Digital photogrammetry in GIS Sofia Ltd.

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ABSTRACT

GIS SOFIA Ltd. is a Sofia Municipality company, established in 1999, in order to create and maintain the cadastal information system. The staff is about 100 persons in 8 departments. The Photogrammetry Department has 7 engineers (Master Degree) and their task is to apply digital photogrammetry. Two experimental projects with an area of 4.5 km^2 each have been implemented in Sofia territory. They are photographed twice at scale of 1:4500 by the aerial survey cameras RMK 15/23 and MRB 30/2323. The aerial pictures are used for experimenting of several digital photogrammetric technologies for production of urban cadastral maps at scale of 1:1000. One production project with 50 km^2 is prepared for being photographed by camera RC-30. The Photogrammetry Department study 7 digital photogrammetric systems.
In the beginning of 2003 GIS SOFIA received from RACURS Co. one month license for all modules of the digital photogrammetric system PHOTOMOD 3.11. It is applied to an experimental project, and the accuracy obtained on X, Y, Z-axis is: for the control points ± 4.8, ± 5.6, ± 20.5 cm; for the check points ± 4.0, ± 4.9, ± 18.9 cm. For the estimation of the accuracy of close-range photogrammetry an experiment on a façade of a building by PHOTOMOD Lite is performed. The pictures are taken by non-metric analogue (film) and digital cameras. In April 2003 GIS SOFIA bought modules of PHOTOMOD 3.11.
PHOTOMOD is a contemporary software for a digital photogrammetry, which fully satisfy modern production. PHOTOMOD is entirely comparable with the other digital photogrammetric systems, and better than some of them. The priority of PHOTOMOD is the proper balance between its capacity and price.

1. Introduction

Bulgaria is located in the central part of Balkan peninsula in south-eastern part of Europe. The country has the ancient culture and remarkable history. From time immemorial Bulgarian territory was the important crossroads that influenced on its dynamical development in different periods. The country area is 111,000 sq.km including 58% agricultural grounds (44% cultivated land), 33% forest area, 4% urban area, 2% water area, 3% other territories. Country consists of 28 regions (including Sofia region) and 263 communities, each consist of 4615 landuse parcels. Population is about 8 million, living in 5336 populated places (240 cities, 5096 villages).

1.2. Sofia community has more than 1 million population and consists of 24 districts with total area 1300 sq.km., including Sofia city (with 180 sq.km. area), and also 3 towns and 35 villages. Sofia city has thousand years history. It preserves the cultural and religious

impression of different ages and rich in architectural, archaeological, historical and art memorials. Sofia became the capital in 1879 after Russian-Turkish war (1877-1878), which brought the freedom to the Bulgarian people.

1.3. GIS Sofia Ltd. (Geographic Informational System – Sofia) was created in 1999 as a Company of Sofia community. It is a successor to the structures involved to the city cadastre works previously. Main destination of the company is to create and support the Cadastre Informational System of Sofia as well as current city cadastre map in 1:1,000 scale, which consists of more than 1100 cadastre sheets. GIS Sofia' stuff includes about 100 employees and also a number of temporary ones. The company divides into 8 departments, one of which is Photogrammetric.

1.4. Bulgarian photogrammetry started its development 30 years after the end of Russian-Turkish war. Our country was the first on Balkan peninsula, which begin to use photogrammetry. Our ground photogrammetrical images were acquired as far back as 1907-1908, and they were processed and mapped in Vienna Cartographical Institute by Dr. *Eduard von Orel* using *Stereoautograph* constructed by him. After that during the Balkan war (1912) and the First World War (1914-1918) first airborne and ground photogrammetrical surveys as well as photo-surveys from airplanes and zeppelins over some cities were executed. More strong efforts on photogrammetry applying were made in 1928. At that time it was started topographical mapping in 1:25,000 scale, initially using ground survey, later airborne. And since 1952 using airborne stereo-photogrammetry the topographical map in 1:5,000 scale was started. In 1930 the first Bulgarian manual "Photogrammetry Course" was published. Photogrammetry is studying in 3 universities and 6 colleges in Bulgaria. About 20 institutions, organizations and companies in Bulgaria are developing and applying photogrammetry in a variety of spheres, including international projects. Analogue and analytical stereo-photogrammetrical methods are successfully applying for many long years. Nowadays digital photogrammetry implementation begins. We have qualified specialists, able to resolve each task in photogrammetrical field. They perform their professional skills and achievements in Bulgarian Geodesists and Surveyors Union, in national and international scientific events, and also in our and foreign periodicals. The Union is the member of *International Society for Photogrammetry and Remote Sensing (ISPRS),* and Bulgarian professionals take an active part in its activity.

