GEOMETRIC ACCURACY TEST OF THE NEWEST LARGE FORMAT DIGITAL AERIAL SURVEY CAMERAS

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ABSTRACT

The latest and technically more perfect digital aerial survey cameras require the further improvement and refinement of the calibration methods. To satisfy this requirement a new method was developed. This process analyses the accuracy of photo measurements by statistical methods in dependency of distance points from image center. The result of this new process led to a general consequence to show a functional connection between accuracy and radial distance and to provide a method how to check and enhance the geometrical capability of the cameras. The latest and most accurate large format digital aerial survey cameras have been tested in this paper with the newly developed radial variance component estimation. The conclusion shows the radial reliability of these cameras in several different real aerial projects.

KEY WORDS: Camera Calibration, System Evaluation, Radial Variance Component Estimation

INTRODUCTION

The latest versions of digital aerial cameras require significant steps of develop both photogrammetric hardware and software systems. The increasing accuracy which is already far below the micron in the photo space and the new and modified hardware design also induce additional steps for the calibration software. The so far unresolved error effects should be examined and eliminated in the calibration software resulting a considerably higher accuracy.

This was the motivation behind analyzing further the calibration possibilities and testing the accuracy of photo measurements in dependency of the distance of points from image center (Kruck 1985). A software development project had been initiated to analyze these effects.

RADIAL VARIANCE COMPONENT ESTIMATION

The definition is defined as follows: First, the "Variance Component Estimation" has to be calculated. These components prove the correctness of the a priori introduced weights for each measurement group. This control number for each group is calculated from the a posteriori standard deviation divided by the a priori standard deviation. This control number has to be 1.0 or close to this value. It is an iteration process until all the values are satisfactory. Then the image measurements will be split into several groups according their distance from the image center and the variance components are calculated again for these groups. These values are shown in a figure in dependency to the radial distance for each group. The curves are the target of our study. There is a clear functional connection between radial distance and accuracy for each camera, each curve dependent on the camera types and camera groups (Melykuti, Kruck 2014).

In the image center there was always higher accuracy detected while at the edge of the images always less accuracy (after cleaning the data from gross errors and systematic effects). The graphs were between linear and exponential according to the camera types. The accuracy was about 20 to 50 percent higher in the center of the image than at the edges, which can lead to huge accuracy differences between two images connected along the edges to each other. These accuracy changes were analyzed with different methods for the newest aerial photogrammetric camera types comparing the improvement to the previous generation of cameras.

USED METHODS FOR THE INVESTIGATION

During the analysis uniform methods were selected for comparability of measurements. The first important step was to create symmetric circular areas.

The possibilities were:
- to use equal sized areas (Method 1.),
- equal number of tie-point areas (Method 2.),
- or equal step widths for radii (Method 3.).

The first two test-methods we tried to use and apply as one group. In the test projects we have always had a large number of measured tie-points and we have already seen nearly homogenous distribution of the points in most cases. It was necessary to use SAMBA – a tool in the BINGO software package - to achieve homogeneous point distribution in image space. The first two methods were practically the same with no need to examine it separately (Figure 1).

To select equal radial distances geometrically could give a true picture, however, here the problem is the fact that the most critical zones were the inner and outer regions with very low numbers of points. This distribution does not correctly reflect the true accuracy (Figure 2).

