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DIGITAL IMAGE PROCESSING BY MEANS OF RESEAU-SCANNING

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Introduction

CCD-matrix sensors are used as digital components in photogrammetric recording and processing systems. The rather small image surface of available matrix sensors often does not allow to record a whole photogrammetric scene simultaneously with sufficient resolution; larger image formats are recorded by partial frames, orientated in an entire image coordinate system.

Analytical stereo-plotters are equipped with CCD-matrix sensors in order to carry out automatic digital stereo-correlation (Ackermann, 1983). A digital high accuracy automatic mono-comparator, using a CCD-matrix sensor, was presented by Fraser and Brown (1986). Albertz (1986) proposes a grid-like arrangement of several matrix sensors to achieve simultaneous digital recording of a total scene.

These systems require high optical and mechanical stability in order to obtain precise orientation of the partial images in projection space. Introducing a réseau glass plate as a transparent reference plane into the photogrammetric projection system, it is possible to orientate the partial image frames opticalnumerically with high accuracy and low instrumental effort (Wester-Ebbinghaus 1984). This principle is called réseau-scanning.

Réseau-scanning can be applied to digital processing of analogue images and to digital object recording and processing on-site. A réseau-scanner (ROLLEI-METRIC RS, fig. 2) and a réseau-scanning camera (ROLLEIMETRIC RSC, fig. 8) are developed by Rollei-Fototechnic, Braunschweig, in cooperation with the Institut für Photogrammetrie und Ingenieurvermessungen der Universität Hannover and the Institut für Photogrammetrie und Kartographie der Technischen Universität Braunschweig (Luhmann and Wester-Ebbinghaus, 1986).

1. Digital on-line image processing using a réseau-scanner

Fig. 1 shows the principle of réseau-scanning, as it is instrumentally realized by the scanner ROLLEIMETRIC RS (fig. 2). Sensor and lens can be shifted parallel to the image plane. The size of the réseau meshes corresponds to the size of the sensor surface and the chosen projection scale. The projection scale defines the pixel size of the image recording.

With at least four réseau crosses, projected onto the sensor, it is possible to carry out a rigorous perspective transformation of the partial images, recorded by the sensor, into the entire system of the scan réseau. Therefore the shifting device may be rather simple. It only has to be made sure, that the sensor frame always covers at least one whole mesh (Wester-Ebbinghaus 1984, Luhmann and Wester-Ebbinghaus 1986).

In order to carry out a reliable automatic determination of the réseau crosses (Luhmann 1986), réseau and photogrammetric scene are recorded seperately. According to fig. 3, light, projected by means of a beam splitter onto the réseau plate, is reflected by the cross markings, producing on the sensor a pseudo-binary image, only consisting of the réseau crosses; then, by a seperate digital image, the photogrammetric scene is recorded using transmitting light (fig. 4).

Fig. 5 shows the principle of an automatic digital mono comparator, realized by means of réseaus-canning. The automatic point determination is supported by approximate a priori coordinates of the object point, given in the system of the scan réseau. This first allows to shift the sensor to the réseau mesh which is concerned. Then, in the partial digital image recorded by the sensor, the visible réseau points are determined. This can be carried out automatically (Luhmann 1986), because the shifting device of the sensor provides their approximate position. By means of these réseau points, the approximate coordinates of the object point in the réseau system are transformed into the sensor system in order to support there the precise automatic point determination. Finally the coordinates of the object points, determined in the sensor system, are transformed by means of the réseau points into the system of the scan réseau.

Using several réseau-scanners simultaneously, as shown in fig. 6, digital online multi-image processing may be carried out.

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2. Digital on-line object recording and processing, using a réseauscanning camera

The principle of réseau-scanning can be used in order to design a high resolution digital photogrammetric camera (fig. 7 and 8). The réseau plate is mounted in the image plane of the photogrammetric camera. The sensor can be shifted parallel to the réseau plate.

Similar to fig. 3 and 4 the réseau points and the object are recorded seperately. By means of a semi-reflecting glass plate an internal illumination projects light through the réseau, while the camera shutter is closed (fig. 9). Because of a very small aperture of the illumination source, the réseau points are projected with great depth of sharpness. Therefore réseau and sensor need not be in the same plane in order to get a sharp image of both, the réseau points and the object (fig. 10). It is possible to focus the camera individually for every single mesh by shifting the sensor perpendicularly to the réseau plane. Because of the perspective reprojection into the réseau plane, all the partial images are defined finally in one entire and constant image space coordinate system. This leads to a focusable camera with constant interior orientation.