2. Photogrammetry in GIS Sofia

2.1. Photogrammetry Dep't was organized in the beginning of 2001 in the Company. The Dep't stuff includes 7 computer-educated engineers, which also got additional theoretical and practical photogrammetric skills while working in GIS Sofia. Main direction of the Dep't is digital photogrammetry applying to cadastre creating and updating, as well as digital terrain models, which are using for cadastral and topographical mapping (both digital and hardcopy), ortho-photo-map and other digital geodata producing as well as close range photogrammetry applying for buildings fronts mapping.

2.2. In 2001 training course **"Photogrammetry Basics"** was organized for the specialists of the Photogrammetry Dep't. There were 56 lessons, 228 lections, where the main issues of photogrammetry, divided into 15 parts were studied. Additionally to the lectures there was provided the practice for obtaining necessary skills of spatial photogrammetric models

observation and measuring. The practical course consisted of 1476 lessons or 211 lessons averagely per each person. The books "Photogrammetry basics" and "Collection of Photogrammetric Reports" were published including 8 articles of Department's specialists. Now the collection "Theoretical and Applied Issues of Photogrammetry", consisting of 22 themes is scheduled to publish.

2.3. Experimental objects. On the territory of Sofia two objects for experiments were chosen - **"Yavorov"** and **"Mladost**" with area 4.5 km^2 of each one. Both objects surveyed twice in 1:4,500 scale using the following air-cameras:

- RMK A 15/23 by *Zeiss-Oberkochen,* with focus 153 mm and frame size 23x23 cm from the average height 690 m.
- MRB 30/2323 by *Zeiss-Jena,* with focus 305.5 mm and frame size 23x23 cm from the average height 1380 m.

Airborne survey features:

- Black-and-white panchromatic filter *Agfa-Gevaert.*
- Twice survey of the each object by 18 images, collected in 3 strips.
- Images and strips overlapping - 80% and 30% respectively. (For photogrammetric measurement every other images with 60% overlapping were used).
- Before airborne survey there were marked and measured on the terrain 24 ("Mladost" object) and 77 ("Yavorov" object) ground control points using GPS.
- The airborne survey was executed in early spring of 2001, in clear sun daytime.

The images were used for several photogrammetric methodologies probations for urban cadastral mapping in 1:1,000 scale. Original air-films were scanned in *Oberkochen* by photogrammetric scanner *PhotoScan2001*.

Using "Mladost" object data the following digital photogrammetric systems were tested:

- *ImageStation 2001 (Z/I Imaging)*
- *Geomatica (PCI Geomatics)*
- *VirtuoZo (Supresoft)*
- *PHOTOMOD (Racurs)*
- *ERDAS IMAGINE* (*ERDAS Inc.).*

The experiment was executed with images block consisted of 6 images in 3 strips. For triangulation process 9 control points were used and for results estimation – 11 points. Control points coordinates, measured photogrammetrically in comparison with geodetic mode have the following differences in the accuracy 5-9 cm on X axis, 5-25 cm on Y axis, 20-45 cm on Z axis, depending on software used.

2.4. Now the **object** "**Vitoshka Yaka**" is preparing for airborne survey. It is located on area of 50 km^2 on southern part of Sofia near the Vitosha mounting. The airborne survey foreseen in 1:4,500 scale from 750 км height with images overlapping 60% and strip overlapping 30%. There will be used *Leica RC-30* camera (focus 21 cm, frame size 23 x 23 cm) and color film. Ground control points needed for triangulation should be marked on the terrain and measured with *GPS.* The film will be scanned with pixel size 14 μm and processed by digital photogrammetric system *PHOTOMOD*. The survey will be used for

cadastral informational system updating for this district of Sofia in frames of periodical updating of Sofia Community Cadastre.

