CHALLENGES OF THE MODERN AERIAL PHOTOGRAMMETRY

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***Abstract**: Currently, photogrammetry has changed the practical approach. If 20 years ago it was all about images, today it is possible to obtain many other informations. In the first place, connecting the camera with a GNSS receiver that gives the position of the objective, then with a LiDAR system, which gives a digital terrain model. For each type of activity it is approached a practical way of work and a combination of technologies to ensure the required parameters. The actions of establishing working technology, systems that will be combined, is taken by the specialist familiar with all these requirements. Each beneficiary shall establish requirements and the specialist will have to combine the requirements to fit in accuracy.*

Keywords: photogrammetry, LiDAR, remote sensing.

1. History

1.1 History of photography and the first aerial images

Photogrammetry beginnings are indispensable linked of the appearance of the photography and the manner in which evolved over time. The oldest photography was taken by Joseph Nicéphore Niepce, who took a photography on a coutyard seend from his window and the exposure lasted 8 hours.Year of the capture, 1839. Louis Jacques Mandé Daguerre is the one that has progressed in the domain. He was the associate of Niepce and continued to word independently creating simple images directly onto the surface of metal. The resulting images were very fragile to the touch and they had to be protected by glass, but they were able to keep even the smallest detail.

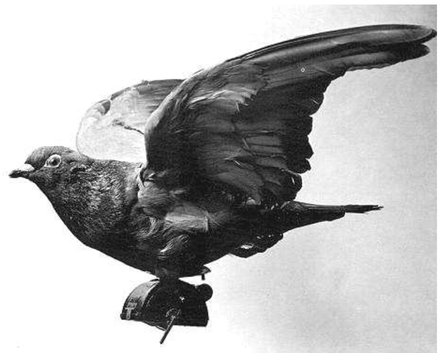


Figura 1.1 Pigeon used to transport a photo camera

In the same period,William Henry Fox Talbot British physicist managed to get negative images printed on paper, made with solutions of silver salts, sensitive to light, first established in commen salts and, later, at the suggestion of Sir John Herschel (famous English astronomer) in sodium thiosuphate, also known as „hypo".

In 1840, Arago, director of Astronomical Observatory of Paris, claims the use of photography in surveying purposes.

In 1849, Colonel Aimé Laussedat, officer in French Corps of Engineers, is involved in an extensive program for topographic mapping using phoyographies.

From 1858, ballons are used to obtain images on large areas, so Felix Tournachon (also known by Nadar) performed the first aerial images of Paris (Figure 1.2), and later, between 1880 and 1900, are used hawks and pigeons for transporting photographic cameras hundred of meters altitude (Figure 1.1).

Figure 1.2
Nadar photo of a Parisian area – 1868

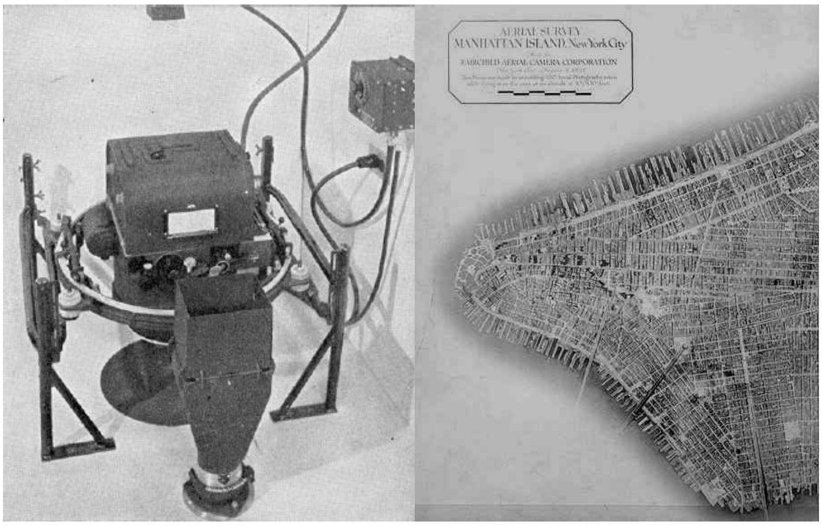
Figure 1.3 – Photo obtained by Lawrence at San Francisco 1906

In 1879, George Eastman discovered the formula for gelatinous emulsion meant to cover dry surfaces, also building an installation for coating such emulsion. Ten years later, his company, Kodac, introduced flexible celluloid film, growing popularity of photo.

