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Shorter Contributions

PHOTOGRAMMETRIC PERFORMANCE EVALUATION OF A 4096 × 4096 PIXEL DIGITAL CAMERA BACK

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Abstract

The paper deals with the determination of the metric quality of a 4096 × 4096 pixel high resolution digital camera back achieved from testfield measurements.

INTRODUCTION

IN close range photogrammetry, digital image data can be obtained by various direct image acquisition systems (Atkinson, 1996) such as camcorders, standard or high resolution CCD cameras, HDTV and still video cameras or sequential image recording devices (video theodolite, turning and tilting camera or micro- and macro-scanning camera). In addition, digital camera backs which fit onto medium and large format analogue cameras like a standard film magazine can be used for photogrammetric applications (Godding and Woytowicz, 1995; Peipe, 1995). They have been developed for professional studio photography and allow easy interchange between film and digital acquisition. All the existing equipment of conventional photographic cameras can be utilized. These studio camera backs are designed to be connected via an interface to a computer.

In professional studio photography, usually high resolution colour images are to be produced. Area array and scanning camera backs are available (Peipe, 1995). Scanning devices are characterized by high resolution, such as 6000 × 7520 pixel (linear CCD) or even 11 000 × 15 000 pixel (macro-scanning camera with shifted area CCD), and rather slow image acquisition. Stationary objects and constant lighting conditions are required. Linear CCD scanning backs may result in relatively low geometric accuracy of the digital image data due to the mechanical positioning of the linear sensor. However, the use of area array cameras or camera backs, respectively, for high precision photogrammetric measurement is highly recommended.

Area array camera backs are equipped with CCD sensors of up to 3 k × 2 k pixel (Peipe, 1995). The same pixel number applies to area array still video cameras widely used for photogrammetric applications. Recently, "ultra-high resolution" solid state sensors providing more than 16 million pixels have been introduced. Such a 4 k × 4 k pixel CCD sensor is built into the Dicomed BigShot digital camera back. The 60 × 60 mm sensitive area of the CCD array covers the image format of an analogue medium format camera.

The aim of this paper is to report on the metric performance of the Dicomed camera back. First test measurements to evaluate the accuracy of three dimensional object reconstruction by means of a multistation self-calibrating bundle adjustment are descibed.

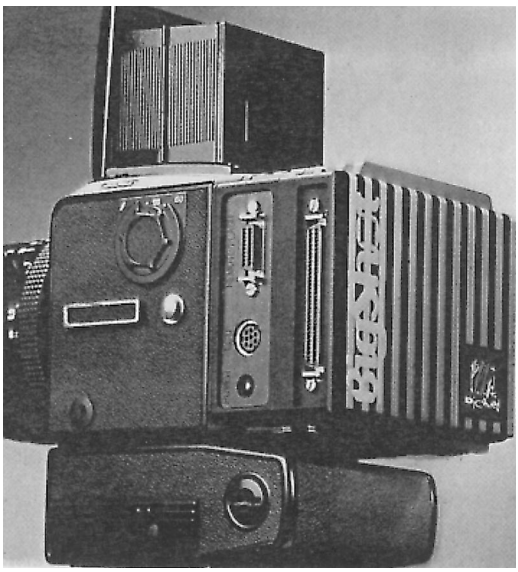

FIG. 1. Dicomed BigShot digital camera back attached to a Hasselblad camera body.

CAMERA DESIGN

The Dicomed BigShot digital camera back (Dicomed, 1996) features a 4096×4096 pixel Loral Fairchild CCD sensor with $15 \times 15\,\mu$m pixel size. The very compact device can be adapted to Hasselblad 500 EL, EL/M and 553 ELX camera bodies (Fig. 1). All standard lenses can be used. Instant colour capture, 3-shot sequential colour and black and white versions are available. Due to the large imager, the image area is 60×60 mm.

The camera back requires a fast/wide SCSI connexion to a Macintosh PowerPC for data transfer and storage. The image file size amounts to 16 MB (8-bit b/w), 32 MB (12-bit b/w), 48 MB (8-bit colour) or 96 MB (12-bit colour).

PHOTOGRAMMETRIC PERFORMANCE EVALUATION

The metric quality of a BigShot camera back linked to a Hasselblad 553 ELX with 50 mm Zeiss Distagon lens was determined by testfield measurements. The three dimensional test range consisted of 60 regularly distributed targets covering a $2{\cdot}6 \times 2{\cdot}6 \times 1{\cdot}0$ m volume. Ten digital black and white images were acquired from eight camera stations.

The images were measured in the DPA-WIN PC based digital photogrammetric station (Schneider, 1996). The bundle adjustment resulted in three dimensional co-ordinates of the targets with a standard deviation of $s_X = s_Y = s_Z = 0{\cdot}024$ mm. The accuracy of image co-ordinate measurement amounted to $0{\cdot}75\,\mu$m corresponding to 0·05 pixel in image space (internal precision from bundle adjustment). The additional parameter model used for simultaneous camera calibration included terms for principal distance, principal point offset, radial symmetric and tangential distortion, affinity and non-orthogonality.

CONCLUDING REMARKS

The Dicomed BigShot has the highest resolution and size of any area array CCD camera or camera back available at the moment (November 1996). The image area even exceeds the image format of a Hasselblad medium format camera.

The result of the photogrammetric test measurement is satisfactory but not as

good as might be expected when using such a large imager. However, sensor enlargement does not lead automatically to a more precise outcome. There exist some potential and more or less unknown sensor-specific obstacles such as warm up effects, unflatness of the sensor surface and quite a lot of defect pixels. From a practical point of view, the portability of the recording system is restricted. Camera and camera back are permanently linked to the computer by several cables, and the SCSI cable is very short.

More detailed investigations are necessary in the future to evaluate the potential of the BigShot camera back as an accurate digital image acquisition tool for high precision close range photogrammetry.

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Supplement

The results discussed in the paper refer to the specific camera/digital back combination which was used. Sensor problems as well as the insufficient stability of the camera itself and the connexion to the digital back prevented a better outcome. In order to overcome these obstacles, it is advisable to design a digital "metric" camera providing a stable link between lens and camera and between camera body and digital back.

In the meantime, such a metric camera has been developed, the Rolleimetric Q16 consisting of a 6008 body and the Dicomed 4096×4096 pixel digital back. A performance test similar to the measurement described above resulted in standard deviations of three dimensional object co-ordinates of $s_X = s_Y = 0{\cdot}012$ mm, $s_Z = 0{\cdot}019$ mm relating to an object volume of $3 \times 3 \times 0{\cdot}5$ m, a much more accurate outcome than was achieved with the "non-metric" Hasselblad/Dicomed combination. In addition, the Rollei camera will be provided with a portable image data storage unit.

Résumé

On traite dans cet article de la détermination de la qualité métrique d'une caméra numérique à 4096×4096 pixels, à haute résolution, telle qu'elle résulte de mesures sur un polygone d'essai.

Zusammenfassung

Es wird über Untersuchungen zur Bestimmung der metrischen Qualität eines hochauflösenden digitalen Kamera-Rückteils (4096×4096 Pixel) mit Hilfe von Testfeldmessungen berichtet.