2.5. Software analysis. The department stuff had a possibility to familiarize (during training abroad, using time limited licenses, demo versions and available systems) with following digital photogrammetric working stations:

- *ImageStation 2001* of *Zeiss / Intergraph Imaging.*
- *ImageStation SSK (Stereo Softcopy Kit)* of *Zeiss / Intergraph Imaging.*
- *DVP (Digital Video Plotter)* of *Leica - Helava.*
- *VirtuoZo* of *Supresoft.*
- *PHOTOMOD* of *Racurs Co.*
- *Geomatica OrthoEngine* of *PCI Geomatics.*
- *ERDAS IMAGINE* of *ERDAS Inc.*

3. PHOTOMOD

In early 2003 GIS Sofia have got from RACURS Company 1-month license on all modules of digital photogrammetric system *PHOTOMOD 3.11*.

3.1. PHOTOMOD for airborne photogrammetry. Specialists of Photogrammetry Department are working now on the entire photogrammetrical processing of experimental object "Mladost", using airborne imagery collected by the camera RMK A 15/23.

After images input and transformation in special PHOTOMOD format, we execute manual and automatic interior images orientation. Control, ground control and tie points coordinates were input also. On each stereo pair selected tie points accuracy was estimated using measured RMS and vertical parallax. The air triangulation results were comparatively analyzed. 9 ground control points were used for triangulation process and 9 control points for results estimation.
We obtain the following results:

- For ground control points: X ± 4.8 cm,
  Y ± 5.6 cm,
  Z ± 20.5 cm.
- For control points: X ± 4.0 cm,
  Y ± 4.9 cm,
  Z ± 18.9 cm.

3.2. PHOTOMOD for close range photogrammetry. Using *PHOTOMOD Lite* software we have investigated the accuracy of close range photogrammetry using non-metric analogue camera and non-metric digital camera. Experimental object was residential building front in Sofia downtown. Using station *Leica* TC 1610 50 non-marked check and control points were measured on the front with RMS ± 0.5 cm. Photo-survey of the building front was executed using the following non-metric cameras:

- Analogue camera *Olympus AF-1*, with focal length 35 mm, luminosity 1:2.8, objective *ZUIKO,* film *Fudjifilm Superia 100.*
- Digital camera *Canon S230, ELPH* objective, 3 Mpixel.

Photogrammetric works included survey by two cameras, acquisition of 4 stereo models with distance from the object 16 and 20 m. The front was surveyed from the tripod with camera height 1.60m and basis 4m. The main surveying arrays were parallel and divergenced in vertical plane. Image negative was scanned and transformed to *.BMP format according to the *PHOTOMOD Lite* requirements. Stereo model was oriented using 8 control and 30 tie points. On the stereo model the coordinates of 33 geodetically measured points. The differences between geodetic and photogrammetric coordinates were calculated, and afterwards the following RMS in photogrammetric coordinates were calculated:

- In plane of the image (in front plane) ± 1.9 cm.
- In depth (at right angle to the front) ± 6.1 cm.

Building front was vectorized in stereo mode and its 3D model (DTM) was produced using the vector data. Using this DTM the image was ortho-rectified, and the coordinates of 30 points were measured and compared with geodetically measured ones. At that RMS in points location is ± 2.2 cm. Points location RMS in comparison with DTM and ortho-image is ± 1.4 cm.

In April 2003 GIS Sofia company purchased the following modules of **PHOTOMOD 3.11** system in RACURS Company:

- PHOTOMOD AT *(block data measurement in aerial triangulation, adjustment).*
- PHOTOMOD StereoDraw *(3D stereo feature extraction)* - 2.
- PHOTOMOD DTM *(creating and editing DTM, orthophoto, contour lines)* - 2.
- PHOTOMOD Mosaic *(orthorectification and mosaic of block images).*

4. Conclusion

PHOTOMOD is up-to-date digital photogrammetric system, which meet the requirements of modern photogrammetric production. PHOTOMOD has easy and user-friendly interface and work with each module is suitable thanks to solid and helpful User Manual. The most part of processes is automatized. Also there is good built-in vectorization system. The process of TIN creation and editing is very complicated process and could be considered as system disadvantage.

Thereby, PHOTOMOD is quite comparable with other well-known digital photogrammetric systems and, moreover, exceeds some of them. Special technical and economical PHOTOMOD system merit is optimal balance between its cost and capability.

References:

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