In 1906, George R. Lawrence performes an oblique image of San Francisco after an earthquake and a large fire. The image was obtained using a specially designed camera and lifted into the air by a number of interrelated kites and taking the camera in a state of equilibrium in different wind conditions. He called the system thus developed “Captive Airship” (Figure 1.3).

These developments allowed that with the advent of airplanes, aerial images to become a very useful tool, in order to obtain data on large areas under total control. First images obtained under such conditions were recorded out of an airplane piloted by Wilbur Wright, in 1909, above the Contocelli City in Italy.

Another important point is 1920, the year in which Sherman M. Fairchild sets up an aerial camera (Figure 1.4), superior from all points of view to the previous ones. The following year, with this camera were made 100 images partial overlap of wich have made an aerial map of Manhattan Island (Figure 1.5), the first aerial map used commercially.



Figures 1.4 – 1.5 Fairchild aerial camera and part of Manhattan Island aerial map.

1.2 History of photogrammetric technology

Oskar Messter, in 1915, made the first automatic aerophotography camera which led to the execution of aerophotography on tapes. In the same year, surveyor Max Gasser performed double projector. The first stereoscopic photogrammetric restitution camera was built according to the principles made by surveyor Theodor Scheimflug and also there were made the first procedures of guidance and practical operation of aerial photographs. German company producing optical switchgear, Carl Zeiss from Jena built the first universal precision stereoscopic restitution machine, after the project of German physicist and engineer Walther Bauersfeld, using principle of optical projection in 1923..

From that moment began the modern photogrammetry, based on interpretation of stereomodel and that has led to plans and cadastral surveying large areas in a short time. It was also possible to determine altitudes otherwise than by traditional methods.

For a long time, the images were taken on film and plans were made on paper scrapped on zinc sheets in order to cause no damages. Later, they were passed on the cartographic service and became maps or topographical plans. Only with the development of computers and digital imaging technology could take over the next step, digital photogrammetry. Data were stored on magnetic hard, and maps and topographic plans were made without input cartographers, but through editing programs, for exemple CAD.

According to the principle of achieving exterior orientation, for getting the connection between image and real coordinates, of the land, needed 4 photogrammetric control points on each photogrammetric couple. With the advent of aerotriangulation, number of points was reduced at 2 to 6 photogrammetry couples.

When onboard device that was mounted to retrieve images was set also a GNSS receiver, number of points was also reduced.

Today we speak about modern photogrammetry, which can achieve high images resolution and can provide centimeter accuracy for planimetry and altimetry.

2. Possibilities to obtain planimetric and altimetric informations using aerial photogrammetry.

2.1 Data acquisition.

Currently, there is a possibility that in addition to the instrument that acquisition images, on board of the aircraft to be also located other tools that provide better quality and other helpful informations:

- GNSS receiver. To better highlight the location of GNSS receiver, we presented not a plain, but a helicopter that has two arms on which the receivers are placed.

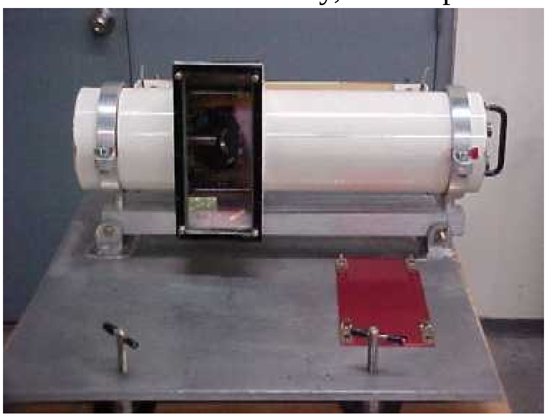
The fact that there are used two GNSS antennas allows satellite data to be received continously, without the risk of blocking.