The reprojection of the partial images is carried out according to the perspective centre of the réseau illumination. This changes the perspective of the object recording, if the perspective relation between the projection centre of the camera lenses and the réseau plane and the perspective relation between the réseau illumination centre and the réseau plane do not correspond exactly. In this case we get a perspectively transformed new image plane for the object recording; according to this plane we have to define the parameters of interior orientation. Simultaneous calibration of the camera within the orientation process takes this into accout automatically.

The semi-reflecting glass plate, which reflects the light for the réseau illumination, causes asymmetric distortion when projecting the object (fig. 10). This can mathematically be described by parameters, which are used for asymmetric lens distortion (Brown 1966).

Orientation and calibration of the réseau-scanning camera can be carried out by means of a bundle adjustment as it is used in analytical non-topographic photogrammetry (Wester-Ebbinghaus 1985, Wester-Ebbinghaus 1986). Assuming a stable object, a réseau-scanning camera can be applied to automatic determination of image points on-site (fig. 11). Dynamic processes which can be recorded with partial images may be analized real-time by a multi-image system shown in fig. 12.

Conclusion

The principle of réseau-scanning is suitable in order to realize precise computer-controlled photogrammetric image acquisition systems. High accuracy is resulting from optical-numerical sensor orientation, while low mechanical effort is required. As a recent state of development a réseau-scanner and a digital réseau-scanning camera are available.

REFERENCES

Ackermann, F., 1983: High Precision Digital Image Correlation, Proceedings 39th Photogrammetric Week, Institut für Photogrammetrie, Stuttgart.

Albertz, J., 1986: Digitale Bildverarbeitung in der Nahbereichsphotogrammetrie - Neue Möglichkeiten und Aufgaben. Bildmessung und Luftbildwesen 54 (1986), Vol. 2.

Brown, D.C., 1966: Decentering Distortion of Lenses. Photogrammetric Engineering

Fraser, C., Brown, D.C., 1986: Industrial Photogrammetry - New Developments and Recent Applications. The Photogrammetric Record, 1986.

Luhmann, T., 1986: Ein Verfahren zur rotationsinvarianten Punktbestimmung. Bildmessung und Luftbildwesen 54 (1986), Vol. 4.

Luhmann, T., 1986, Wester-Ebbinghaus, W.: Rolleimetric RS - A New Digital Image Processing System. ISPRS Commission II Symposium, Baltimore, 1986.

Wester-Ebbinghaus, W., 1984: Opto-elektrische Festkörper-Flächensensoren im photogrammmetrischen Abbildungssystem. Bildmessung und Luftbildwesen 52 (1984), Vol. 6.

Wester-Ebbinghaus, W., 1985: Bündeltriangulation mit gemeinsamer Ausgleichung photogrammetrischer und geodätischer Beobachtungen. Zeitschrift für Vermessungswesen, 110 (3).

Wester-Ebbinghaus, W., 1986: Analytische Kammerkalibrierung. ISPRS Commission V Symposium, Ottawa.

ABSTRACT

In order to achieve sufficient resolution and accuracy with small format CCDmatrix sensors, a photogrammetric scene has to be recorded with partial frames, orientated in an entire image coordinate system.

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By means of a réseau glass plate in the image plane the orientation of the matrix sensor is achieved with high accuracy and low instrumental effort. This technique is called réseau-scanning. The paper presents principles and instrumental realizations, applying réseau-scanning to digital processing of analogue photographs and to digital object recording and processing on-site.