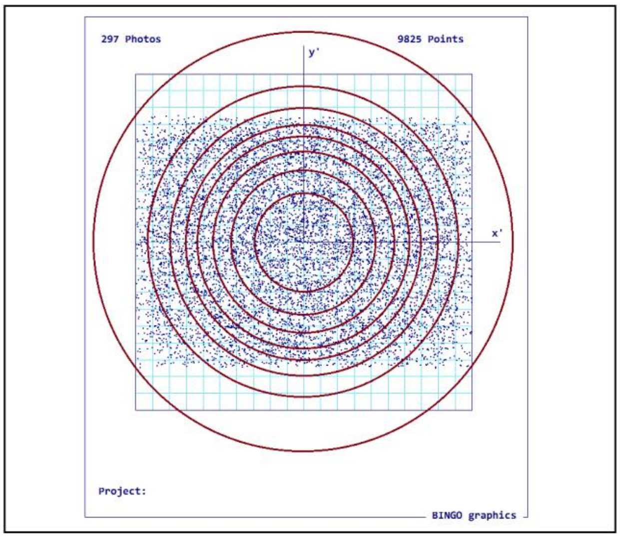

Figure 1., Equal number of tie-point areas

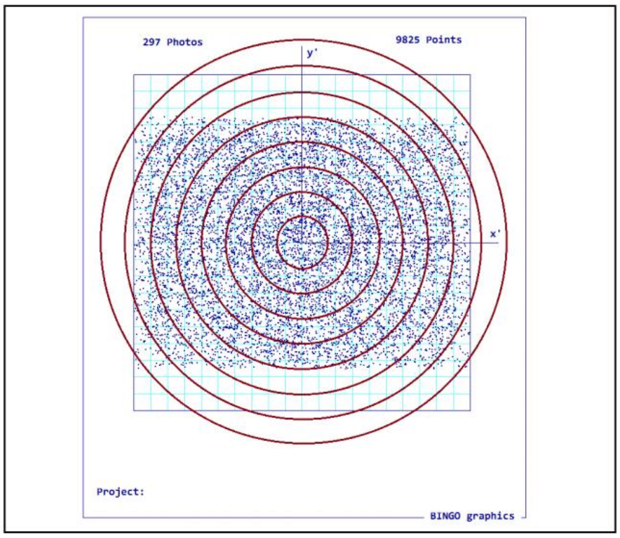

Figure 2., Equal step widths for radii

As a conclusion of this test the radial-symmetric rings with equal number of points were used as a reference for all tests.

The choice of the zones with equal steps of radius (Method 3) clearly shows that at the edge of the images the accuracy decrease significantly where the alternate method (method 1) was more balanced because of the higher numbers of points in that group.

This motivated us to do further test at the edges and in the center. Taking very small radial steps it conspicuously shows the edges even more radical decrease accuracy. This result also shows that in the center are not so significant, but the edges very dominant. This can be important in practice when there is minimal overlap between images - such as the recently very popular multi-head camera system or a moving camera head - in these cases a much lower accuracy to be calculated (can be reduced to half) as the center of the image area(Figure 3.).

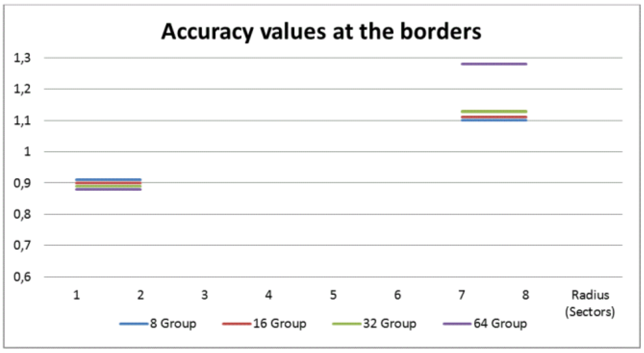

Figure 3. Accuracy values of different groups at the borders

Different test methods

During the tests, we study the variety of technical parameters and how these factors impact the radial accuracy.
We tested cameras under the same conditions with:

- different types of CCD sensors
- sensors of different pixel sizes

The studies showed that the sensors had no dominant effect to the radial accuracy.

The external parameters such as the significant changes in the flying height were studied under the same conditions. It provided very similar accuracy curves for the radial distance independent of the flying height - no significant implications could be detected.

Comparing identical camera types

The tests of same camera types, as well as cameras with the same hardware characteristics, provided very interesting results. The tests showed similar radial accuracy curves for the same camera types. This confirms that the radial geometry is strongly dependent on the optics and the hardware of the camera systems.

One of the tested new-generation camera type was the DMC II. Different resolutions of this model has been examined under the same conditions. The behaving of the cameras were very similar. The curve of the DMC II cameras are extremely flat, with very small difference in accuracy between the center and the edges. Compared to the previous generation of DMC cameras the radial accuracy increases very noticeably while the deviation between the different curves decrease (Figure 4.).

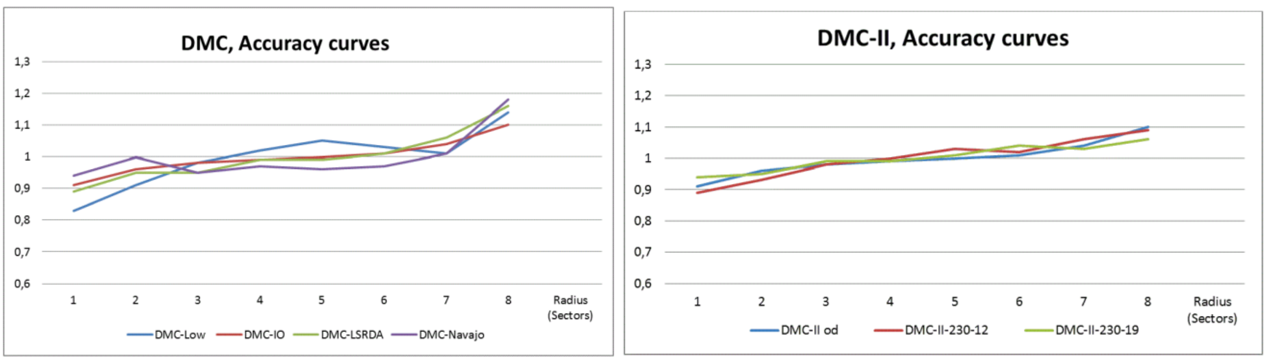

Figure 4. Radial accuracy curves for DMC and DMC II

The test of the latest generation of UCE cameras showed the following results. In this case, several versions were tested. The curves are extremely similar to each other. This indicates a very stable accuracy for the entire image surface.
The changes of the accuracy curve to the former camera generation is remarkable, the curve stays much closer to the average accuracy and at the edge has a high accuracy enhancement compared to the former generation (Figure 5.).

