POLISH-BELGIAN CO-OPERATION. DEVELOPMENT OF AN EDUCATIONAL DIGITAL PHOTOGRAMMETRIC SOFTWARE.

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ABSTRACT

This co-operation takes place in the framework of co-operation between the U.E.B.L. (Union Économique Belgo-Luxembourgeoise, economical union between Belgium and Luxembourg) and Poland. The two partners are the Institute of Geodesy and Cartography of Warsaw (IGiK), and the laboratory SURFACES of University of Liege. The project began in 1997 and is still in progress.

The main goal is the technology transfer between both institutions. It is achieved through the realisation of photogrammetric software for educational purposes. This collaboration is divided in two steps. The first one is the training of the Belgian specialists in digital photogrammetry methods in IGiK, and the realisation of the basic photogrammetric modules. The second one is a complete collaboration between the partners for the realisation of photogrammetric software for educational purposes.

This system for educational purposes must be able to:
- correct scanned aerial photographs done using low quality scanner and integrate them to the system;
- calculate internal orientation parameters of scanned photographs;
- calculate external orientation parameters of photos (relative and absolute);
- generate epipolar images;
- generate DTM.

Professional system will be used for verification of elaborated software and results.

After two years of co-operation, the results have encountered most of the wishes formulated in the beginning of the programme. The SURFACES laboratory has developed its knowledge in digital photogrammetry. Four modules were developed so far:
- correction of geometric distortion due to use the low quality scanner;
- computation of internal and external orientation parameters;
- mono restitution;
- generation of epipolar images.

Now we are engaged with a third party, the National Remote Sensing Centre of Beijing, in a more ambitious task : - the realisation of a complete educational digital photogrammetric software. This means that all the common photogrammetric processes must be considered (from acquisition to production of softcopy and hardcopy products). Different type of remotely sensed data can also be taken into account (aerial photography, SPOT Pan and Ikonos-2 images).

INTRODUCTION

This scientific co-operation between Poland and Belgium takes place in the framework of a global co-operation between the U.E.B.L. (Union Économique Belgo-Luxembourgeoise, economical union between Belgium and Luxembourg) and Poland. This goal of this co-operation is the development of a digital photogrammetric system. The two partners are the Institute of Geodesy and Cartography of Warsaw (IGiK), co-operation leader Romuald Kaczynski and the laboratory SURFACES of University of Liege, co-operation leader Jean-Paul Donnay. The project began in 1997 and is still in progress.

OBJECTIVES

The main goal of this co-operation is the technology transfer between both institutions. It is achieved through the realisation of a photogrammetric software for educational purposes. This collaboration has been be divided in two steps. The first one is the training of the Belgian side in digital photogrammetry and the realisation of the basic photogrammetric modules. The second one is a complete collaboration between the partners for the realisation of a photogrammetric software for educational purposes. In order to achieve this objective, precise tasks have been assigned to the two sides.
Belgian side tasks includes:
- training of a few students in the field of digital photogrammetry;
- realisation of a digital photogrammetric system for educational purposes. This system must be able to:
    - correct and integrate scanned aerial photographs done by low quality scanner;
    - calculate internal orientation parameters;
    - calculate extern orientation parameters (relative and absolute);
    - generate epipolar images;
    - generate DTM.
Polish side tasks includes:
- to disseminate their practical knowledge in the field of digital photogrammetry;
- to check and assess the system's modules. This could be done by the use of the IGiK professional photogrammetric equipment (precise photogrammetric PS-1 Zeiss scanner, ImageStation Intergraph photogrammetric workstation, etc.).

