Q16 - A NEW DIGITAL MEASURING CAMERA WITH HIGH RESOLUTION

R. Godding
Rollei Fototechnic
Salzdahlumer Str. 196
D- 38126 Braunschweig
E-mail: r.godding.rolleimetric@t-online.de
GERMANY

Commission V, Working Group I

KEY WORDS: Digital camera, high resolution, industrial measurements

ABSTRACT

Current developments in close-range photogrammetry are marked by the change from analog to digital methods. This affects both the image evaluation, which can be largely automated via digital image processing, and the image recording process. Especially in industrial applications digital cameras have become an essential tool. It allows on-line processing of image data without wasting time waiting for film to be developed and digitized.
For high accuracy measurements special requirements on the digital cameras are necessary, i. e. the interior orientation has to be very stable. Large sensor resolution allows the measurement of small object details and is necessary for reaching high accuracies. In the paper the new high resolution digital measuring Rollei Q16 Metric Camera is described. The Q16 has been developed especially for photogrammetric and industrial measurements. It has a resolution of 4096 x 4096 sensor elements and an image format of 60mm x 60mm. The camera can be used either as a portable camera with an external storage unit or connected directly to the PC for online measurements.

1. INTRODUCTION

With the growing importance of industrial quality assurance, ever more 3D metrology problems have to be solved rapidly and reliably. To satisfy this need, the measurement system used has to meet extremely high requirements regarding measurement accuracy in order to guarantee the quality demanded. The measurement process should take only a minimum of time, and the system should be optimally adapted to various users in the industrial environment.

2. THE Q16 METRIC CAMERA

2.1 System Setup

Based on the camera body of the Rolleiflex 6008 Integral System, Rollei Fototechnic has developed a microprocessor-controlled camera, the Rollei Q16 MetricCamera. The heart of the Q16 is a digital CCD sensor which for the first time makes full use of the entire negative size of a medium-format camera of 60 mm x 60 mm. With a pixel size of 15 µm, the sensor attains a resolution of 4096 x 4096 image points. The data are read out with a depth of 12 bits, equivalent to 4096 gray levels in monochrome images. In the first step each pixel is stored with 2 bytes.
The Q16 MetricCamera is primarily designed for highly precise metrology work at medium and close range, for example in industrial applications, but also e. g. for applications in the construction and measurement of industrial plants.

The high resolution also gives advantages in the measurement of complex surfaces with high accuracy or with small object details. Its compact size (only about 150mm x 100mm x 140mm) allow the Q16 MetricCamera to be used for metrology in confined spaces.
Making use of the entire format, the full angular field of the lenses can be used. With the aid of its sensor, the Q16 MetricCamera is the first digital metrology camera to attain a degree of accuracy previously possible only with large-format analog metric cameras (Dold, 1991).

Fig. 1: Rollei Q16 MetricCamera

As opposed to the analog cameras, the Q16 MetricCamera offers the decisive advantage of digital image acquisition. The Q16 MetricCamera stores the images directly in a computer compatible

memory instead of the 23cm x 23cm silver-halide film used e. g. in the RolleiMetric Large Format Camera (LFC). As a result, the data can be processed directly.
The resolution of the sensor of 4096 x 4096 pixels and a data depth of 12 bits give a data volume of 33.6 Mbytes per image. The data volume involved in photogrammetric work requires the use of appropriate memories. The Rollei Q16 MetricCamera uses a portable storage unit with IOMEGA JAZ drive with a storage capacity of 1 GB. Image transfer is made via an interchangeable Iomega Jaz Drive Cartridge. The portable unit measures about 240mm x 75mm x 175mm and is connected to the Q16 MetricCamera by a Firewire interface.