Also, it is introduced redundancy, which contributes to the accuracy of the determined position. GNSS data are is well loaded twice per second, both airborne system ans base stations (can be permanent stations ANCPI).

Figure 2.1 Helicopter used for acquisition images

- INS. The system's position is determined at a rate of 200 times per second by a IMU device (Inertial Measurement Unit). IMU is located on the aircraft ans is able to accurately determine tge orientation of the system in space, measuring the rotation of the three spatial axes (Roll, Pitch and Heading), and also three dimensional velocities and accelerations. These measurements are used by the system INS (Inertial Navigation System) integrated to calculate the exact altitude of the helicopter..

- Laser scanner. Is meant to provide redundancy and to ensure data accuracy and quality. Laser scanners are safe vision, and devices without measuring beam reflector are capable of measuring the first rays of return from 15-200 meters. Each scan makes a certain number of measurements, depending on the type on a open angle (depending on the type of laser). Coverage is approximately equal to the altitude of the aircraft above the earth. Each scan contains time, the laser altitude, information about checking data / error detections, information on intensity, which provides the active ability to capture infrared images. From an operational standpoint, laser scanning is performed 53 times per second (sweeps), resulting more than 21000 points per second.



The density of points required is calculated according to customer's demands and varies from 4 laser points per square meter at highest altitudes and over 25 points per square meter if details and very accurate overflights, low altitudes are desired.

Figure 2.2 Type of laser scan.

Laser beams are directed to 7 degrees in the front and back. In this way the shadow effects are minimized. Beeing Class 1 lasers type, they do not harm the view in any way.

Moreover, during the flight is not necessary any kind of precautions or safety measures regarding lasers

We did not spoken about cameras, because these are tools indispensable for photogrammetry. We still need to remind of new cameras types with multiple objectives. One is nadiral, the others being arranged in certain angles in order to take oblique images.The images obtained look like Figure 2.3. As the figure shows, they can be used for measuring the facade, for seeing the facades' type, building's height etc. The images are mainly used for urban planning, but also for urban directions of cities, which in this way can determine which buildings should be rehabilitated and which not. Also can be distinguished many other necessary items for town planning direction of City Halls.

Another accessory that can also help town planning is a thermographic camera. Attaching this kind of camera can provide a lot of information about heat loss of buildings or district heating networks. In Romania there have been made images with this kind of camera by BLOM.

Figura 2.3 Images of Bucharest taken with multiple frame camera.

2.2. Data processing.

Considering the instruments on board of the aircraft, data processing will be done in order to obtain complementary results. Thus, the information obtained from processing stereomodel and orthophotoplan must be correlated with data from point cloud and from data collected with GNSS receivers. Scalling is much simpler, does not need so many points for control. Also, the digital terrain model is no longer obtained by stereorestitution but by LiDAR technology, as preocessed point cloud.

A very important element is the existence of GNSS receivers on aircraft's board and his very accurate positioning as against ANCPI permanent stations. Permanent stations are designed to permanently set position of GNSS receivers from aircraft's board. These receivers are positioning themselves photogrammetric camera and LiDAR. Having the position known for camera and LiDAR, translations of three-dimensional transformation are removed. Also, it takes a network of points on the ground, a geodetic network, which secures both planimetric position and altimetric position of stereomodel.

