DIGITAL AERIAL CAMERAS

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INTRODUCTION

Today airborne 3D data acquisition is quickly moving from film based analogue cameras to digital mapping cameras. With the introduction of digital aerial cameras, significantly more vendors have come into the market, whereas for the film cameras, only three large format camera vendors existed. For business decisions, either to purchase a new camera system or to contract aerial image acquisition, it is important to recall some of the main camera parameters and to understand the differences between the old traditional analogue cameras and the new state of the art digital cameras. The latter are divided into several categories: large format cameras (e.g. the Intergraph DMC), medium format cameras (e.g. the new Intergraph RMK D) and small format cameras.

ANALOGUE CAMERA PARAMETERS

All large format film cameras have a standard square sensor format, 9” x 9” film or 230 mm x 230 mm. Calculation for mission planning is based on this square sensor format. The most common focal lengths are 150 mm (wide angle camera) and 300 mm (normal angle camera). There are other focal lengths available as well. Because of the square sensor format, the field of view is the same in both the flight direction and across the flight line. The optical system of a film camera has a very high resolution. Good cameras have more than 100 line pairs/mm optical resolution. This is required to meet the specs of high resolution film, although for film based aerial colour images, only 40 to 50 line pairs/mm resolution can be achieved on average. This is influenced by the film type, atmospheric effects like dust and haze, and film development.

The mission parameters for the photo flight with film based cameras are determined by the photo scale required for the project.

The photo scale for analogue cameras is calculated with the following formula

$$\text{photo scale} = h_g / c_k \qquad (1)$$

Where h_g = flying height above ground

c_k = focal length

In most cases the analogue image is scanned. Very common scan resolutions are between 12.5 micron and 21 micron. By digitizing the analogue film, a ground sampling distance (GSD) is introduced for each pixel.

The GSD for a scanned aerial image can be calculated using the following formula:

$$GSD = \text{photo scale} \times \text{scanning resolution} \quad (2)$$

DIGITAL CAMERA PARAMETERS

For digital cameras there is no standard sensor format. Most of these cameras have a rectangular image format, where the larger dimension is across-flight direction to minimize the number of required flight lines for photo flights. The sensor size is defined in pixels (e.g. for the Intergraph DMC 13824 x 7680 pixels). There is a wide range of focal lengths from around 62 mm up to 120 mm. Because of the rectangular sensor format, the field of view is different in flight direction and across flight line.

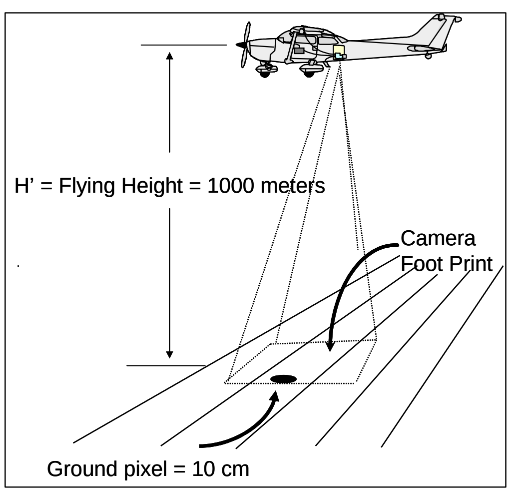

Fig. 1: calculation of GSD for the Intergraph DMC

The GSD for digital cameras is calculated with the following formula:

$$GSD = h_g / c_k \times \text{CCD pixel size} \qquad (3)$$

Where h_g = flying height above ground

c_k = focal length

For digital cameras, the pixel size of the CCD must be considered. Depending on the CCD manufacturer, there are CCDs with pixel size varying from 6 micron to 12 micron. For each digital camera, the combination of focal length and pixel size determines its operation profile. Mission parameters for photo flights with digital cameras are determined by the required ground sampling distance (GSD). For the Intergraph Digital Mapping Camera DMC, the GSD can be calculated by dividing the flying height above ground by a factor of 10,000. The DMC has 120 mm focal length and 12 micron CCD pixel size.

IMPORTANT CAMERA PARAMETER FOR 3D AIRBORNE DATA ACQUSITION

For 3D data acquisition with digital aerial cameras some new aspects are introduced. First and foremost the required ground resolution (GSD) has to be specified. This has a major impact on flying cost and later on also data processing cost. If the GSD is specified too high (high GSD means small pixel size on the ground) more flight lines will be required and the amount of data per area will increase. It is recommended to specify both a target GSD and a minimum GSD to allow some flexibility because of terrain variation.

The overlap (forward and side overlap) has to be specified. Because film costs are eliminated it looks alluring to specify higher overlaps (e.g. 80% or 90% forward overlap) The downside is that the user has to deal with a huge amount of data, which effects processing time, required hardware resources and final processing cost. The majority of applications can be addressed using standard 60% forward and 30% side overlap.

A huge benefit for digital cameras is the superior image quality. To take advantage 12 bit pixel depth minimum is strongly recommended. Especially for automated feature collection a higher bit depth per pixel will give better results.

NEW SENSOR DEVELOPMENTS

Customers familiar with film cameras and who consider entering the digital world are looking for the same accuracy they had been used to for many years, plus all the advantages of digital camera systems on top, all at the price of a film camera. This is a challenge for the industry.

Development of digital aerial cameras is also a technical challenge for the vendors. Compared to old film cameras, the amount of electronic components has increased and thus the life cycle time of the product reduced. The challenge is to mitigate the risk using components with long life cycles and at the same time to develop a high performance sensor at reasonable cost. Another challenge the vendors are facing is limited influence on CCD manufacturers to tune their sensors for aerial camera application. CCD technology is dominated and influenced by consumer cameras which have different requirements for application.

As explained earlier in this paper, digital camera systems can be divided into 3 categories, large format, medium format and small format systems. There are 3 vendors for large format cameras, Leica ADS40, Vexcel UltraCam and Intergraph DMC. There is a variety of small format camera systems on the market, with few exceptions they are based on components developed for studio cameras, such as commercial digital backs.

With the RMK D Intergraph introduced the first high precision, multispectral, metric, medium format camera system on the market. The RMK D is a camera system with half the footprint of a large format camera, but with the same geometric accuracy and high radiometric quality.

For large scale and high resolution 3D data acquisition the RMK D will provide an excellent planimetric and vertical accuracy at standard 60% forward and 30% side overlaps. High base to height ratio of 0.42 and 14 bits per pixel.makes the RMK D an ideal platform for 3D data acquisition and stereo feature collection

FUTURE OUTLOOK

So far all large format digital frame cameras have combined small CCD sensors to generate large footprints. Intergraph is now working with CCD manufactures to design one single large format CCD which will produce a footprint close to what analogue film cameras had. This CCD will have a size beyond 100 MPixel and will have a square format. Current development activities include a PAN camera which can be added to RMK D as a fifth camera head. In the futue customers will have the option to upgrade RMK D to a large format digital camera by adding such a PAN camera head.

References

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