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APPLICATION OF AEROSYS SOFTWARE TO CALIBRATION OF DIGITAL CAMERA CANON EOS 300D.

This publication demonstrates the possibility of use of free AeroSys Consulting software to calibration of digital cameras. Investigations were carried out with digital camera Canon EOS 300D. Before the elements of internal orientation of camera were determined, the stability of CMOS matrix registration of images was checked out. Appropriate pictures were taken to measure coordinates of checkpoints by AutoCAD 2000. Parameters of camera calibration were determined with the modules Direct Linear Transformation and Camera Calibration program AeroSys.

Introduction

The development of digital photography within the last ten years caused that digital cameras have been applied in practical tasks solved with the methods of digital photogrammetry. Frequently photos executed by non metric digital cameras as well as by photogrammetric cameras have became source material, which with regard on their accessibility allows for cheap photogrammetric data collection. This has significant influence on the expense of the study, as well as its accessibility for various groups of recipients. However, it causes deterioration in precision of study if compared with standard methods. With regards of accuracy and economy, digital cameras should not be used to inventory control of shape of large objects, while their application increases for small objects like architectural details, paintings etc.

At present, practical digital cameras increase their resolution and dimensions of CCD disks. Advantages of these cameras include:

- quick access to digital image after its realization (no negative processing and scanning);
- possibility of storing many images in camera's memory;
- high sensitivity of CCD disks enabling taking pictures with poor lighting;
- colour efficiency;
- good quality of camera body and lens verified in analog photography

(Boroń A. 1998).

Some of digital cameras were based on standard, usually one-lenses reflex cameras; such a solution allows for use of interchangeable lenses, composing equipment of basis camera . However the majority of digital cameras are new compact designs with built-in lens. Matrix of CCD or CMOS elements replaces photosensitive material.

The cheapest digital cameras have automatic focusing effect and comparatively low resolution, more expensive ones have adjustable zoom lens, and are equipped with functions of manual settings of parameters, including diaphragm, shutter time, distance of sharpness adjustment. These models have the highest resolution up to several million pixels (Boroń A., Tokarczyk R. 2000).

From the point of view of photogrammetry the most interesting are cameras with high resolution and repeatability of elements of internal orientation. Such is the investigated model - Canon EOS 300D. Considerable part of photogrammetric measurements requires acquaintance of parameters of projection, so called camera calibration parameters, delimitation of which was the object the conducted investigations.

Profile of digital camera Canon EOS 300D

Canon EOS 300D (fig. 1) is a digital reflex camera with 6.3 Mpix matrix, equipped with interchangeable lens EF S 18-55 f/3.5-5.6, equivalent to focal length 28-90 mm in small format.

The model has 7-field system of automatic sharpness measurement. Fields may be chosen either manually or automatically. AutoFocus works in three modes. The camera has three methods of light measurement (evaluation, partial and centrally - averaged) sufficient to apply in majority of exposition situations.

The other functions include: function of simultaneous image recording in formats RAW and JPEG (quality *middle / fine*), management of memory cards CompactFlash Type I and II with 2GB capacity or more, the color space Adobe RGB and standard colour space RGB as well as *bracketing of* whiteness balancing. Sensitivity equivalents of ISO 100, 200, 400, 800,1600.

The following features qualify this camera directly for photogrammetric applications:

- high matrix resolution of (6.3 Mpx)
- high-quality of lens (the clearness, resolution, distortion)
- possibility of manual adjustment of zoom and sharpness (which has direct influence on repeatability of adjusting internal orientation elements) (Kwoczyńska B., Płaczek Ł. 2007).

Fig.1. Reflex digital camera Canon EOS 300D

Calibration parameters of a digital camera

The parameters of calibration of photogrammetric camera allow for reproduction of the bundle of central projection from pictures executed with this camera . They include:

- position of centre of projection in reference to picture, defined by x_o and y_o (coordinates of the main point of a picture) and c_k (distance image), which are called elements of internal orientation of camera;
- the data relating to lens distortion error;
- for metric cameras the coordinates of background marks in background system.

Digital cameras as non - metric device have no background marks in image plane; their function port takes pixels of image corners. The distortion of lens of photographic cameras differs significantly from distortion of metric cameras, and what is most important, constancy of elements of internal orientation of such cameras can not be assured because image distance is variable and depends on sharpness adjustment.