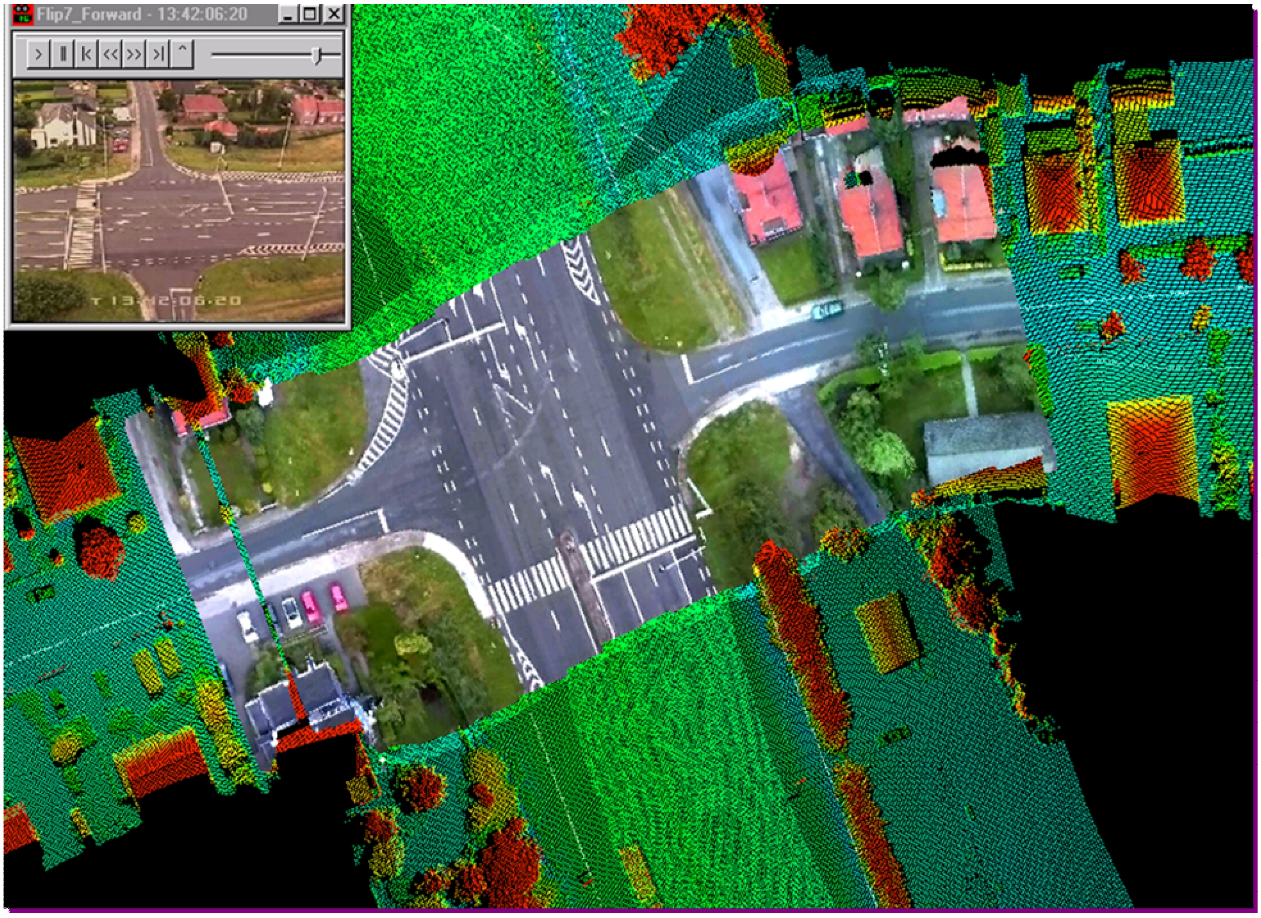


Figura 2.4 Cloud point; nadir and oblique images taken over the same objective.

Data processing.

Data processing is divided into two parts : pre-processing and post-processing. Data pre-processing is made during overflights. This allows full control of the quality of field data. If there are gaps in the data, more flight lines can be planned in order to ensure the quality of the final data.