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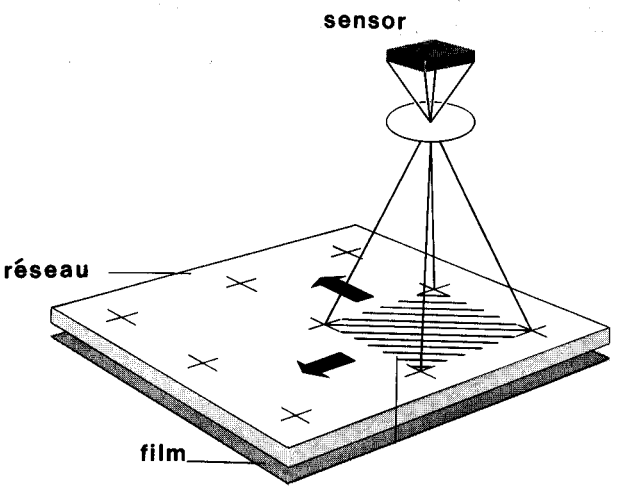

Fig. 1: Principle of réseau-scanning, optical-numerical sensor orientation by means of a réseau plate in the image plane

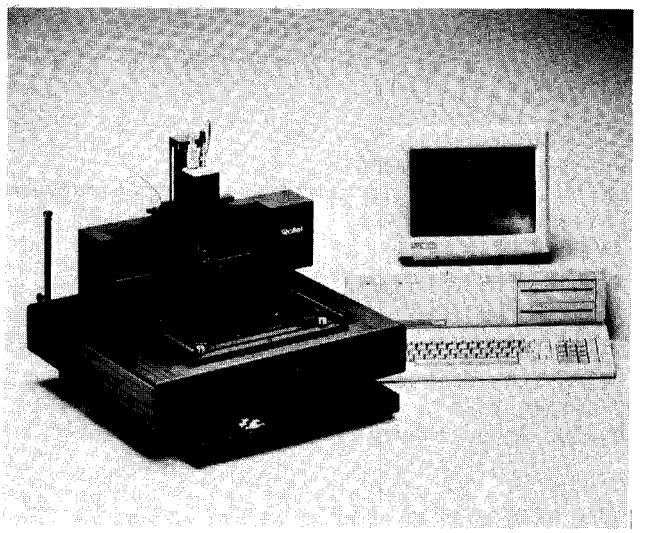

Fig. 2: Réseau-scanner Rolleimetric RS

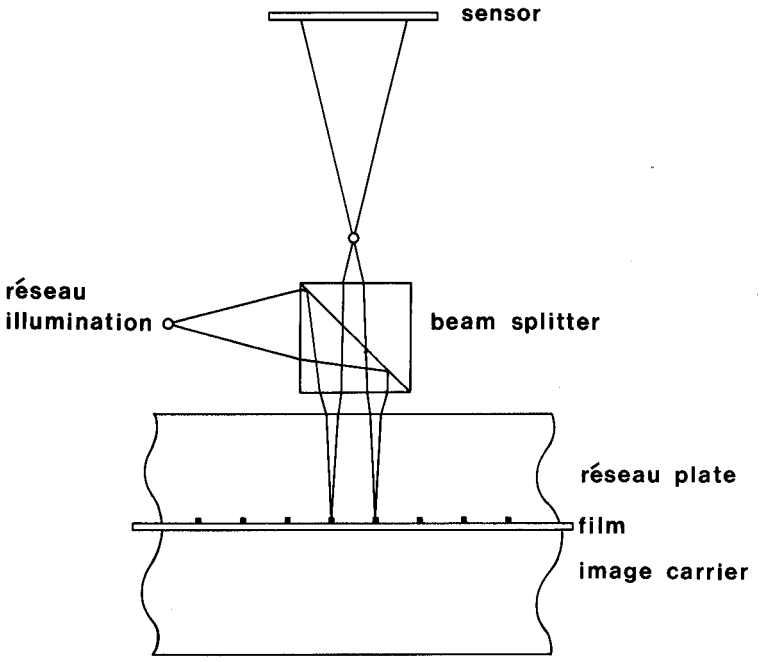

Fig. 3: Réseau-scanner, réseau recording: Projection by means of reflected light

