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EDUCATIONAL SOFTWARE FOR DIGITAL PHOTGRAMMETRY

1. Introduction.

This project takes place in the framework of co-operation programme 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 the University of Liege.

In the second part of the project prof. Zygmunt Paszotta from Warminsko-Mazurski University of Olsztyn has been involved.

The main goal of the project is a transfer of technology between the institutions. This was achieved through the realisation of a photogrammetric software for educational purposes. The collaboration was divided into two stages. The first one was the practical training of Belgian students in digital photogrammetry in IGiK, and the realisation by the students of the software modules dedicated to softcopy photogrammetry. Various professional systems available in IGiK were used for the assessment of the elaborated software and evaluation of the results. The students from the University in Liege have acquired a sound background in digital photogrammetry and were able to develop software modules for:

- creating a project;
- correction of geometric distortions due to the use of not professional scanners;
- computation of inner and external orientation parameters;
- relative orientation;
- monoscopic restitution;
- absolute orientation;
- generation of epipolar images.
- automatic detection of homologous points;
- image matching and DTM generation;
- orthophoto generation;
- generation of the perspective view.

2. Basic principles of developed modules

2.1. Geometric correction of a scanner

The use of a professional photogrammetric scanner is not common in the classroom. Therefore the use of non-photogrammetric scanners has to be considered. This kind of device likely is responsible of significant geometric errors that must be corrected. The software module for these corrections is based on the comparison of a reference grid and its scanned image. The reference grid has been drawn on a polyester sheet with a co-ordinatograph and the positions of the reference nodes are recorded in a file. Global correction parameters are obtained from a first order polynomial model fitted between the positions of the reference nodes and the homologous positions in the image of the scanned grid. Then residual deviations at nodes are measured in x and y and kept in order achieving local correction. Global and local corrections are optional routines applied during the operation of restitution. When a point is collected, the global transformation is first applied. Then, according to the stitch where it stands, the local transformation is applied to the point. The effects of this correction were tested on the monoscopic restitution of various images and the tests have shown that the accuracy of the restitution was twice better compared with the restitution without correction.

2.2. Internal orientation of aerial photography

The module follows the description of the procedure given by Krauss (1993). It allows reconstructing the original geometry of the perspective rays within a projection system. Most of the required parameters are attached in the calibration camera certificate: the focal length; the principal point position in the image plan; the characteristics of the radial lens distortion. A first order polynomial was used to express the relationship between the calibrated fiducial marks and the homologous marks in the image.

2.3. External orientation parameters of aerial photography

Two alternative modules are dedicated to the computation of external orientation parameters of aerial photographs. The first one achieves the external orientation of a single photo. The second one completes the relative and the absolute orientation of stereo- photos. Both modules provide the spatial parameters required to orient the camera and to get co-ordinates in a specify cartographic projection. However, the second method implies the creation of a stereoscopic model (relative orientation) before referencing it with the help of ground control points (absolute orientation). In order to achieve the relative orientation more than 10 homologous points must be collected in the pair of stereoscopic images. Besides more than three ground control points are needed for the absolute and external orientation in order to register the parameters to the cartographic projection system. Several tests were carried out to validate these modules. The spatial orientation parameters related to different photographs were computed with these modules and then compared with similar parameters determined by IGiK using Z/I Imaging photogrammetric software.

2.4. Monoscopic restitution

This module consists in applying the previous transformations to a given set of collected points. The module performs also the scanner correction and geocodification. The tests were completed with points collected from images scanned with different devices: PhotoScan PS-1 at IGiK and HP ScanJet IIc at the laboratory SURFACES. The results show that the module works correctly.

2.5. Generation of epipolar images

The generation of epipolar images consists in zeroing the parallax along the y-axis between the images of the stereoscopic pair. Taking the left image as a reference, the process comes down to the generation of a transformed right image. The purpose of the creation of this kind of images required in order to visualise the stereo image in three dimensions and make easier the automatic generation of the digital terrain model (DTM) by correlation. The preliminary version of the module makes use of the nearest neighbour resampling method and then bilinear resampling method.

2.6. Area Based Matching (ABM*)*

Image matching allows the automatic search of homologous points on the overlapping area of several images. With an Area Based Matching, points are associated if they have similar grey values. This method works with pattern, search and target window. The pattern window is the window surrounding the matched pixel on the first image. In the search window are the matched pixels for which correlation coefficients are computed (the central pixels of the different tested target windows). The target window is the window surrounding the matched pixel on the second image. A correlation coefficient is calculated to measure the correspondence of the grey values between the pattern and the target window.

2.7. Automatic detection of homologous points and DEM generation

A DEM is a numerical representation of the heights of a surface as a regular grid of points, located with their planimetric coordinates. Thus when a sufficient number of points are known in the ground coordinate system, it is possible to interpolate the values of all the points in the image. The interpolation can be made with different methods. The method of interpolation used in this program is inverse distance to a power in a regular grid built on the original image.
Inverse distance to a power is a fast interpolation method, considering only values, that are already present in the original image.
For each point, there is a search in the four quadrants surrounding it, up to a fixed planimetric distance that depends of the size of the DEM area.

2.8. VRML Model Generation and Visualization

The Virtual Reality Modeling Language is used for representation of every 3D space with a sufficient reality. Before the realization of this module, we had some doubts about the possibility to achieve one's aim with this type of file. The size of text files and the large consumption of resources (particularly for the 3D graphic card memory) made us being afraid of solving of the problems. Tests were done with geometric forms (globe, cubes, etc.) and our fears were confirmed; images of 50.000.000 pixels are already fastidious for the visualization, then 3D scenes of the same number of objects!

Two solutions were found: less of the quality or simplify the structure of the 3D objects. The first was really too restrictive because the represented objects were far from the reality. The second choice that was implemented in the software was a better one. With VRML, there is a “Field Grid” which seems to good enough for this type of problem.

3. Result, hardware and software

During the development of digital photogrammetric software, every aspect was investigated.

Five principal aspects were taken under consideration:
- the application design,
- the windows environment and MFC,
- the photogrammetric process and mathematical solutions,
- the algorithmic and optimalisation,
- the didactic point of view.

All these requirements have been achieved.

The system includes of the following modules:
Create a project; Scanner and radial distortion correction; interior orientation; relative orientation; exterior orientation; epipolar resampling; monoscopic restitution and geocoding; image matching and DTM generation; orthophoto generation; Visualisation (view of DTM draped on orthophoto.

The system is based on a standard computer environment:
PC station with Pentium 3 or Celeron 500; 196 MB RAM; 16 MB Graphic Card; monitor 1280 x 1024 pixels; Windows 98; Windows 2000; Windows NT or XT; COSMO or CORTONA 4.0; Text file Editor; Internet Explorer C++ / Delphi languages; TIFF; BMP and IDRISI image raster formats.

The system is not considered as a "black box" which means:
- every photogrammetric process can be run separately, with a standardised interface, normalised input data and output results,
- every process produce a comprehensive log file of intermediate results,
- the system is fully documented (source code and on-line help),

- the new modules could be developed by student/user,
- theory and implementation are presented,
- step by step examples are attached.

ACKNOWLEDGEMENTS

We want to present our acknowledgements to the Belgian Federal Office for Scientific, Technical and Cultural Affairs (OSTC) and Polish State Committee for Scientific Research (KBN) for support and financing of this co-operation.

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