты определения элементов внешнего ориентирования стереограммы 803-801 цифровым методом помещены в таблице 4.

Принимая определённые элементы внешнего ориентирования на аналитическом автографе Р-1 Planicomp как безошибочные, вычислено

ошибки определения их методом цифровой фотограмметрии на трёх станциях. Результаты помещены в таблицах 5, 6 и 7. Самые большие ошибки определения центров проекции получены для SoftPlotter, а наименьшие - для PRI²SM/VI²STA.

В таблице 8 помещены результаты анализа выгенерированных ортофотографий с пикселями размерами 0,20 м, 0.30 м, 0.40 м и 0.50 м на разных станциях. На точность генерированной ортофотографии влияют все факторы в процессе цифровой обработки изображений, а именно:

- проведение внешнего ориентирования,
- проведение взаимного ориентирования модели,
- проведение абсолютного ориентирования модели или единичного снимка,
- создание эпиполярных изображений,
- генерирование NMT /и её издание/,
- величина пикселя генерированной ортофотографии.

Наибольшее влияние на точность ортофотографии имеет выгенерированная NMT.

Планиметрическая точность ортофотографии проверена на основе ситуационных опознаков, координаты которых определены были во время аэротриангуляции на P-1 Planicomp.

Из литературы известно, что аэрофотоснимки, выполненные фотограмметрическими камерами с исключением мазков изображения /FMC/, разрешают получить ортофотографию с точностью порядка 1.5 пикселя сканированного снимка, т.е. для обрабатываемых снимков около 0.27 м. Такая точность была получена единственно для SoftPlotter, а близкая ей для PRI²SM /для величины пикселя в ортофотографии 0.3 м/. Это вызвано тем, что NMT созданная в ИГиК на рабочих станциях ImageStation и PRI²SM/VI²STA не была печатана, как это имело место в случае SoftPlotter.

Учитывая то, что ортофотокарты должны характеризоваться ошибкой положения деталей mp< ±0.3 мм в масштабе разрабатываемой ортофотокарты, старые аэрофотоснимки, выполненные камерой RC-10 WILD могут быть использованы для цифровых разработок в трёх вышеуказанных системах.

В этом случае возможным является выполнение цифровой ортофотокарты в масштабе 1:2 000 с пикселем 0.2 м - 0.4 м.

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