Application of digital cameras for photogrammetry requires therefore check of stability registration of digital images, as geometrical repeatability of images recorded by motionless camera.

Calibration of Canon EOS 300D digital camera with AeroSys software

Non-metric camera used for photogrammetric studies may have three applications: to calibrate pictures during calculations of coordinate points of photographed object (self-calibration) or determine

elements of internal orientation and distortion for camera, then accept designed values as familiar and to proceed as with study of metric images or to use non-calibrated images and DLT function (Boroń 1998).

Accessibility of the software for calculations is the basic barrier of independent realization of calibration. In the present study, free version of AeroSys software was used for aerotriangulation (Fig. 2).

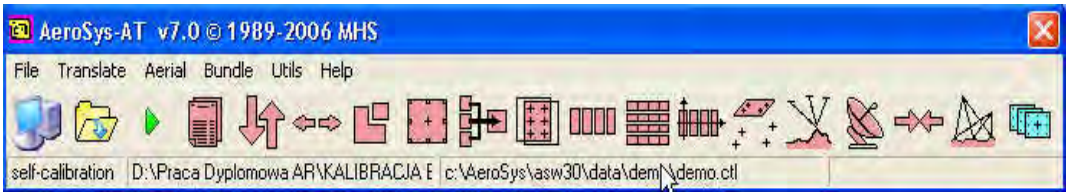

Fig. 2. Interface of AeroSys software

Program consists of two parts: the first one with modules for project establishment, data management and *pre processing* to formatting series and block of pictures, while settlement of the net is carried out in the second part.

For calibration of digital camera with one picture, two subroutines included in module *Utils*. They are:

- *Direct Linear Transformation*
- *Camera Calibration (close range)*

Before beginning of delimitation of elements of camera internal orientation, stability of images registration on CMOS matrix was checked out. Therefore three images were executed from one stay position in such way that any change of paints localization on the image was resulted by instability of the image – applied was self-timer and maintained was constancy of parameters of the focusing effect (the constancy of position of ring *zoom* and ring of sharpness).

The co-ordinates of checkpoints on every image were measured (in pixels) by AutoCAD 2000. These coordinates were compared in the following way:

- the first image with the second one
- the first image with the third one

The results are listed in table 1.

Table 1.

Registration stability of images by camera Canon EOS 300D

Images	Systematic factor by "x" [pxl]	Systematic factor by "y" [pxl]
1st and 2nd	0.96	0.71
1st and 3rd	1.12	0.55

With the obtained results it is possible to confirm, that Canon EOS 300D has good stability of images and may be applied for photogrammetric studies.

Delimitation of the internal orientation was carried out in two stages with the use of AeroSys modules - *Direct Linear Transformation and Camera Calibration (close range)* .

Direct linear transformation facilitates calculation of co-ordinates of points on the basis of on-calibrated camera, what is necessary for this aim is the presence of at least six spatially disposed points of adaptation on every picture(Tokarczyk R., Stanios I. 2003).

In the *Direct Linear Transformation* AeroSys module (Fig.3) for every picture DLT coefficients are calculated, and then final calculation takes place of unknown quantities of co-ordinates of points measured object.

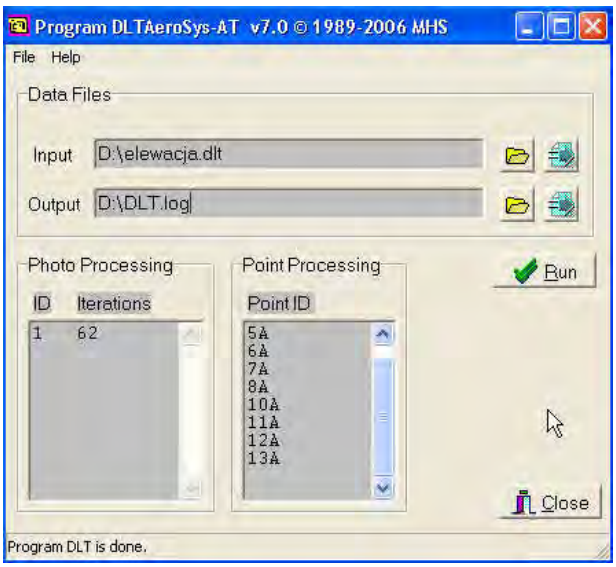

Fig. 3. Window of module *Direct Linear Transformation*

Calibration with this module has to be carried out on spatial test field. Therefore image of building elevation with maximum spatial differentiation of check points was chosen for calibration. Additionally because of high method sensibility on measuring mistakes, easy to identify points were determined on image.

