

PHOTOGRAMMETRIC COLOR SCANNING

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ABSTRACT:

Scanning of analog image material remains a key function in the photogrammetric production chain as long as digital aerial cameras have not completely overtaken. Therefore it remains a conducive intention to strive for optimal scanning results. This contribution gives a short recapitulation on how the scanning procedure has evolved since 1990, compares photogrammetric and non-photogrammetric scanning applications and focuses on the scanning of color material. The implementation of such concepts is presented by several examples.

1. FROM CENTRALIZED SERVICE TO DISTRIBUTED FUNCTION

After an initiation in about 1990, photogrammetric scanning by now has become a routine and standard element of each digital photogrammetric work flow. Initially, the concept was to set up scanning service bureaus which would centralize the scanning function for many photogrammetric mapping workshops. But since the photogrammetric equipment manufacturers were able to develop increasingly more affordable products the scanning function has become very distributed and has been brought into each photogrammetric operation. This improves the work flow and offers the photogrammetric production managers complete control over the end-to-end work flow for extraction of information from blocks of initially analog photography. The photogrammetric industry has come back to a situation that existed when analog and analytical technologies “ruled”, with a clear interface between the raw data creation by means of aerial photography specialists, and the information extraction by photogrammetric processing specialists.

2. PHOTOGRAMMETRIC VERSUS NON-PHOTOGRAMMETRIC SCANNING

However, bringing the scanning function into a photogrammetric mapping operation has led to a need to better understand the workings of scanners on a routine basis. “Document scanning” is a rather traditional function in industry with many different manifestations. There are the color graphics and printing industries with their need to change a color photograph into separate cyan-magenta-yellow-black channels for offset printing, producing the justification for the largest investments in scanners compared to other industries. Since about 1990, this has been changing over from a simple task of color separation into an input to digital image processing systems. There is medical scanning of X-ray films and of histological specimens. The manufacturing industry has for several decennia studied the need to convert paper drawings into CAD-documents. And the most recent developments have been inspired by the transition to the “paperless office”, leading to the need for low cost, low quality scanners in each office. Today, millions of scanners are being produced each year as peripherals to personal computers.



Figure 1. Scanning examples from medical application (x-ray, monochrome, up to 4.0 OD) and graphics art application (highly dynamic color diapositive)

In this context, photogrammetric scanning is a niche with very distinct requirements which are set apart from all other scanning applications, first and foremost by the need to offer a

1. high, well defined and verifiable geometric accuracy.
- In analogy to photogrammetric coordinate measuring equipment, this accuracy is typically seen in the range of ± 2 mm. Other specifications typical for photogrammetry exist as well, to include the need to work with
2. a comparatively large format at 25 cm x 25 cm;
3. transparent film;
4. uncut and rather heavy rolls of film;
5. comparatively large data quantities, given 23 cm x 23 cm color imagery and small pixels;
6. high geometric resolution of up to 5000 dpi.



Figure 2. Aerial image, 23 mm by 23 mm results into a digital file of several hundred megabyte of data (e.g. 705 MByte @ 15 μ m pixel size and 3 by 8 bit color depth)

While some attempts have been made to convert graphic arts scanners into photogrammetric systems, these have generally not been successful, except where the application was for low quality ortho photo production. Today it is generally understood that the needs of the photogrammetric application can only be met by specialized scanning systems.

3. NEED FOR HIGH RADIOMETRIC PERFORMANCE

Converting analog film into digital information means to resolve the radiometric range of the film. We know from

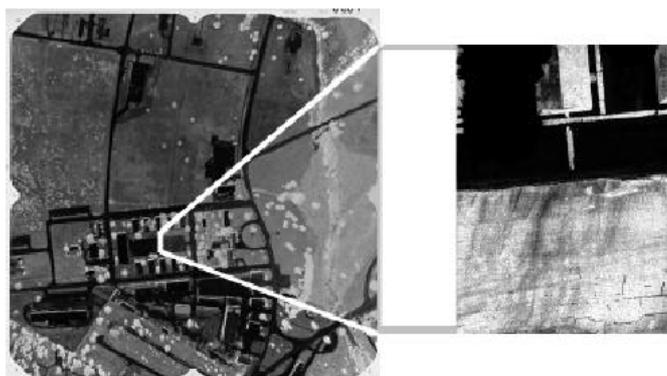


Figure 3. B/W negative aerial frame, showing an extreme dynamic range of 3.1 to 0.3 OD. Details like cracks in the asphalt are clearly visible in the digital image after radiometric enhancement of the image detail

densitometric measurements, that b/w film material may cover a dynamic range from appr. 0.1 D up to 2.5 D, eventually up to 3.0 D in special cases. Investigating color diapositive material one may observe even more dynamic range, e.g. up to 3.5 D.

