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INTRODUCTION IN ARCHITECTURAL PHOTOGRAMMETRY

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Abstract

The work suggests the theoretical first step on close new-range photogrammetry, in general, and architectural photogrammetry, in particular. The purpose is that to promote the new geomatics technologies, very useful for our world, specialists but non-specialists too, to solve many civil engineering works, old buildings, historic bridges, castles, feudal fortress, archeological sites, historic and art monuments, to protect them, to restore them in order to point out the real, original values of a people, his works, his true achievements.
A complete approachment of analytical and digital photogrammetric methods using CAD systems, combined with laser scanning and other non-destructive research techniques of remote sensing has the purpose of finding the best solution for surveying, inventorying, monitoring, restoration and conservation of space-objects. The benefit of combination closing-range photogrammetric methods with others geomatics and geophysics researches is that it provides a solid technical documentation of a space-object as a basis for technical rehabilitation or restoration planning, a total inventory, both quantitative and qualitative. In the framework of our research, we are going to talk about photogrammetric work in general, about representative techniques of space object obtained by photogrammetric methods in close-range photogrammetry, about methods to obtain the photogramma.

Key words*: Architecture, Close-Range Photogrammetry, Photogrammetry, Stereographic Restitution..*

INTRODUCTION

For a good definition of the Photogrammetry concept, it is necessary for us to refer the Remote sensing too. Photogrammetry is a measurment tehnologies of obtaining reliable information about physical objects or about the environment, using the process of recording, measuring and interpreting photographic radiant energy and other phenomena.
We consider that we need aerial photography for having a good plotting of different objects: buildings, castles, fortress, archeological sites, settlements, historic and art monuments etc.
Unlike the map, which is a vertical projection of a landscape elements on a zero level plane surface, the photogram is the image into a plan of these elements, seen from a space-point.
In photogrammetry, we can draw up topographic maps with level curves, based on measurements and data, obtained from aerial photos, with analogical instruments, optical or/and analytical computers.
Similarly, the principles of topographic measurements accuracy are being applied on close range photogrammetry, for representing the objects which cannot be studied other ways, or whose studying is very difficult on other ways, to register deformations of measured value in engineering models.

MATERIALS AND METHODS

Compared with aerial photogrammetry, close range photogrammetry and particularly architectural photogrammetry isn't limited to vertical photographs, with special cameras. The methodology of terrestrial photogrammetry has changed significantly and various photographic acquisitions are widely in use.
New technologies and techiques for data acquisition (CCD cameras, Photo CD photoscanners), data processing (computer vision), structuring and representation (CAD, simulation, animation, visualization) and archiving, retrieval and analysis (spatial information systems) are leading to novel systems, processing methods and results.
The Close-Range Photogrammetry (CRP) relies on the reconstruction of the object

simultaneously from several images from different and best possible perspective, to ensure a suitable geometry of intersecting rays.
So that, close-range photogrammetry is meant to be in that situation when the distance (range) from the camera to the object of interest is somewhere from 1 m to aprox.300 meters.
The improvement of methods for surveying historical monuments and sites is an important contribution in recording and monitoring of cultural heritage , in preservation and restauration of any architectural or cultural monument, object or site, as a support of architectural, archeological and other art-historical research.
Images processing. Close range photogrammetry is a technique for getting geometric information (position, size and shape) of any object, that was imaged on photos before.
To achieve a restitution of a 3D point, it is necessary to have the intersection between at least two rays (from the camera to the object you are going to take the photo) in space.
If more than two rays are available, the solution is that we will have a better restitution of the object or the monument. That solution provides from all the measurements and, in that situation, it will be more accurate.
Single images. A very common problem is that we know the shape and position of an object's surface in space (digital surface model), but we are interested in having details on that surface: patterns, texture, additional points etc. In that case, a single image restitution can be appropriate to obtain the fotogramma (figure 1.)