PROGRESS

The co-operation began in March 1997 with the visit of R. Billen in IGiK. During this on-the-job training the members of the photogrammetric department of IGiK guided the Belgian student. He followed all the different steps of the digital photogrammetric process. In addition to a concrete photogrammetric training, it gave him reference products for each step of the process. R. Billen presented, in September 1997, his licence thesis: "Conception d'un système de photogrammétrie digitale et développement de procédures de corrections et d'orientations". The following modules were realised:
- low quality scanner geometric correction;
- internal orientation of aerial photography;
- external orientation of aerial photography.
In March 1998, a second student S. Belche went to IGiK to prepare his thesis on the generation of epipolar images and DTM. He brought back from his visit knowledge and results of his work. S. Belche presented, in September 1998, his licence thesis: "Génération d'images épipolaires dans le cadre d'un système de photogrammétrie digitale". An epipolar image creation module was developed. The theoretical background for an automatic DTM generation was formulated.
After each of the Belgian visits, R. Kaczynski came to the University of Liege to check and confirm the work of the students. He also conducted workshops on digital photogrammetry for the students and staff of the Department of Geomatics. The last Polish visitor was I. Ewiak, from IGiK, in October 1998. These visits started a more ambitious co-operation with a new partner, the National Remote Sensing Centre of Beijing.

ACHIEVEMENTS

Training periods, conferences and visits.

This co-operation required exchanges and training periods. At this moment, a total of 7 visits have taken place. Most of them were from Belgium to Poland. This corresponds to the first step of the co-operation, i.e. the training of Belgian students and the creation of preliminary version of educational software. The mean length of these visits was one week. In order to diffuse the photogrammetrical knowledge to a maximum number of students and researcher from Belgium, two papers were presented by Professor Kaczynski within the framework of the *Société Géographique de Liège*. The subjects were aerial and space photogrammetry. Although the web capabilities enable easy and quick contact between partners, the physical meeting of the researchers is necessary to discuss the different aspects of the project. Furthermore, it is a very important social experience for young and senior researchers.

Software development.

Some modules are already realised in a preliminary version : - low quality scanner geometric correction; - internal orientation of aerial photography; - al orientation of aerial photography; - mono restitution; - epipolar image generation. The preliminary version means that the program code is not optimised. This task is actually done in framework of the new co-operation. All the modules presented were linked with the IDRISI software. The visualisation and the data capture were done with the IDRISI tools. All the modules were tested with some reference data. Some of them came from products realised by IGiK using their professional systems:- PS1 Zeiss/Intergraph photogrammetric scanner; - Intergraph ImageStation 6487 and ImageStation -Z.

Low quality scanning data geometric correction.

The use of flatbed, high quality professional scanner is usually too expensive for an educational institution. Therefore we had to evaluate the possibility of using non-photogrammetric scanner in the system. This module is based on the comparison of a reference grid and its scanned image data. The process can be presented as follows. In the first step, the parameters of a global first order polynomial correction between the nodes of the reference grid and their homologues in the image are determined. Although three nodes are required, ten or more nodes are collected to use the least square adjustment. When this global correction is applied to all the nodes some deviation still exists. For each stitch, the deviation in x and y co-ordinates are measured for each of the four nodes. So when a point is collected, the global transformation is applied to it. Then, after finding the stitch where it stands, the local transformation is applied proportionally to its distance to each node (see Figure 1 and Equation 2). The effects of this correction were tested on the restitution of a single image. The accuracy of the restitution was twice better then before correction. The main problem of this procedure is the amount of labour time necessary to the capture the nodes. Therefore automatic solution must be found.
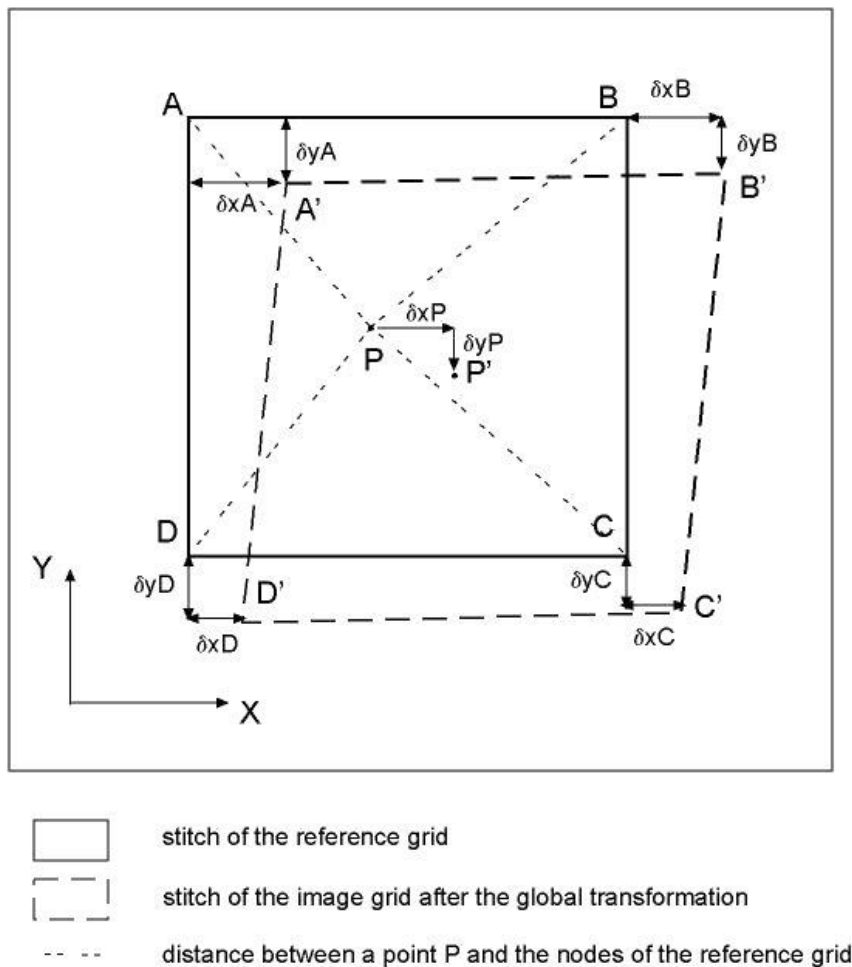