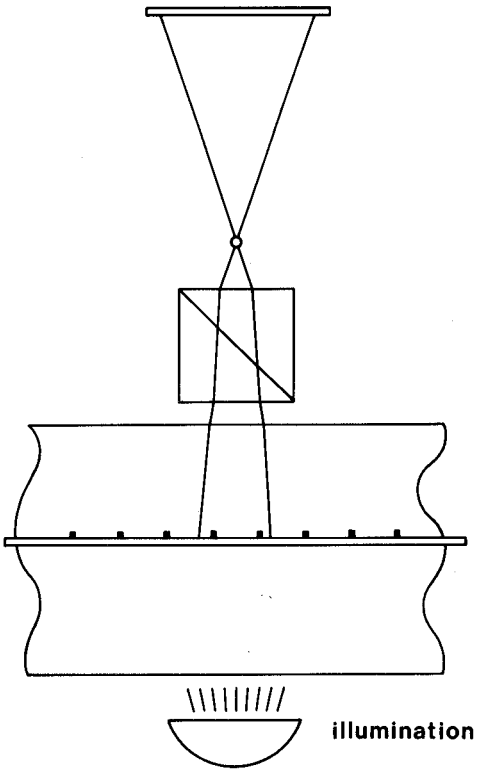

Fig. 4: Réseau-scanner, image recording: Réseau-illumination off, image projection by means of transmitting light

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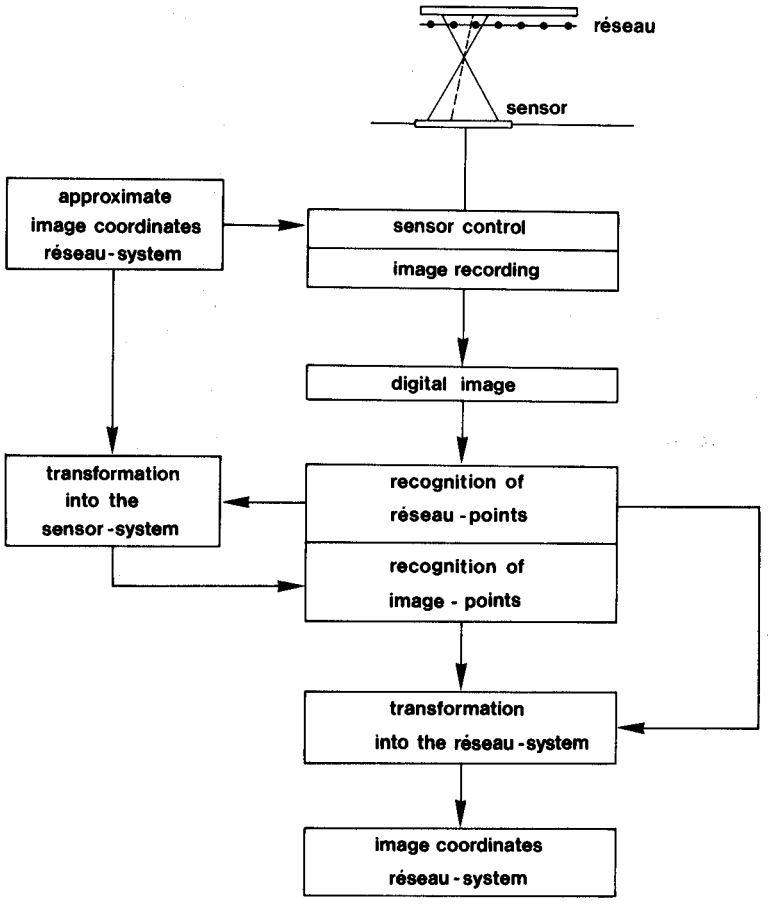

Fig. 5: Digital on-line image processing by means of a réseau-scanner, automatic mono-comparator

