Aspects Regarding Digital Cameras Used in Aerial Photogrammetry

Iosif VOROVENCII, Conf. dr. ing. ec. – Universitatea "Transilvania" din Braşov, icatop@yahoo.com

Abstract: *In this paper are presented aspects regarding digital cameras used in aerial photogrammetry. The appearance of this leads to the rethinking the whole process of taking over the images as well as the kind of processing and interpretation of these. The diversity of digital cameras, besides the software, made possible to obtain images with superior quality, in short time and with small costs. The technical characteristics of this, the lightness in the exploitation and the high degree of automatisation make these cameras to be more and more used to take the aerial images.*

1. General aspects

The technology used for digital photogrammetry is continuously changing, reason for which the development of digital aerial cameras has advanced significantly over the past 4-5 years and there has been a boom in sales due to the advantages offered by such cameras. Modern aerial film cameras have reached a high level of development with very high spatial resolution, geometric quality, a wide covering angle and an overall efficiency in capturing images. All these performances of aerial film cameras are surpassed by the features of digital aerial cameras which are capable of acquiring images of a resolution at least similar to that achieved with film cameras, ensure a better accuracy, feature a cover angle comparable with that of film cameras and captured images can be used for obtaining ortho-photos.

The use of digital cameras offers multiple *advantages:* the image quality and accuracy is superior (2,5 x film), the interpreting of digital images is achieved at high level, the longitudinal covering of successive images may reach 95%, high quality digital models of the land are obtained, noise levels are low due to the absence of granularity, the inner orientation is done automatically, images feature no distortions and duplicates may be obtained, accuracy may be enhanced by acquiring images in different wavelengths, the image control and quality enhancing may be operated in-flight; operations are performed automatically based on digital techniques, starting with the image acquisition until their editing, no consumables such as film are used and therefore there is no need of developing it, this resulting in the reduction of the additional costs for obtaining images in infrared or duplicates and in the reduction of manual work.

One of the greatest advantages of the digital camera technology is the increase in the number of flight hours per day and in the number of days of aerial photography per year due to the superior radiometric quality as compared to the film-based technology. In this sense, there is the possibility to carry out flights under weak light conditions or at low sun angles meeting the image quality requirements for mapping.

As compared to classical aerial images, which consider as parameters the square shape of the images, the focal length and the field angle, in the case of digital images these parameters needn't be given a special consideration. In the case of film-based cameras, wide-angle lenses are used for economy purposes and for obtaining a smaller number of images for an easier editing. Such is not the case with digital cameras, as the image editing is done automatically. As for the angle of field of the lenses of digital cameras, even though it is low, it has been noticed that the high number of images acquired does not significantly increase the cost price of the records.

Digital cameras are also available in modular form and the operating conditions are much improved in the sense that certain aspects related to temperature and wetness do not constitute anymore restrictive factors as in the case of classical photogrammetry. The diversification of these technical means gives the user the possibility to choose depending on performance and costs. Moreover, software systems enabling the editing of aerial images under different forms and for different purposes are available.

2. Digital camera systems

In principle, digital images may be obtained in two different ways, using *analog systems* based on cameras with film and a scanner for digitizing the information stored in the image and *digital systems*, based on *linear sensor arrays* capable of storing digital data directly in-flight.

Pushbroom scanner systems (linear array sensor cameras) acquire data by scanning the land with linear sensors transversely on the plane flight direction. The system consists of at least three sensors, one looking to the front, a vertical one and one looking to the rear, which makes possible the acquisition of three images with covering between them, thus permitting to determine the dimensions. Moreover, it is possible to acquire multispectral images with a more poor resolution than that of images in panchromatic or even with the same resolution. In order to determine the position of the camera and the angles at the moment of capture, a GPS/IMU integrated system is used, considering the fact that image acquisition is a continuous process.

Area array systems involve acquiring a sole image on the same area with an average resolution or several images which merged form a larger overall image for the same area. The image format is similar to that of images captured with aerial film cameras and is not always square. The presence of the GPS/IMU system is not absolutely necessary in the case of these cameras, but certain parts may be included as options.

The main *features* of *linear array sensor cameras* (*pushbroom)* are as follows:

- The image is not a perspective projection, for which reason a special software is required to edit these images;
- The accuracy of image geometry is dependent on the quality of the GPS/IMU positioning system;
- The possibility to lose certain pixels is smaller than in the case of area array cameras. This advantage is obstructed by the fact that in the case of occurrence of pixels erroneously recorded only neighboring pixels can be used for interpolation in order to reconstruct the lost data;
- Linear sensors require capture in a broader dynamic range;
- in principle, they are much more appropriate for images captured on small areas than area array cameras due to the plane movement effects;
- images with a 5 cm pixel size can be obtained;
- many linear systems are capable of acquiring only three images per point in the plane flight direction, yet are capable of capturing multiple images transversely on the plane flight direction.