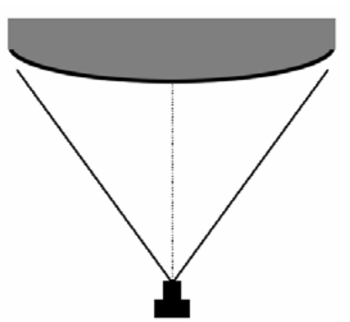

Figure 1. Photogrammetric restitution from a single image.

a) When there are known camera parameters and exterior orientation.In that case, there is necessary to know the interior orientation of the camera and camera's position and orientation. That so, we can reckon the points, by intersection of rays from camera with the surface whose shape and position we know.
Interior orientation does not mean only the calibrated focal length and the position of the principal point, but also the the polynomial coefficients for describing lens distortion (if the photo does not provide from a metric camera).
If the camera position and orientation is unknown at least 3 control points on the object (points with known co-ordinates) are necessary to compute the exterior orientation.
When there are unknown camera parameters.
This is a very frequent problem in architectural photogrammetry. The shape of the surface is restricted to planes only and a minimum number of four control points in two dimensions have to be available. The relation of the object plane to the image plane is described by the projective equation of two planes:

$$X = \frac{a_1 x + a_2 y + a_3}{c_1 x + c_2 y + 1}$$

$$Y = \frac{b_1 x + b_2 y + b_3}{c_1 x + c_2 y + 1}$$

Where X and Y are the co-ordinates on the object's plane, x and y the measured co-ordinates on the image and ai ,bi, ci the 8 parameters describing this projective relation, the measurement of a minimum of 4 control points in the single photo leads to the evaluation of these 8 unknowns (a1, a2, a3, ... , c2).

As a result, the 2D co-ordinates of arbitrary points on this surface can be calculated using those equations. This is also true for digital images of facades. Digital image processing techniques can apply these equations for every single pixel and thus produce an orthographic view of the object's plane, a so-called orthophoto or orthoimage. (Popescu, 2015)

Stereographic processing. If its geometry is completely unknown, a single image restitution of a 3D object is impossible. In this case, the use of at least 2 images is necessary. According to the stereographic principle, a pair of "stereo images" can be viewed together, which produces a spatial (stereoscopic) impression of the object. This effect can be used to achieve a 3D restitution of the facades (Figure 2).

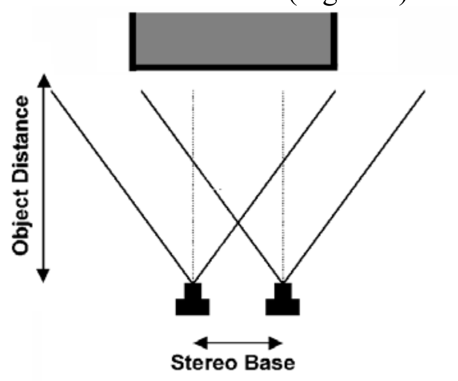

Figure 2. Photogrammetric restitution (stereographic) from a pair of images

Using "stereo pairs of images", arbitrary shapes of a 3D geometry can be reconstructed as long as the area of interest is shown on both images. The camera directions should be almost parallel to each other to have a good stereoscopic viewing. This process can be seen in a suggestive way in our experiment, of creating the 3D model of the Chemistry building façade (Figure 3).

Figure 3. a. Pair of images of Chemistry laboratory building

Figure 3. b. Pair of images of Chemistry Laboratory building

Before taking the photos we have to plan a shooting sesion which consists in a sketch that contains the locations of the object is photographed, so to respect both the transverse and longitudinal coverage (between 60-70 % for longitudinal coverage and 25-30 % for trasverse coverage). In order to that, we have taken two photos in front of the building

Metric cameras with well known and calibrated interior orientation and negligible lens distortion are commonly used in this approach. To guarantee good results, the ratio of stereo base (distance between camera positions) to the camera distance to the object should lie between 1:5 and 1:15.

Results of stereographic restitution can be: 2D-plans of single facades, 3D-wirefame and surface models, lists of co-ordinates, eventually complemented by their topology (lines, surfaces, etc). For our study work, we have made these photos (Figure 3) with a Sony camera that has a focal length of 4.7 mm and resolution of 12 MP.

Figure 4. The Chemistry laboratory after the stereographic processing

Bundle restitution. In many cases, the use of one single stereo pair will not suffice to reconstruct a complex building. Therefore, a larger number of photos will be used to cover an object as a whole. To achieve a homogenous solution for the entire building and also to contribute additional measurements, a simultaneous solution of all photo's orientation is necessary.