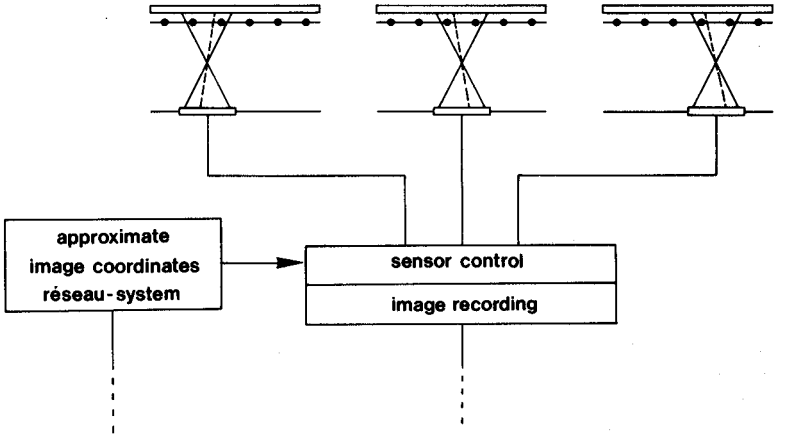

Fig. 6: Similar to fig. 5, but
digital on-line multi-image processing

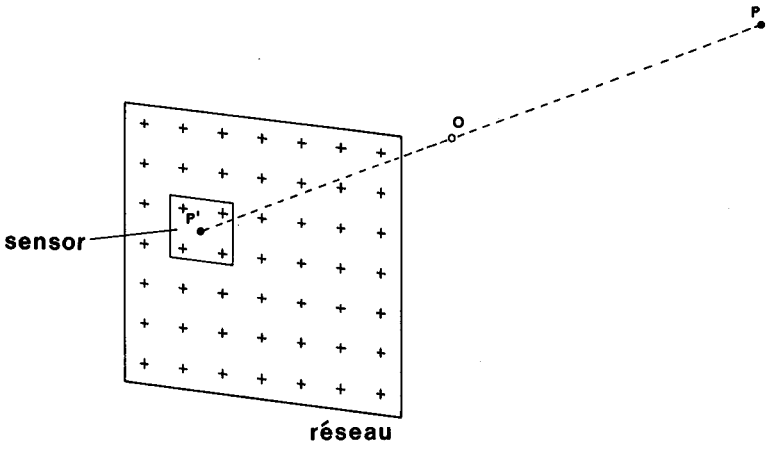

Fig. 7: Réseau-scanning in a photogrammetric camera (compare fig.1)

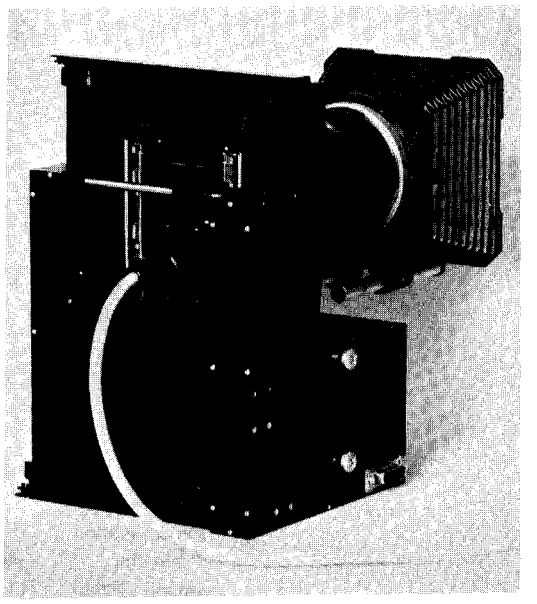

Fig. 8: Réseau-scanning camera Rolleimetric RSC (prototype)

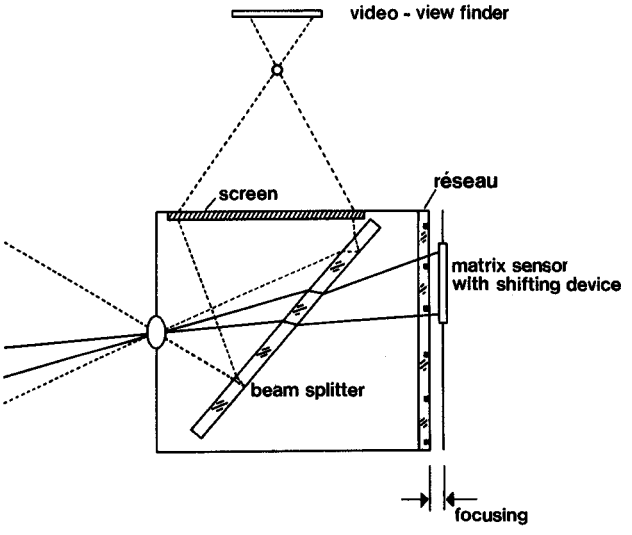

Fig. 9: Réseau-scanning camera.
Object recording:
lens shutter open, internal
réseau illumination off.
Focusing individually for every
single mesh without changing
the interior orientation.

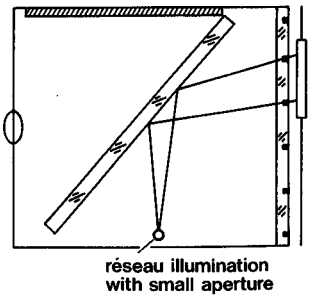

Fig. 10: Réseau-scanning camera.
Réseau recording:
lens shutter closed, internal
illumination on.

