DIGITAL OBJECT RECORDING BY MEANS OF RÉSEAU-SCANNING

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ABSTRACT

The principle of réseau-scanning allows sequential high resolution digital object recording by shifting a small format matrix sensor in the image plane of a réseau-scanning camera RSC.
A system of several RSC will be combined by computer control. Simultaneous multi-image video recording enables sequential object recording and nearly real-time processing.

INTRODUCTION

The small size of CCD-matrix sensors, which are today used for data recording in photogrammetric real time systems restrict the precision which can be achieved by these systems in the object space /Haggrén 1987/. Larger image sizes like those normally used in photogrammetry can be recorded sequentially by partial images (fig. 2) with the help of available CCD sensors and can be put together to form a complete image according to the réseau technique by means of optical-numerical transformation /Wester-Ebbinghaus 1984/.
This principle was realized with the first prototype of the digital photogrammetric réseau-scanning camera RSC /Luhmann, Wester-Ebbinghaus 1986/. It has been proved that object points which have been projected on a CCD sensor can be detected with a precision of 0.1 pixel or even better /Fraser

and Brown 1986, Beyer 1987, Luhmann 1987/. Consequently the precision of this prototype in the object space was increased nearly by the factor of 10 in comparison with systems using CCD cameras and is similar to the precision achieved with comparable analogue photogrammetric systems.
The recently developed computer controlled RSC (fig. 1) allows to focus while maintaining the interior orientation of the camera. This is desireable and often necessary for close range photogrammetric applications.

THE FOCUSABLE RÉSEAU-SCANNING CAMERA RSC

As a basic condition for réseau-scanning at least four réseau crosses have to be projected, detected and measured on the sensor. In order to achieve this, réseau and object are seperatly projected onto the sensor. The RSC makes it possible to project the réseau on the sensor with the help of an internal illumination source (fig. 5). The Object is projected on the sensor through the lens (fig. 4).
By means of the small aperture of the internal illumination source the réseau is projected with a great depth of focus while the lens shutter is closed. When the sensor is shifted perpendicular to the réseau plate the réseau projection is still sufficiently sharp. When the object is projected on the sensor, with the lens shutter opened and by means of the camera objectiv, the réseau is out of focus and remains only as an indistinct image on the sensor and does not hide the object information.
Consequently it is now possible to focus any single point individually by shifting the sensor perpendicular to the image plane /Luhmannn, Wester-Ebbinghaus 1987/. The focusing is performed computer controlled by analysing the gradients in different image planes. When all individually focused partial images have been transformed to the réseau plane, all projected points can be located in a constant image coordinate system, which is realized by the réseau crosses. The spatial difference between the perspective centre of the camera and the perspective centre of the réseau illumination is taken into account for the transformation. By defining additional parameters of the interior orientation the above mentioned spatial difference can be calculated by simultaneous calibration by means of bundle adjustment /Wester-Ebbinghaus 1988/.
The present mechanics of the camera allows focusing in a range from 1 to 7 mm between réseau plate and sensor. Fig. 6 shows a réseau cross which has

been projected on the sensor with the internal illumination source. In this case the distance between réseau plate and sensor is 1 mm. The cross on the réseau plate, which is originally 40 µm wide, is projected on the sensor as a cross which is 7 pixel in line direction and 10 pixel in column direction, i.e. 100 µm. The white outlines of the cross result from the deflection. Fig. 8 shows a réseau cross which has been taken with a 7 mm distance between réseau plate and sensor. In spite of the blurred projection the centre of the cross can be determined by convolution of the image function with a gradient operator; the standard diviation achieved in both cases is less than 0.1 pixel.

The sensor can be positioned in the image plane either by program control with the help of approximate image coordinates or else by joystick control by an operator who views the entire photographic scene via viewfinder (fig. 3).

OUTLOOK

As a further development a computer controlled fully digital system as a combination of several RSC is planed. After a orientation process with bundle adjustment sufficiently stable objects will be measured pointwise, nearly in real-time.

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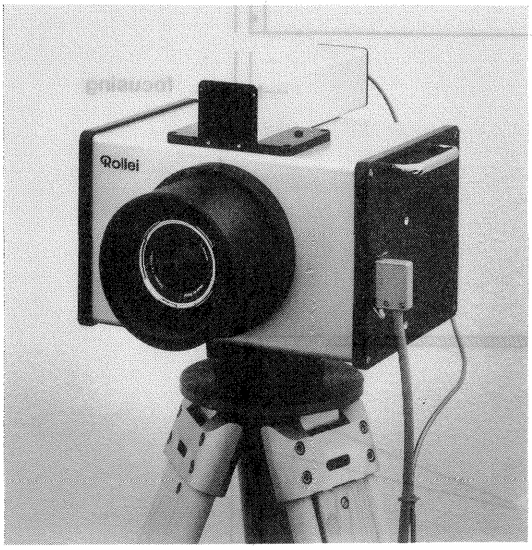


Fig. 1: Réseau-scanning camera Rolleimetric RSC

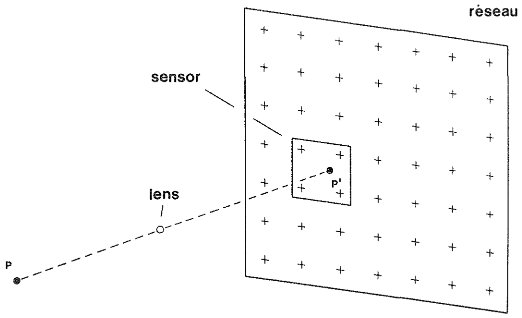


Fig. 2: The principle of reseau-scanning in the RSC

Fig. 3: Sensor positioning:
Lens shutter open, mirror turned down. For positioning of the sensor in the image plane the operator views the entire photographic scene via viewfinder.