4. THE NEED FOR COLOR

When photogrammetry was based on analog measurement devices color was a factor of extra costs when copies had to be made for work and finally color was expensive and critical in the analog production line. This has no longer any meaning in the digital photogrammetric work flow. Therefore the color information of photogrammetric products is highly appreciated. Scanning color images has become a every day job and photogrammetric scanners need to support the operator through a smart user interface and to show the technical ability to transfer color information from the analog film to the digital file.

5. COLOR NEGATIVES

Color negative film has become the media of aerial photography. Not as critical against exposure setting and light conditions like diapositive materials this film type has become the favorite media. The transition of this film is the issue of modern photogrammetric scanning. We show on the hand of an example, how masked color negativ film interacts with electronic imaging and how problematic images can be managed.

6. COLOR CALIBRATION

In the beginning of photogrammetric scanning the calibration of the geometry of a scanner was most important. Not much later the radiometric calibration became an issue when asking for the radiometric behavior of a scanner.

The calibration of the color response of the scanner shall now give full control over the digital workflow and make color management possible. Known from graphic arts these so-called color profiles need to be produced by scanning a specific color target and added as collateral information to the output image data.

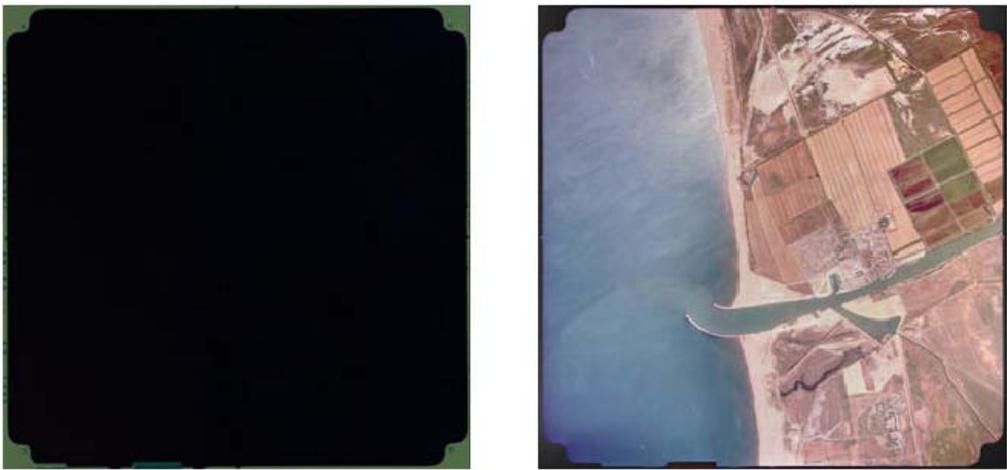


Figure 4. Color negative aerial frame, showing a dynamic range of 2.8 to 1.1OD. The image quality seems to be acceptable after image enhancement.



Figure 5. The IT8 color calibration target is used control the radiometric performance of a scanner. Left: full target, showing 246 color tags and 24 greyscale tags. Middle: scale of the 6 primay colors and black. Right: Transform of measured color values and reference values.

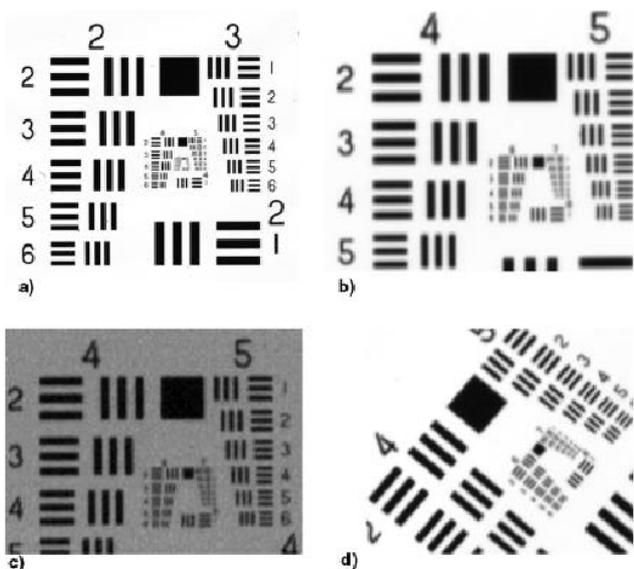


Figure 6. The US-Airforce Resolution Target. a) entire target, b) central part, showing the resolved pattern of section 6.1, c) same as b) at a lower dynamic range and d) target scanned at a rotation angle of 45 deg



Figure 7. Aerial image at scale 1:5000. The AGFA X100 color negative film shows a remarkably fine granularity and allows scanning at a resolution of 2500 dpi

7. EXAMPLES

We show some results and practical experiences from scanning with the photo-grammetric scanner UltraScan5000. One example shows the well known US-Airforce Target, scanned at a resolution of 5080 dpi (5 μ m pixel size). Another example shows a part of the high resolution color negative film Agfa X100. The granularity of this film comes close to that of well known B/W material like the Kodak Panatomic X.

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