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SOME ASPECTS IN PHOTOGRAMMETRY EDUCATION AT THE DEPARTMENT OF GEODESY AND CADASTRE OF THE VGTU

Birutė Ruzgienė

Dept of Geodesy and Cadastre, Vilnius Gediminas Technical University,
Saulėtekio al.11, LT-10223 Vilnius, Lithuania
E-mail: Birute.Ruzgiene@ap.vgtu.lt

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Abstract. The education in photogrammetry is very important when applying photogrammetric methods for the terrain mapping purposes, for spatial data modelling, solving engineering tasks, measuring of architectural monuments etc. During the time the traditional photogrammetric technologies have been changing to modern fully digital photogrammetric workflow. The number of potential users of the photogrammetric methods tends to increase, because of high-degree automation in photographs (images) processing. The main subjects in Photogrammetry (particularly in Digital Photogrammetry) educational process are discussed. Different methods and digital systems are demonstrated with the examples of aerial photogrammetry products. The main objective is to search the possibilities for training in the photogrammetric measurements. Special attention is paid to the stereo plotting from aerial photography applying modified for teaching analytical technology. The integration of functionality of Digital Photogrammetric Systems and Digital Image Processing is analysed as well with an intention of extending the application areas and possibilities for usage of modern technologies in urban mapping and land cadastre. The practical presentation of photos geometry restitution is implemented as significant part of the studies. The interactive teaching for main photogrammetric procedures and controlling systems are highly desirable that without any doubt improve the quality of educational process.

Keywords: teaching photogrammetry, education, internet/Web, training, digital photogrammetry, image processing, stereoscopic measurements, orthophoto generation, photogrammetric restitution.

1. Introduction

Surveying and mapping technologies are in evolution between such disciplines as geodesy, surveying, cartography, geoinformatics etc and photogrammetry as well. The results from images photogrammetric restitution are widely used in geographic information systems in vector or raster form (Konecny 2003). Therefore the education in photogrammetry is very important in application photogrammetric methods for the terrain mapping purposes, spatial data modelling, solving engineering tasks, measuring architectural monuments etc. Up-to-date digital technologies are widely used and replace the traditional photogrammetric methods. Considering there facts, the above mentioned education in photogrammetry (especially in digital photogrammetry) is very significant. The training in digital photogrammetry is convenient because it is based on computer processing the digital images.

The traditional way of teaching is based on presentation (in oral or written form) of the educational subject of theoretical and practical units. The more appropriate method is interactive teaching - the information transmission by computer supported presentation, as well as receiving materials through Internet in the form of e-learning. The didactic digital photogrammetric systems can be used for practical training in basic photogrammetric workflow as orthophoto generation and 3-D terrain models creation. The degree of automation in different photogrammetric systems is different.

Digital photogrammetric systems can be divided in 3 sets: low level, intermediate level, and high-level systems. The low-level systems usually do not have possibility of high automation measurement by photographs. There can be supplied only the monoscopic or anaglyph methods for measurement. The *Digital Video Plotter* (DVP) is a system that enables to create modern topographic 2,5-D maps as well as digital terrain reconstructions using data derived directly from conventional aerial photos.

The intermediate set of digital photogrammetric systems means a higher automation of photogrammetric procedures. For example, the systems of such level are: *VirtuoZo*, Supresoft; *SISCAM*, DVP Geomatics; *Ortho-Engine*, PCI Geomatics, *Photomod*, Racurce, etc. These systems involve orthophoto production technology and

digitizing functionality as well as creation of digital elevation model (DEM) from aerial photography.

The high-level photogrammetric systems operate with the highest degree of automation in separate stages of processing and are more flexible, the obtained measurements results are more accurate and reliable as well. The Image Station *Z/I Imaging,* ZEISS-Intergraph and Digital Photogrammetric Workstation *Helava* belong to the group of systems mentioned above.

The objective is to find out the best solution in education with a highly efficient feedback. The preparation of learning module, which main goal is the creation of an appropriate guide that includes operative reference and theoretical elements of photogrammetric restitution.

2. Fundamentals for the education in photogrammetry

The main objective of education in photogrammetry is gaining knowledge in reconstruction of spatial object position from photographs as well as obtaining ability in application the photogrammetric methods for territory mapping.

The basic knowledge has to be appointed on stereophotogrammetric and orthophotographic mapping technologies, digital photogrammetric mapping, terrestrial (close range) photogrammetry and laser scanning methods (Albery e*t al.* 2000; Lillesand e*t al.* 2000; Pereira, Oliveira 2004).