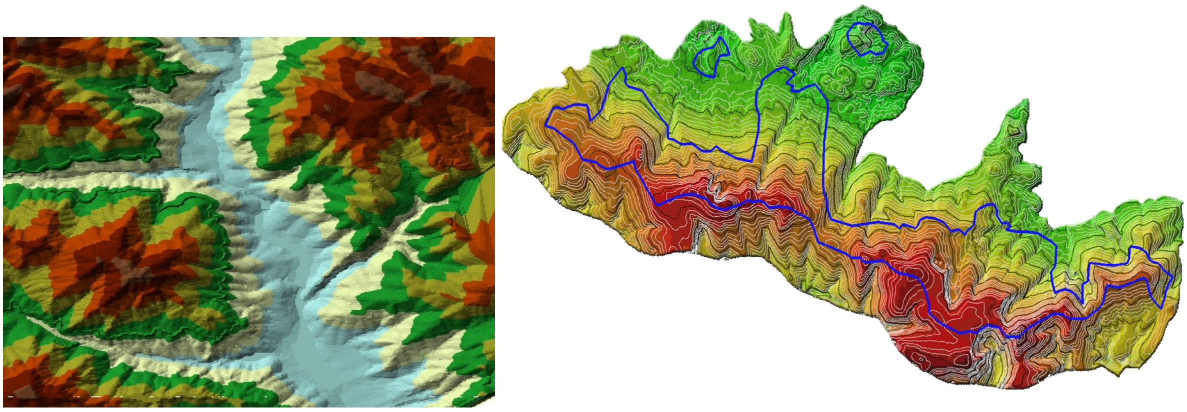
Pre-processing. Pre-processing begins with the calculation of references between base stations and antennas from airborne system. These multiple references are combined in order to have a precise position of the aircraft in every moment. GNSS positioning solution is integrated with INS data to accurately calculate flight direction of the system. In the meantime, it is checked data coverage and density of points. Finally, the absolute precision of laser data is verified using information regarding location and height of reference points.

Post-processing. The main software for data processing is a processing package, specifically developed to see, manipulate and analyze photogrammetry camera data and laser data. The software will help the user with special filters to classify laser data, to extract specific information on points and lines, to combine images with laser data in order to obtain orthorectification mosaics. Processing results can be exported in various CAD, GIS and DTM packages.

The program must fully control coordinate transformations (coordinate systems, projections in which the maps are defined, geoid model for altitudes) to ensure that the exported data can be integrated with data from other sources using the same reference coordinate system

2.3 Products obtained.

The first product, which is used also by photogrammetry to achieve orthorectification images, is the digital terrain model (DTM – Digital Terrain Model). (Figure 2.5)



a *b*

Figura 2.5 Digital terrain model. a – red – heights, blue – lowlands; b – red – heights, green – lowlands

Using DTM it can be made topographic profiles, technical studies for designing various engineering works (highways, irrigation channels, landslides etc.). To achieve the topographic profiles is sufficient to select points and automatically, the profile between the two points is generated.

Orthorectification images can be used for other products : the cadastral plan or topographic plan on that area. The cadastral plan can only be made by unraveling at terrain or by filling with classical measurements. There are used high-resolution images, with relative and absolute orientation calculated, which means that coordinates in reference system chosen can be read (usually Stereographic projection 1970 for Romania).

The resulting products can be thematic maps or plans : flood risk maps, maps of transmission lines for electricity, cadastral maps, maps of belowground pipes (on the aircraft is mounted a thermal camera, too), etc.

Applications does not end here, there are many more and depend on beneficiaries and on the projects they have and they want to develop.

3. Conclusions

This statement clearly shows that for many typical work of engineering, accuracy geographic and topographic information, the method set is of extreme importance.

The ability to collect these data in a fast, safe and effective way is the essence of any practical use of information. Intregrated system capacity to collect needed data accurately and in a fast and efficient way makes integrated system photogrammetric camera + LiDAR + GNSS + INS to be an excellent overflight system which allows various engineering applications.

Facility of integration and reuse of data provides value to the data collected by this system and cand be used with various GIS packages.

Integrated system advantages compared with traditional techniques can be summarized as follows:

-Low costs.

-Very short execution time to the final product

-In comparison only with photogrammetry, integrated system is less dependent on weather conditions and has a greater share precision because LiDAR component.

-Providing static images or geo-referenced video, ortho-rectified (up to the pixel dimensions of 4-5 cm.) can be considered an additional product that can be used for 3-D visualization studies, engineering studies and very precise DTM for design studies.

2. References

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