stitch of the reference grid

stitch of the image grid after the global transformation

distance between a point P and the nodes of the reference grid

Figure 1. Local transformation of a point P

$$X_{P'} = X_p + \frac{\delta xA}{AP} + \frac{\delta xB}{AB} + \frac{\delta xC}{AC} + \frac{\delta xD}{AD}$$

$$Y_{P'} = Y_p + \frac{\delta yA}{AP} + \frac{\delta yB}{AB} + \frac{\delta yC}{AC} + \frac{\delta yD}{AD}$$

Equation 2. Local transformation of point P

Internal orientation of aerial photography

The internal orientation of aerial photographs is the first step of the photogrammetric process. A complete description of this process can be found in Krauss (Krauss, 1993). It allows reconstructing the original geometry of the perspective rays within a projection system. Some parameters are needed that are usually reported in the calibration camera certificate : - the focal length; - the principal point position in the image plan; - the characteristic of the lens distortions. The principal point position is determined by the fiducial marks. A first order polynomial was used to express the relationship between calibrate fiducial marks and their homologues marks in the image. A least squared adjustment was applied. In the preliminary version, the lens distortions were not taken into account, as the distortion of the modern photogrammetric cameras is very low.

External orientation parameters of aerial photography

Two modules are dedicated to the external orientation parameters of aerial photographs The first one provides the external orientation parameters of a single photo. The second one allows the relative and absolute orientation of stereophotogramme. Both methods provide all the spatial orientation parameters of the camera in a specific cartographic projection. But the second one implies the creation of a stereoscopic model (relative orientation) before liking it to reference through ground control points (absolute orientation). To realise the relative orientation some (> 10) of homologous points must be collected. For the absolute and external orientation of a single photo, at least 3 ground control points are needed to related the parameters to the cartographic projection system. Some tests were made to validate these modules (see table 3). The spatial orientation parameters of different photos were also compared with parameters determined in IGiK with the Intergraph software.

	Image 4023			Image 4024		
	Reference	Result	Difference	Reference	Result	Difference
Ω (°dec)	0,6489	0,6506	-0,0017	0,6997	0,7100	-0,0103
Φ (°dec)	-5,7624	-5,7565	-0,0059	-4,6132	-4,6053	-0,0079
K (°dec)	3,1569	3,1622	-0,0053	1,6800	1,6813	-0,0012
X_0 (m)	234875,339	234875,359	-0,020	235286,331	235286,422	-0,091
Y_0 (m)	157931,792	157931,703	0,089	157970,270	157970,141	0,129
Z_0 (m)	963,850	963,937	-0,087	969,680	969,775	-0095

Table 3. Comparison of the external orientation parameters computed with the module and the reference parameters.