Another advantage is the possibility to perform an on-the-job calibration of the camera. This helps to increase the accuracy when using images of an unknown or uncalibrated camera. So this approach is not any more restricted to metric or even calibrated cameras, which makes the application of photogrammetric techniques a lot more flexible. It is also adjustable concerning the geometry of camera positions, meaning one is not forced to look for parallel views and stereo pair configuration. Convergent, horizontally, vertically or oblique photos are now well suitable. Combination of different cameras or lenses can easily be done.

In Figure 5 and Figure 6, we have examples of different configurations for bundle solution, for a circle building or paralelipipedic one.

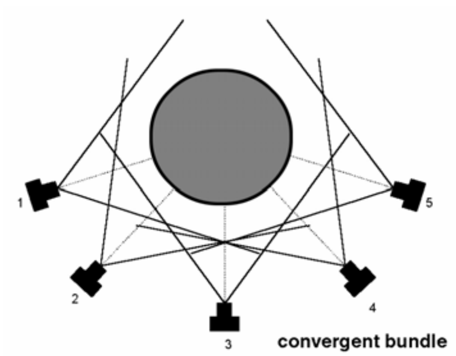

Figure 5. Bundle restitution for a circle building.

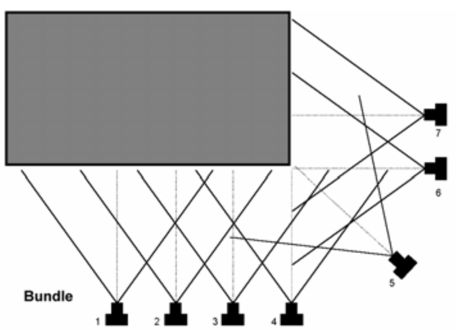

Figure 6. Bundle restitution for a paralelipipedic building.

The strategy of taking photos is that each point to be determined should be intersected by at least two rays of satisfactory intersection angle. This angle depends only upon the accuracy requirements. Additional knowledge of e.g. parallelism of lines, flatness of surfaces and rectangularity of features in space can be introduced in this process and helps to build a robust and homogenous solution for the geometry of the object.

The entire number of measurements and the full range of unknown parameters are computed within a statistical least squares adjustment.

Bundle adjustment is a wide spread technique in digital architectural photogrammetry of today. It combines the application of semi-metric or even non-metric (amateur) cameras, convergent photos and flexible measurements in a common computer environment. Because of the adjustment process, the results are more reliable and accurate and very often readily prepared for further use in CAD environments.

Results of bundle restitution are usually 3D-wireframe and surface models of the object or lists of co-ordinates of the measured points and their topology (lines, surfaces, etc) for use in CAD and information systems. Visualizations and animations or so-called "photo-models" (textured 3D-models) are also common results. Usually the entire object is reconstructed in one step and the texture for the surface is available from original photos.

Photogrammetric Architectural Survey Methods. For simple photogrammetric documentation of architecture, simple rules which are to be observed for photography with non-metric cameras have been written, tested and published by (Waldhaeusl & Ogleby, 1994). These so-called “3x3 rules” are structured in:

3 geometrical rules: preparation of control information, multiple photos all-around coverage, taking stereo-images for stereo-restitution.

3 photographic rules: the inner geometry of the camera has to be kept constant, select homogenous illumination, select most stable and largest format camera available.

3 organizational rules: make proper sketches, write proper protocols, don’t forget the final check.

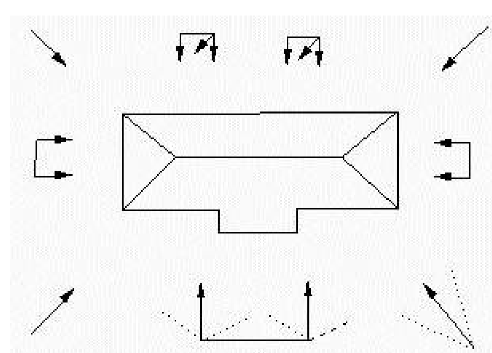

Figure 7. Ground plan of a stable bundle block arrangement all around building, as recommended in the 3x3 rules

Usually, metric cameras are placed on a tripod, but shots with small or medium format equipment are often taken “by hand”. Recently, digital phototheodolites, combining total-station and digital cameras have been developed. Digital images are then referenced from object points or targets placed in the field. In this way, the determination of the exterior orientation is simple and the images are directly usable for restitution.