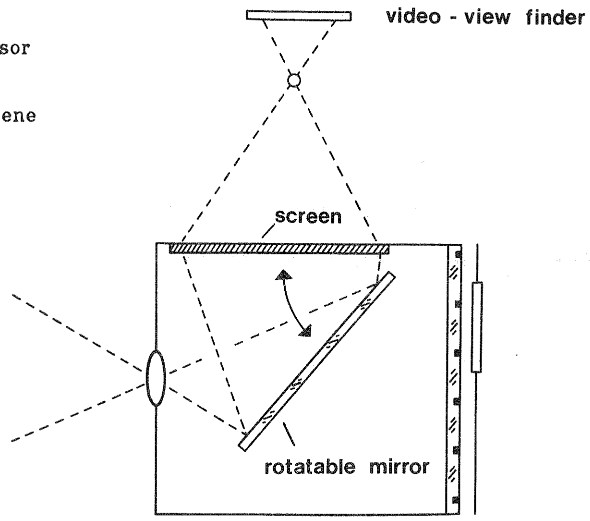


Fig. 4: Object recording:
Lens shutter open. Focusing meshwise without changing the interior orientation.

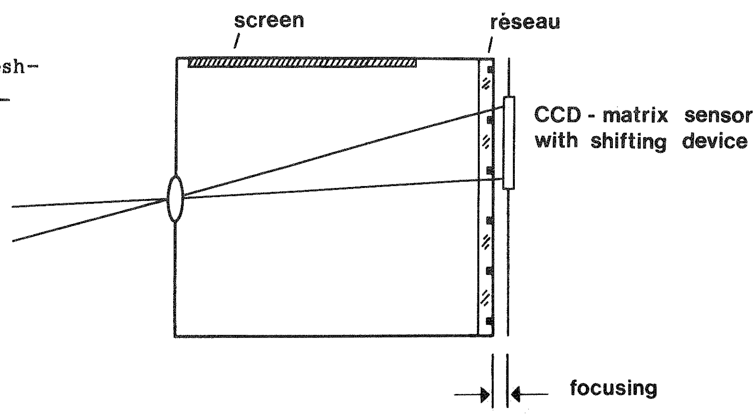
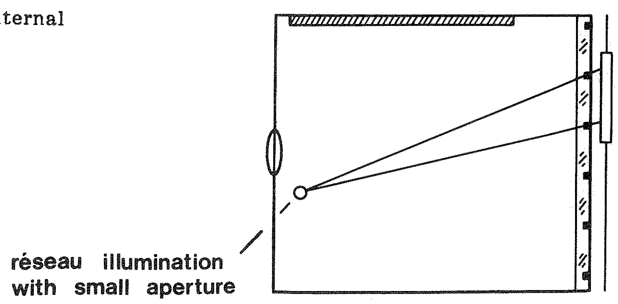


Fig. 5: Réseau recording:
Lens shutter closed, internal illumination on.



A réseau cross projected on the sensor by the internal illumination source.

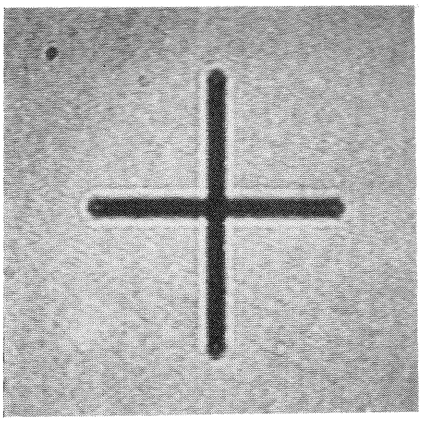


Fig. 6: Distance between réseau plate and sensor: 1 mm

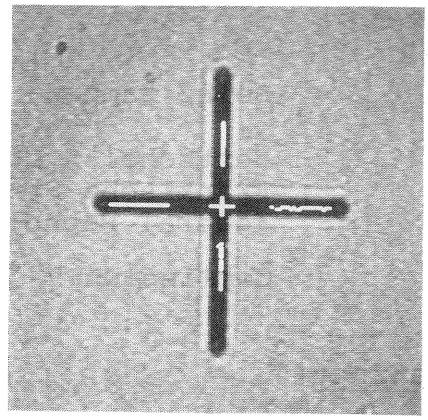


Fig. 7: The calculated centre of the cross in fig. 6

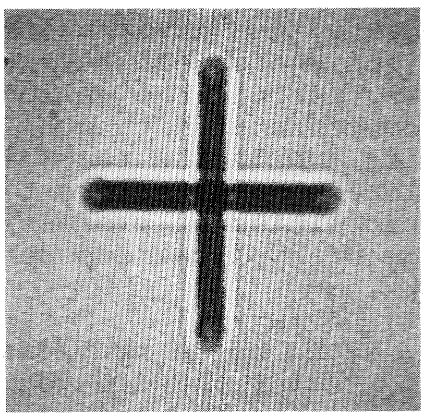


Fig. 8: Distance between réseau plate and sensor: 7 mm

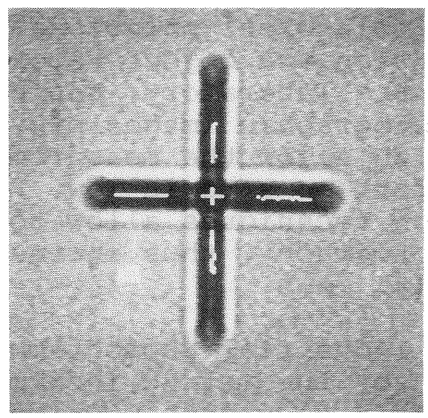


Fig. 9: The calculated centre of the cross in fig. 8