On the basis of education experience in photogrammetry at the Dept of Geodesy and Cadastre (VGTU), the module of subject in advance have been constructed regarding the following principles: separating subject-matter into theoretical and functional (practical) units; displaying the differences and correspondences of methods; presenting the examples using technical means and digital systems; evaluating the profound knowledge; understanding overall aspects of photogrammetry.

The suggested annotation of subject is as follows:

- geometry of aerial photographs,
- planning of aerial photography,
- technical means of aerial photography,
- processing of aerial photographs,
- creation of control for aerial photographs,
- aerial triangulation,
- interpretation of photographs,
- digital photogrammetric mapping,
- characteristics of digital images and methods of processing,
- terrestrial photogrammetry,
- terrestrial digital cameras,
- terrestrial laser scanning systems,
- aerial laser scanning systems.

The usage of modern technologies, analysis of digital photogrammetric systems functionality and digital image processing is the main subject because of extension field of application and possibilities of integration in geographic information systems.

The photogrammetric image processing for getting the final product includes two main digital technologies:

- 3-D digitising,
- orthophoto generation.

These two main traditional photogrammetric technologies correspond to the digital technologies as well. Both technologies require determination of the elements of the images of inner and outer orientation for transforming to a ground coordinate system.

The process of aerial triangulation in digital systems corresponds to traditional triangulation as in analytical photogrammetry using specific software based on the bundle block adjustment or orientations are based on the method of models. The measurement of photogrammetric tie points and ground control points is needed in both cases.

Inner orientation requires measurement of image coordinates of fiducial marks, and training for improvement of such measurements, based on residuals, is very important.

The measurement of homologous points for relative orientation is based on the image matching. The training for this processing step includes a correct selection of photogrammetric tie point's position and accurate measurement of corresponding points in stereo pairs. Estimation of the **relative orientation results** can be done by checking residuals in vertical parallaxes.

The measurements of ground control points for **outer orientation** of the photogrammetric model need the knowledge about a proper definition of their position and is important for quality control in a training process. The received residuals on measured control points show correctness of control point's identification.

The stereoscopic measurements of tie points and ground control points are possible. The quality of stereo viewing systems is important for visual stereo interpretation. It is preferable monoscopic and stereoscopic measurement combination for getting best results.

Generation of epipolar images is very important stage in digital photogrammetry when the transformation is applied to entire images. This procedure based on the epipolar geometry allows finding corresponding points in the parallel image rows of transformed images. The epipolar transformation is necessary for DEM creation, orthophoto generation and for spatial digitalisation as well.

Digital elevation models could be created from different sources: using analogue instruments, survey data, vector topographic maps, analytical photogrammetric systems, digital processing of stereo photographs. Usually a raster terrain model with different resolution can be generated. The additional measurements of the terrain often have been done for achieving a more correct terrain model. Generation **of DEM** from stereo images pairs is based on the matching of homologous points in rows of epipolar transformed images. The correctness of DEM depends on several parameters that correspond to the maximum heights difference between two adjacent points in the model. An appropriate selection of this parameter is very important for creating a proper elevation model.

Analysing a created DEM, the process of model editing is necessary. In the process appears a fail of correlation function and terrain data in some parts of the model are false. The training for proper correction (eg analysing the values of correlation matrix it is possible to

find out the wrong values DEM areas) is significant matter in creating the correct DEM.

The process of orthorectification requires knowledge of external orientation parameters and height data from DEM. The time duration for processing depends on the order of interpolation (calculation output pixel value) and image size (pixel numbers). Practical training for different types of transformation is possible.

The mosaicking of images presents understanding a full photogrammetric image block, obtained from generated orthoimages. The results of image merging can be analysed depending on different methods of image processing, eg equalising etc.

The process of stereo (3-D) digitising in digital images is important stage in process of data (feature extraction in forms of lines, closed polygons, etc. or 3-D measurements) capture. Training in the above-mentioned step, should be done by different approaches of editing and for different types of primitives.

3. Training for photogrammetric images processing

Several data sources are used for training, one of them is analogical images at a scale of 1:6000 covering the Eastern-Northern part of city Vilnius. The aerial photos diapositives taken by analogue aerial camera (*RMK TOP*) were converted into digital format with pixel size of 14 μm. Aerial camera's calibration certificate and data of control points are at one's disposal.

Despite the fact that photogrammetric mapping technologies turn towards the digital technologies, the traditional photogrammetric methods (analytical and in some cases analogical) can be used for the layout of the main principals of photogrammetric processing. Therefore the digital photogrammetric technologies can ot be completely replaced in the process of education regarding a better understanding of fundamentals in photogrammetric modelling geometry. For example, the analytical photogrammetric technologies are used, when digital aerial triangulation will not work correctly under complicated terrain conditions as high urban areas, large height difference in the photographed area, heavily vegetated terrain, etc.