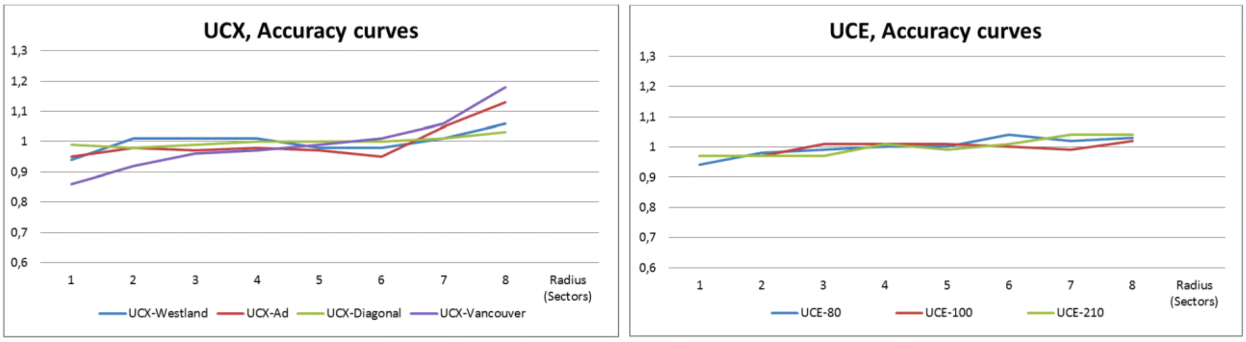

Figure 5. Radial accuracy curves for UCX and UCE

A very interesting effect was the local accuracy enhancement on the image surface at the new-generation cameras. It means the accuracy does not change linearly with the radius but it changes with a higher degree curve form.

After the test of the different camera generations it can be concluded that the general accuracy curve of the aerial photogrammetric cameras has been enhanced. Formerly a linear ascending line was the typical graph, but for the latest camera generation a new form of the curve prevails. Generally, this curve has a much lower deviation to the average accuracy and at the curve endings the distance to the average is also smaller. It is not linear, defining the form would be not as easy as for the former camera types (Figure 6.).

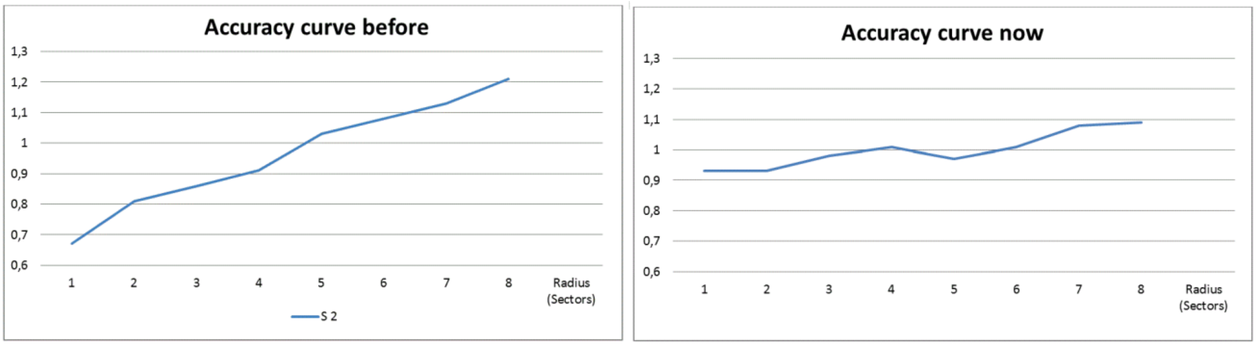

Figure 6. Typical accuracy curves for former generation and for the latest cameras

Overall, it should be noted that because of the many variable external parameters (such as weather, time of day, flight level), these data are not directly comparable to each other – the curve displayed is just a trend.

CONCLUSIONS

The general conclusion of the study is that the sensor size and resolution or the distance in the object space has no significant effect on the radial accuracy curve. After performing all the evaluations it can be determined that the reliability of the radial accuracy of the cameras are determined mostly from the optical and mechanical parts of the cameras. The latest versions of the large format aerial survey camera types achieve at a much higher accuracy compared to earlier models. The accuracy curve is a curve of higher degree. It remains closer to the defined average accuracy and provides more constant reliability of the image along the edges of the images

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