The features of digital cameras equipped with *frame sensors are* as follows:

- images are central perspectives just like classical aerial images captured on film and their digital editing may be performed using standard programs;
- present the possibility to compensate the forward motion;
- are much more appropriate for extensive area flights;
- although the number of erroneously recorded pixels is larger, there is a sufficient number of neighboring pixels based on which interpolations can be made to determine the values of the new pixels in the case of erroneous data;

- area array formats are generally smaller than the formats of film-based cameras, hence the *b/h* base ratio is small. This requires the acquisition of a larger number of images with longitudinal coverage ranging between 80% and 90% in order to obtain a *b/h* ratio similar to film-based cameras;
- obtaining frame images permits to perform the aerial triangulation for a set of frame images, this leading to reliable and high geometrical accuracies in determining dimensions;
- do not require a GPS/IMU system to determine the parameters of external orientation. The use of a high quality GPS/IMU system for direct orientation enables the quick performance of aerial triangulation and image editing in order to determine dimensions and obtain ortho-photos immediately after data download.

The choice of digital camera is made taking into account the ground samples distance (GDS) or the resolution in the field and *not depending on the scale*. *The flight height, focal distance and pixel size* specific to the CCD sensor are parameters used for calculation in flight planning. As a rule, Digital Mapping Camera (DMC) used to capture side and front images with coverage for obtaining the stereoscopic effect observes, in principle, the same rules as film-based cameras. As no materials are used, as in the case of film cameras, when planning the flight there may occur situations in which successive images have a very large coverage, namely 80 – 90%. To obtain ortho-photos, especially in urban areas, the high coverage percentage has become quite widely used.

3. Digital camera types

Among the most advanced aerial digital camera systems available are *Leica ADS 40*, *Vexcel UltraCamD* and *Vexcel UltraCamX* of recent manufacture (2007). These systems capture images in several ways, with high accuracy, in infrared, RGB and panchromatic.

The digital camera *UltraCamD* from *Vexcel Imaging* is nowadays one of the most up-to-date aerial digital cameras used in photogrammetry (fig. 1). The use of this digital camera opens the way to new perspectives, from a technical and economical point of view. Such cameras are equipped with four lenses for the four bands (red, green, blue and infrared) and four cameras for various resolutions. In this sense, the *UltraCamD* - type has the following features: high resolution in panchromatic (11500 x 7500 pixels), pixel size of 9 μm, focal distance of 100 mm, possibility of simultaneous capture of images in multispectral (color RGB) and in infrared (IR).

a. b. c.

Figure 1. Digital digital cameras used in aerial photogrammetry:
a - Vexcel UltraCamX; b – Leica ADS40; c – Vexcel UltraCamD

UltraCamX cameras present a radiometric enhancement comparable to film, permit several flight days and a better image overlapping. *Leica ADS 40* camera operates in various modes

similarly to a linear scanner. It collects images on a pixel row at a certain moment and constructs the image along the flight line over the entire width of the flight strip. The sharpness of the obtained image is superior to that obtained on film and analog cameras.

4. Data post-processing

Acquired rough data captured with aerial digital cameras require post-processing in order to obtain the final product. As regards this operation, there are significant differences depending on the type of camera used, with pushbroom or area array sensors.

Line sensor cameras capture images consisting in line and, as such, it is necessary to correct the distortions of individual lines featuring a shift between each line caused by the movement of the plane. The operation of this correction requires precise information on sensor external orientation at the moment of capture usually acquired by an Inertial Measurement Unit (IMU). Therefore, before starting image post-editing, the user has to perform an initial processing by means of the GPS/IMU system without which image editing would not be possible. An acceptable post-processing time can be obtained with a high-performance computer.

Frame sensor cameras acquire images that constitute central perspectives and post-processing is performed using software incorporating standard processing photogrammetric algorithms. Due to the stability of sensor geometry, in order to obtain the final product there is no need to use a GPS/IMU system. The data post-processing time is considerably shorter than with linear array sensor cameras and the software runs on standard workstations and does not require particularly high-performance computers.

The data for the geometrical and radiometrical calibration of the camera are made available to the user on CD to be used, at the right time, during post-processing. This operation is carried out with a minimum intervention of the user on the program and the final product can be obtained in parallel on multiple formats such as RGB or CIR .

5. Conclusions

Due to the wide range of advantages they offer, digital photogrammetric cameras are nowadays the most advantageous instrument used for capturing aerial images.

One of the greatest advantages of aerial digital cameras as compared to traditional film-based cameras lies in the ready access to images. It is possible to acquire color images of high spatial resolution or infrared images in less than 24 hours from the flight.

Digital cameras offer new possibilities for on-site data quality checking. The image quality evaluation may be performed in-flight, especially in flight restriction areas, which is both time and cost saving.

Reference

1. Chițea, Gh., Kiss, A., Vorovencii, I, 2003 - Fotogrametrie şi teledetecție, Editura Universității "Transilvania" din Braşov.

2. Kiss, A., Vorovencii, I., 2000 - Fotogrametrie. Universitatea "Transilvania" din Braşov

3. Rainer, K,. 2004 - Perspective noi în aerofotogrammetria digitală. Prezentare simpozion. Braşov, 15 iulie 2004.

4. Zegheru, N., 2001 – Camera digitală ADS 40. Buletinul de Fotogrametrie şi Teledetecție nr. 21-22. Societatea Română de Fotogrametrie şi Teledetecție.