Considering the facts, mentioned above, training in aerial triangulation is performed using analogue images for measuring image coordinates by analogue computerised instrument Zeiss *Stereocomparator* or S*tecometer* and bundle block adjustment is realised with software *NLH-BUNT*, developed at Agriculture University, Norway.

The digitising features in analogical stereo plotter Wild *A8* are used for object data collection and linear features extraction from aerial photographs.

Without any doubt, analogue instruments could not be used for a huge amount of practical measurements anymore. Nowadays it belongs to the history of photogrammetry.

3.1. 3-D data capture

One of the main tasks in photogrammetric processing is feature extraction, digitising in spatial mode and getting vector data from stereo images. In education process of that subject, an analytical plotter *Zeiss Stereoplotter PLANICOMP P3* with images orientation software *P-CAP* is used. This instrument is of excellent working condition and additionally equipped (at Photogrammetry Institute of Bonn University, Germany) with CCD cameras. It is very important from the point of view of education, because point's identification and feature interpretation can be observed on the monitors as well (Fig 1). Received geodata from stereo measurements are possible to use in GIS environment like ArcView, AutoCad etc.

Fig 1. Analytical stereo plotter *PLANICOMP P3* with a modification for education

The training in feature extraction (eg 3-D building's model creation) can be performed using digital system *InJECT*, developed at the Photogrammetry Institute of Bonn University. The user of *InJECT* is supported by tools with site modelling. Fragment of buildings extraction from aerial photography is presented in Fig 2.

Fig 2. Fragment of building extraction by wire-frame adaptation method

3.2. Orthophoto production and photogrammetric restitution

The orthophoto maps are the main product from digital stereo images orthorectification.

The Didactic Digital Photogrammetric System (DDPS) is used for education purposes in generation of orthophoto as well as Digital Photogrammetric Station *LISA*.

a)

b)

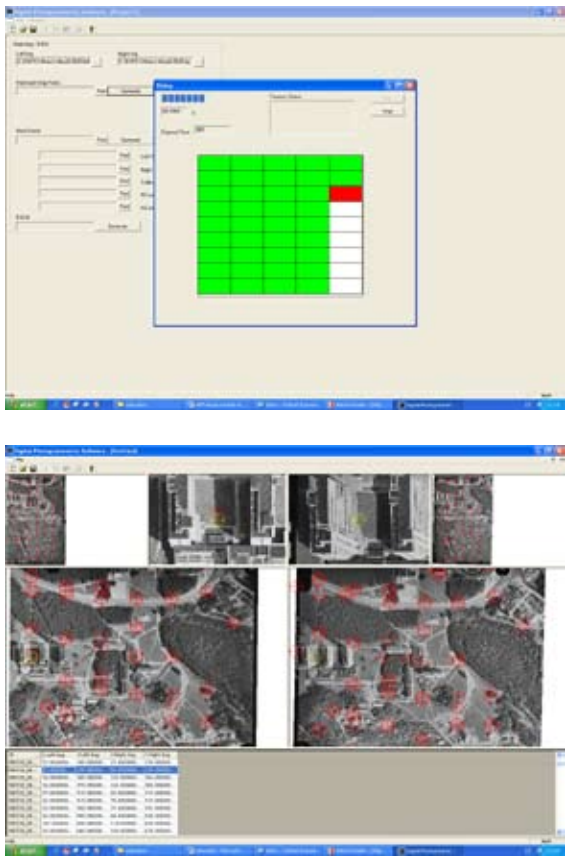

Fig 3. Image matching in DDPS: a) automatic searching homologous points, b) fragment on matching results

a)

b)

Fig 4. Created photogrammetric stereo model: a) for monocular measurements, b) stereoscopically

DDPS software developed at University of Liege (Belgium) and the Warsaw Institute of Geodesy and Cartography (Poland) is complete and integrated educational photogrammetric package with user-friendly graphic interface, with a didactical objective, rapid as possible and easy to understand (Didactic 2005). Fig 3 shows image matching process and fragment from results (searched points number via image matching on that example is 115) in DDPS.

Digital photogrammetric workstation *LISA FOTO*, developed at University of Hanover (Germany), is extension of raster GIS software *LISA BASIC* and has a lot of possibilities in image processes (Linder 2006).

In generating orthophoto, the creation of epipolar images is one of important stages of processing. The epipolar images needed for DEM construction that correctness depended on choosing the step of raster grid. Such a step should not exceed the interval of image digitalisation. Therefore the training at that stage is important for producing an accurate orthophoto.

The advantage of usage the DPWS *Lisa* is that it allows the control in orthorectification when selecting several standard methods of interpolations as well as digital data filtering can be applied. This software flexibility allows making decision on appropriate selection, comparing image processing duration and accuracy of interpolation, testing the chosen methods (Ruzgienė, Aleknienė 2007).