Measurement of co-ordinates of checkpoints was executed by AutoCAD 2000 and conducted with relation to system of defined in the image centre (diagonals crossing). The input file *elewacje.dlt* was created . It was important to bear in mind that in case of cameras of close range, coordinate system has to be changed so as axis Z determines depth of an object.

With obtained output file of calibration *dlt.log* the following values of elements of internal orientation, in pixels, were read: c_k = 660.166, x_0 = 18.075, y_0 = 7.649. These results were used as source of approximate value for the next stage of calculations.

In the module *Camera Calibration (close range)* elements of internal orientation and parameters of polynomial of distortion are calculated on the base of points of adaptation presence on image, using the equation of collinear, which is related to iterative calculation method and necessity to introduce approximate values of unknown quantities. Before actuation of the module, input file *elewacja.spc* should be created according to instructions, and values obtained in module DLT may be applied as approximate values.

Calculation of elements of internal orientation depends on such steering with process of iteration so as to receive individual unknown quantities in the next steps. Therefore it should be decided which values of a stage of iteration are constant and which calculated (Fig.4). Trying to determine simultaneously all unknown quantities leads to divergence of iteration.

As the result of iterative process in output file *SPCamCal.log* the following values of elements of internal orientation, expressed in pixels, were obtained:

$$c_k = 662.630 \text{ , } x_0 = 2.524 \text{ , } y_0 = -0.499$$

These values were recognized as the final ones.

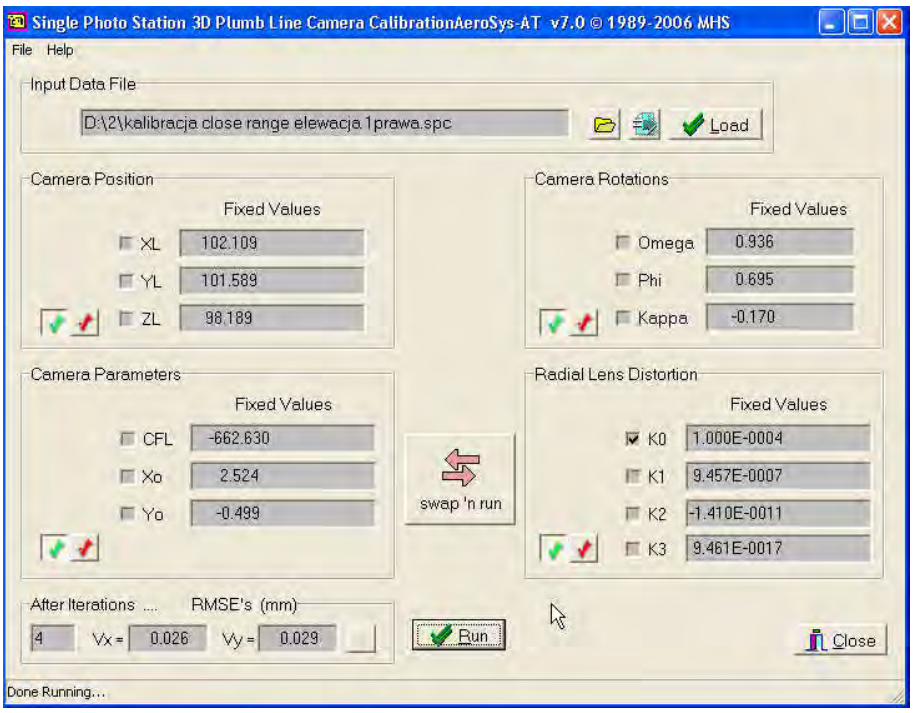

Fig. 4 Window of module *Camera Calibration (close range)*

Conclusions

Digital cameras are becoming commonly applied in photogrammetric studies. The possibility of use of free versions software that enable delimitation of the elements of internal orientation of non - metric cameras contributes to this trend. Such is AeroSys Consulting software, of which chosen modules were used to calibration of digital camera Canon EOS 300D.

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