RESULTS AND DISCUSSIONS

Many parts of architectural objects can be considered as plane. In this case, even if the photo is tilted with regard to the considered plane of the object, a unique perspective is enough to compute a rectified scaled image. We need at least 4 control points defined by their coordinates or distances in the object plane. The data base is usually one or more photogrammetric images which are rectified at any planes defined by the user. Simple drawings (in vector-mode), image plans (in raster-mode) are processed as a result of the rectification. Photographs of building façades should be taken the most perpendicular to the reference planes and only the central part of the image should be considered for a better accuracy.

Figure 8. Building photogrammetric image.

Figure 9. Building rectification after photogrammetric images.

In the case of a perspective rectification, radial image displacements in the computed image will occur for points outside the reference. The rectification obviously fails if the object isn’t somewhat plane.

Some packages include functions for the photogrammetric determination of planes, according to the multi-image process from two or three photographs that capture an object range from different viewpoints. Digital image maps can be produced by assuming the object surface and photo rectification. In the resulting orthophoto, the object model is represented by a digital terrain model. Image data of different planes can be combined into digital 3D-computer models for visualisation and animation with the help of photo editing or CAD software.

Systems presented allow more than two images but homologous points are measured in monoscopic mode. Problems may occur for objects with less texture when no target is used to identify homologous points. Only stereo-viewing allow in this case a precise 3D measurement. Therefore stereopairs of images (close to the normal case) are required. Systems can then be assimilated to 3D plotters for the measuring of spatial object co-ordinates. 3D measurements are required for the definition of digital surface models which are the base of the orthophotos.

CONCLUSIONS

The traditional photogrammetry is based on stereo or multi-image restitution of a block of overlapping images and collinearity equations allow us to determine the 3D model of the overlapped area. A sequence of overlapping images is acquired with calibrated digital cameras. It will be get geo-referencing and block control, depending on hardware and processing facilities:

- measuring a set of ground control points by Total station or GPS;
- determining the camera position by a GPS tied to the camera and synchronized with the image acquisition.

Homologous image point coordinates are measured (manually or automatically by image correlation software) in every image. Bundle block adjustment provides image orientation. Object point coordinates are determined by triangulation or multiple intersections. (Curtaz M., 2012).

In conclusion, the low-cost photogrammetric technology has a lot of possibilities to process the images, no matter how they are being taken (with nonmetric cameras, with metric cameras or with a multi-spectral camera) if we consider conditions above.

The new geomatics technologies, very useful for contemporary world, specialists but non-specialists too, are able to solve many civil engineering works, old buildings, historic bridges, castles, feudal fortress, archeological sites, historic and art monuments, to protect them, to restore them in order to point out the real, original values of our civilization. Collectting also single images, or if it is possible, pairs of images for stereographic restitution, or even bundle restitution (which cannot be done only with pairs of photographs sometimes), anytime people can restore the authentic buildings facades, historic and art monuments, elements which confer value to contemporary world.

Nevertheless we can process images with a goood precision using a low-cost equipment.

REFERENCES

APOSTU, A., 2016, 3D Modeling of a building façade, USAMV, International IFIMCAD Symposium 2016

CURTAZ M., 2012, Terrestrial photogrammetry (TP), P6 Permafrost and Natural Hazards.

HANKE K., GRUSSENMEYER P, 2002, Architectural Photogrammetry. Basic theory, Procedures, Tools, Corfu.

MIHAI, D., - Geomatica în reabilitarea amenajărilor de Îmbunătăţiri Funciare, USAMV , 2014

KRAUS K., 1997. Photogrammetry. Vol.1: Fundamentals and Standard Processes; Vol.2: Advanced Methods and Applications. Dümmler, Bonn.

NEFFRA A. Matthews, 2008, ,Aerial and Close-Range Photogrammetric Technology: Providing Resource Documentation, Interpretation and Preservation, Technical Note 428.

MIHAI D., Modern Technologies Used in Data Updating for a School Farm Modernization, Proceedings of 25th DAAAM International Symposium, 2014.

MIHAI, D., MARINESCU C. Creating the Solid 3D Model of a Building, using Laser Scanning Technology , Published in Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering, Vol. III, 2014,

G., POPESCU G., 2013, Lectures of Stereo-Photogrammetry & Photointerpretation

TSIOUKAS V., Simple tools for Architectural Photogrammetry, XXI International CIPA Symposium, October 2007, Athens, Greece.

VILCEANU, B., 2013, Aplicatii practice in fotogrammetria digitala.