Monoscopic restitution

This module is simply the application of some of the transformation presented above to a given set of collected points. The user can choose or not the application of the scanner's correction module. Some tests were made with collected points from image scanned with PS-1 in IGiK, and with a HP ScanJet IIc in the Laboratory SURFACES (with and without scanner calibration, see table 4, 5 and 6). The commentary is that all the modules work correctly and give very good result. We can see also that the use of a low quality scanner is a critical factor of the all photogrammetric process.

	X	Y	Z
mean (m)	-0,081	0,103	0,017
r.m.s. (m)	0,119	0,137	0,172
+Emax (m)	0,078	0,235	0,468
-Emax (m)	-0,203	-0,109	-0,263

Table 4. Restitution of check points from images 4023 and 4024 scanned with PS-1.

	X	Y	Z
mean (m)	-0,061	0,179	-0,082
r.m.s. (m)	0,666	0,896	1,169
+Emax (m)	0,672	1,859	3,959
-Emax (m)	-2,344	-3,578	-2,527

Table 5. Restitution of check points from images 4023 and 4024 scanned with HP ScanJet IIc.

	Image 4023					
	Reference	Non corrected	Difference	Reference	Corrected	Difference
Ω (°dec)	0,6489	0,6225	0,0264	0,6489	0,6497	-0,0008
Φ (°dec)	-5,7624	-5,8056	0,0432	-5,7624	-5,7299	-0,0325
K (°dec)	3,1569	3,1459	0,0111	3,1569	3,1498	-0,0071
X_0 (m)	234875,339	234874,609	0,730	234875,339	234875,656	0,317
Y_0 (m)	157931,792	157932,375	-0,583	157931,792	157931,891	0,099
Z_0 (m)	963,850	963,676	0,174	963,850	964,153	0,303

Table 6. Comparison of the external orientation parameters from an corrected image and a non corrected image both scanned with HP ScanJet IIc

Epipolar image generation.

Once an epipolar image is created, the process gets back to the normal case of the photogrammetry restitution (Krauss, 1993). The purpose of creation of such image is double. First, this is a necessary step for the 3D visualisation of the stereo image. This kind of image makes easier the DTM automatic generation. A neighbourhood resampling method was used in this preliminary version software. Further developments are needed in order to finalise and improve this module.

THE NEW CO-OPERATION

The first step has been achieved. Now the two partners wanted to continue their co-operation. In fact, that the preliminary version software was completed but it is not yet optimised some developments are necessary in order to finalise this educational software. From then on, a more ambitious project was initiated that will enrich the basic aerial photogrammetric modules with some additional components. The new tasks are the realisations of complete educational photogrammetric software for aerial photographs, SPOT Pan images and Very High-Resolution images (like IKONOS). The term complete means that all the process must be solved, i.e. orientation, 3D visualisation, mosaicking, orthophoto production. Although the partners improved their knowledge, this project is very ambitious. That is the reason why a new partner is involved in order to support it. The National Remote Sensing Centre of Beijing, represented by Professors Chu Liangcai and Li Yangcheng, is now the third partner and give to this project an intercontinental character. This new convention started in late December 1999, and is planned for two years.

CONCLUSION

After 2 years of co-operation, the results have encountered most of the goal formulated in the beginning of the project. The laboratory SURFACES has developed its knowledge in digital photogrammetry by the way of the success of the two students. Four modules were developed: - correction of geometric distortion due to the low quality scanning; - computation of internal and external orientation parameters; - mono restitution; - generation of epipolar images. Therefore, most of the system is developed but it is not yet operational, i.e. there isn't a user-friendly interface.
The first step of the co-operation has been achieved. The two partners wanted to continue a collaboration at a higher degree of complexity. They are now engaged with a third party, the National Remote Sensing Centre of Beijing, in a more ambitious tasks : - the realisation of a complete educational photogrammetric software. This means that all the photogrammetric processes must be considered (from acquisition to production of database and hardcopy products) and also different type of remotely sensed data must be taken into account (aerial photography, SPOT image, Ikonos, Earth Watch images).

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