The created photogrammetric model for monocular measurements or applying anaglyph method in generating DTM using *LISA FOTO* can be seen in Fig 4.

The usage of two digital systems that complement each other is an appropriate solution in getting complete knowledge for orthophoto generation.

Distance learning via the Internet (e-learning) requires a high degree of computer interactivity and is much recommended. For example, the learning program *LDIPInter* (Höhle, J.) introduces images correlation techniques and is supported with the techniques for the automatic measuring and is very desirable for training.

The educational material for use the Internet entered in personal Web pages is appointed as well. Demand for learning via Internet is still going on and continuously will increase in future.

The education in photogrammetric restitution starts with planning, continues by measuring the control points and finishes with extraction of the geodata, according to specifications. Only majority has grown in ability for stereo measurements, because is requires a hard and longer training time.

Processing the satellite images should be the subject of the training process as well.

4. Conclusions

The employment of particular photogrammetric systems in mapping education allows demonstrating the whole technological process of photogrammetric production using separate and integrated systems. It is recommended for learning a different system because of getting the same final results applying a similar or different workflow. The usage of systems developed for education

purposes, for example, as DDPS is highly recommended. Advantage of such system is that software does not require powerful computers (minimal PC technical characteristics are: processor frequency – 400 MHz, RAM – 256 MB, hard disk – 1 GB, graphic resolution –1024 × 768, screen size – 17″) and furthermore all processes are visible.

Educational systems are not production systems and have not power to produce fast the final production. However, such systems have a priority in demonstration and analysis of the complete photogrammetric processing evaluating the most applicable geometrical conditions and introducing different data sources and parameters. On the other hand, solving the appropriate educational tasks and desirable functionality of particular software, there could be impropriation comparing with complete production Photogrammetric Work Station. Such an aspect should be taken into account and solved during educational processes.

The training in fundamental definitions of digital photogrammetry for practical purposes it is recommended to use excellent and attractive system *LDIPInter*.

The learning for photogrammetric image restitution using developed material at Internet and the Satellite Images processing is much recommended as well.

References

Albery, E.; Lingua, A.; Maschio, P. 2000. Learning Kit and Tutorials for the Diffusion of the Digital Photogrammetry, *International Archives of Photogrammetry and Remote Sensing*, XXXIII, Part B6, Amsterdam, 7–12.

Didactic and digital photogrammetric software (DDPS). 2005. User's Guide. Donnay J.–P., Kaczynski R. Dept of Geomatics, University of Liege, Belgium, Institute of Geodesy and Cartography (IGiK), Dept of Photogrammetry, Warszawa, Poland. 71.

Konecny, G. 2003. *Geoinformation: Remote Sensing, Photogrammetry and Geographical Information Systems*. London and New York: Taylor and Francis. 248 p.

Lillesand, T.; Olsen, T.; Gage, J.; Mcenaney, P. 2000. New Paradigm, New Approaches: Reconstruction Geo-spatial Information Education and Training in a Traditional Research Setting, *International Archives of Photogrammetry and Remote Sensing,* XXXIII, Part B6, Amsterdam, 203–211.

Linder, W. 2006. *Digital Photogrammetry. A Practical Course.* Berlin, Heidelberg: Springer-Verlag, 214 p.

Pereira, G. L. M.; Oliveira, J. M. 2004. How to Attract Students to Geo-information Courses: a Different Approach, in *International Archives of Photogrammetry and Remote Sensing,* Commission 6, XXth ISPRS Congress, Istanbul, Turkey, 63–68.

Ruzgienė, B.; Aleknienė, E. 2007. Analytical and Digital Photogrammetric Geodata Production Systems (a Comparison Test), *Geodezija ir kartografija* [*Geodesy and Cartography*] 33(2): 50–54.

Birutė RUZGIENĖ. Assoc Prof., Doctor.
Vilnius Gediminas Technical University, Dept of Geodesy and Cadastre, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
(Ph +370 5 2744703, Fax +370 5 2744705),
e-mail: *birute.ruzgiene@ap.vgtu.lt*

A graduate of Vilnius Civil Engineering Institute (engineer of geodesy, 1968). Doctor (Vilnius Gediminas Technical University, 1999). Research training at Moscow Institute of Geodesy, Aerosurveying and Cartography (1986), at Norway AO Fjellanger Widerøe (1995), at Warsaw Institute of Geodesy and Cartography (1998), at Photogrammetry Institute of Bonn University (2000, 2005). Author of more than 30 scientific papers.

Research interests: digital photogrammetric mapping, image interpretation, features extraction from remote sensing data.