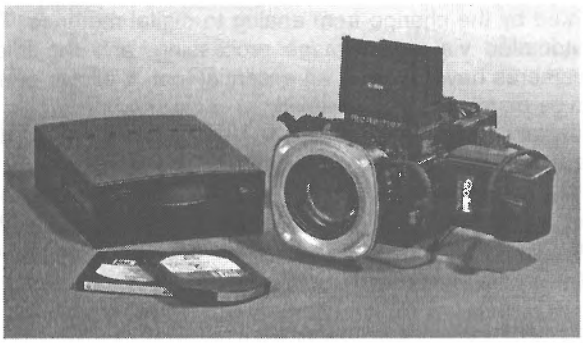

Fig. 2: Rollei Q16 MetricCamera with portable memory unit and storage media

Alternatively, the Q16 MetricCamera may be directly connected to a computer via an ultra-wide SCSI adapter. Images are downloaded to the computer in less than 10 seconds. The advantage of the computer connected solution is that the images can be shown directly on a computer monitor; a disadvantage is limited portability. Applications of this solution are e. g. in the field of arial photogrammetry and for on-line measurement systems
A great variety of metric lenses are available for various types of photogrammetric work and working conditions. These have click-stop focusing to avoid any variation of interior orientation due to focus changes. The exact position of the click stops is determined for the different lens series on the basis of the depth of field.
The Q16 MetricCamera is basically compatible with all (metric) medium-format lenses. The metric lenses generally employed in terrestrial photogrammetry and well-proven in large-scale use, for example with the Rolleiflex 6008metric, are the Schneider-Kreuznach Super-Angulon 40 mm f/3.5, the Zeiss Metric Distagon 50 mm f/4 and the Zeiss Metric Planar 80 mm f/2.8.

2.2 Accuracy of Q16 MetricCamera

To attain the high accuracy required of a photogrammetric measurement system, for example in aviation and aeronautics, large-format metric cameras such as the Rollei LFC have previously been used. The Rollei Q16 Metric Camera targets the same degree of accuracy, though by digital means.
The measurement accuracy of the Q16 MetricCamera can be estimated with the aid of an empirical formula. The value for automatic measurement of signalized targets with center of gravity and elliptical parameters can be determined with appr. 3/100 pixels. For the sensor of the Q16 MetricCamera we thus obtain a value of 0.45 µm for the σ of the image coordinates.

3. APPLICATIONS

3.1 Antenna segment survey

The survey of an antenna segment illustrates the great potential of the Rollei Q16 MetricCamera. Fig. 3 shows a segment with attached targets. To determine the object coordinates, the object-coordinate system was defined with the aid of the coded targets and scaling with the cross scale with a length of 630.3 mm ±0.05 mm.
The size of the antenna segment was approx. 850mm x 750mm x 100mm. Sixteen images were recorded with a Rollei Q16 MetricCamera and a Zeiss Metric Distagon lens 50 mm f/4. The segment contains appr. 80 points signalized by retroreflecting targets, 11 of which were coded.

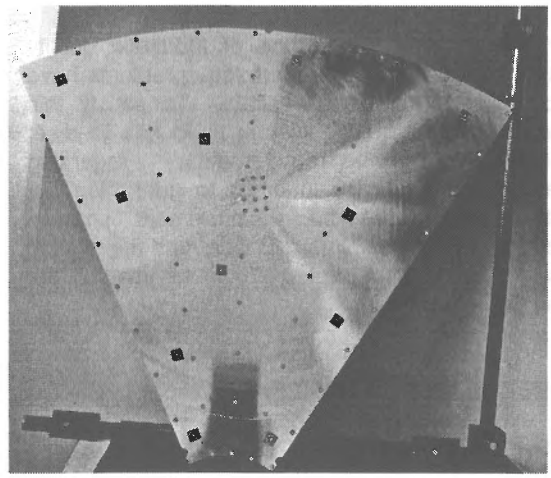

Fig. 3: Antenna segment

For evaluation, image measurement accuracy was assumed to be 0.5 µm. The final bundle adjustment gave a σ_0 of 0.4 µm with standard deviations of less than 10µm for all object coordinates.

3.2 Aircraft industry

Another example for the use of the Rollei Q16 MetricCamera are photogrammetric surveys in the aircraft industry. Contrary to a previous photogrammetric survey with an LCF Rollei Large Format Camera, which took between eight and twenty hours (including film development and scanning of photos), the Rollei Q16 MetricCamera allows photogrammetric acquisition of the large

objects including evaluation within one hour. The accuracy of the image assemblies obtained with an LCF Rollei Large Format Camera and a Rollei Q16 MetricCamera is comparable.