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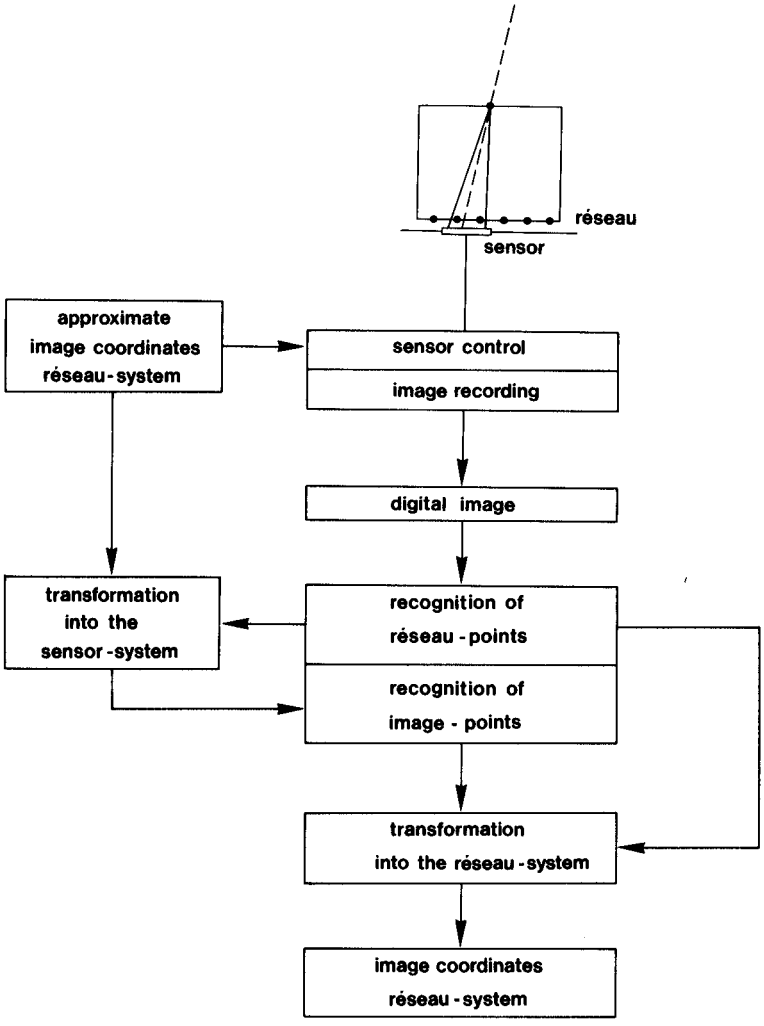

Fig. 11: Digital on-line object recording and processing by means of a réseau-scanning camera

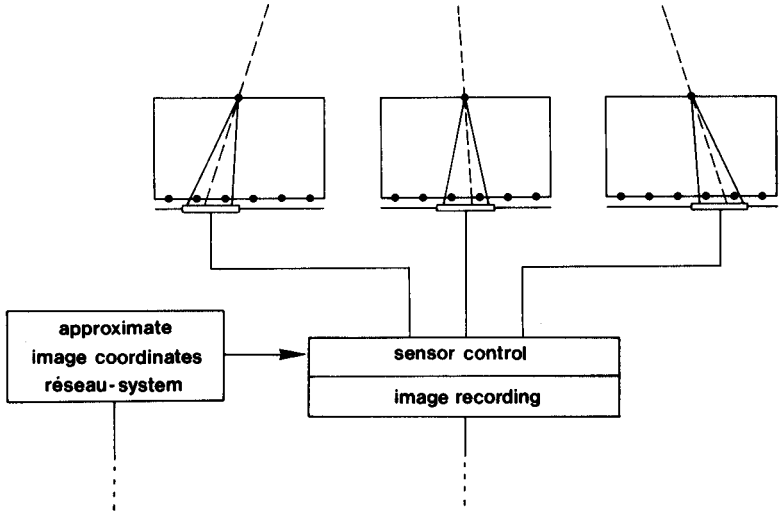

Fig. 12: Similar to fig. 11, but digital on-line multi-image object recording and processing