3. CDW EVALUATION SOFTWARE

Closely connected with the new digital Rollei Q16 MetricCamera is the new RolleiMetric Close-Range-Digital Workstation (CDW (Fellbaum, Godding, 1995)), version 2.0. This 32-bit application offers many new possibilities for industrial 3D metrology.
CDW is project-oriented. Every survey is therefore saved under a project name. When a new project is generated, either default settings or special configurations can be loaded. The user can adapt the data interactively to the project concerned.
When the images to be plotted are loaded for the first time, the program generates reference images whose size can be selected by the user. Using these reference images held on the monitor speeds up the process over the use of original data, even in the case of the Q16 images with 16Mbyte of data for each image. During loading into the project, the images are assigned to the corresponding camera. If the images have a different format, they are converted to the standard Windows BMP image format, in which case data depth (e. g for the Q16) is automatically reduced to 8 bits.
If retroreflective targets and ring flashes are used for image acquisition, as is usual in industrial photogrammetry, quasi-binary images are obtained. In CDW, the marked points are found automatically in the images due to the algorithms used. The image is searched for elliptical patterns. The ellipse centers are determined with the aid of a center of gravity and ellipse algorithm. In addition, coded targets can be detected automatically and decoded. The standard code used offers appr. 150 possibilities of data encoding (Schneider und Sinnreich, 1992). Figure 4 shows a few examples of coded targets. In addition, an extended set of targets with over 500 codes is available. Even for the 16Mbyte images of the Q16, the measuring in the images is done in only some seconds.
For relative orientation of the images, multi-image orientation with the aid of the image coordinates of the coded targets is used. The lower-order image coordinates available for the different images can be automatically tied in with object points, using epipolar geometry (Maas, 1992).
In the final bundle adjustment the calculations are first searched for errors with a balanced L1 standard (Fellbaum 1996), This is then analyzed for measurement errors or erroneous observations due to incorrect assignation, which can then be deactivated under menu control or automatically.
The final results are obtained from the cleared data by L2 estimation. The results of bundle adjustment terminate the evaluation of an image bundle under CDW. The data obtained, such as a list of adjusted object coordinates, can then be processed further, for instance with the aid of CAD software.

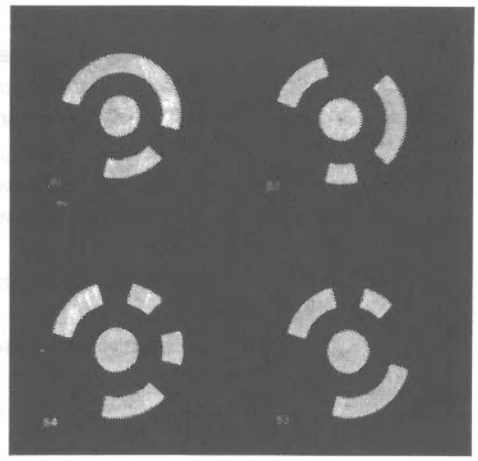

Fig. 4: Coded targets

4. CONCLUSIONS

Summarizing, it may be said that the Q16 MetricCamera has a very high accuracy potential, which makes it well-suited for applications previously reserved for large-format analog cameras. Together with its new software products, RolleiMetric offers its photogrammetric plotting system for highly precise, nondestructive and noncontact 3D metrology.

5. REFERENCES

Dold J., Riechmann W., 1991: Industriephotogrammetrie höchster Genauigkeit; ein neues Meßsystem und dessen Anwendung in der Luft- und Raumfahrtindustrie. Zeitschrift für Photogrammetrie und Fernerkundung, 6/1991, pp. 221 - 228.

Fellbaum, M, Godding, R. 1995. Economic Solutions in Photogrammetry through a Combination of Digital Systems an Modern Estimation Techniques. Optical 3-D Measurement Techniques III, pp. 362-372, Wichmann-Verlag, Heidelberg 1995

Fellbaum, M., 1996: PROMPT - A New Bundle Adjustment Program using Combined Parameter Estimation. International Archives of Photogrammetry and Remote Sensing, Vol XXXI, Part B3, pp. 192 - 196, 1996.

Maas, H.- G. 1992: Digitale Photogrammetrie in der dreidimensionalen Strömungsmeßtechnik. Dissertation Nr. 9665, ETH Zürich, 1992.

Schneider C.-T., Sinnreich, K., 1992: Optical 3-D Measurement Systems for Quality Control in Industry, International Archives of Photogrammetry and Remote Sensing, Vol. 29, B5, pp. 56-59.