REAL-TIME-PHOTOGRAMMETRY BY MEANS OF HIGH-SPEED-VIDEO

Wilfried Wester-Ebbinghaus

Institut für Photogrammetrie und Bildverarbeitung
der Technischen Universität Braunschweig
Gaußstraße 22, 3300 Braunschweig
Federal Republic of Germany

Heinz Zamzow

Hentschel System GmbH
Fränkische Str. 62, 3000 Hannover 91
Federal Republic of Germany

Commission V

Abstract

The paper describes a photogrammetric real-time system. Random-access video cameras are used, which allow point tracing with a frequency up to 7 KHz. A strategy for simultaneous numerical full system calibration is encluded.

Introduction

The classical principal of photogrammetry, the distingtion between the object recording on site and the object restitution in the laboratory, has been proved very useful. The analogue photographic images provide metric documents of high quality, which allow the measurement at any time, while the recording effort on site is low. Recently developed analytical restitution techniques allow to use the possibilities of professional photography, thus encreasing the range of applications considerably.

In industrial photogrammetry however, it is often necessary to get the metric information on site, rather than to get a metric document. CCD-imaging-systems are already used to realize photogrammtric on-line and even real-time systems (El-Hakim 1986, Luhmann and Wester-Ebbinghaus 1986, Beyer 1987, Gottwald and Berner 1987, Haggrén 1987, Wester-Ebbinghaus 1988).

CCD-video with an imaging frequency of 30 Hz is not suitable in order to record fast processes. The paper presents a random-access video system, which allows high speed object recording. First results prove the system suitable for photogrammetric applications.

A random-access tracking system

Fig. 1 shows the principle of a random-access video camera. The rays transmitted from the image plane (cathode) are scanned locally and focused to the anode. The local recording allows high frequency point tracing in the image plane.

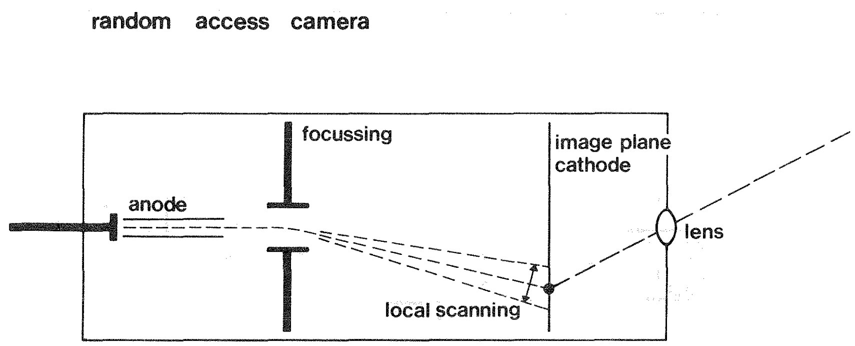
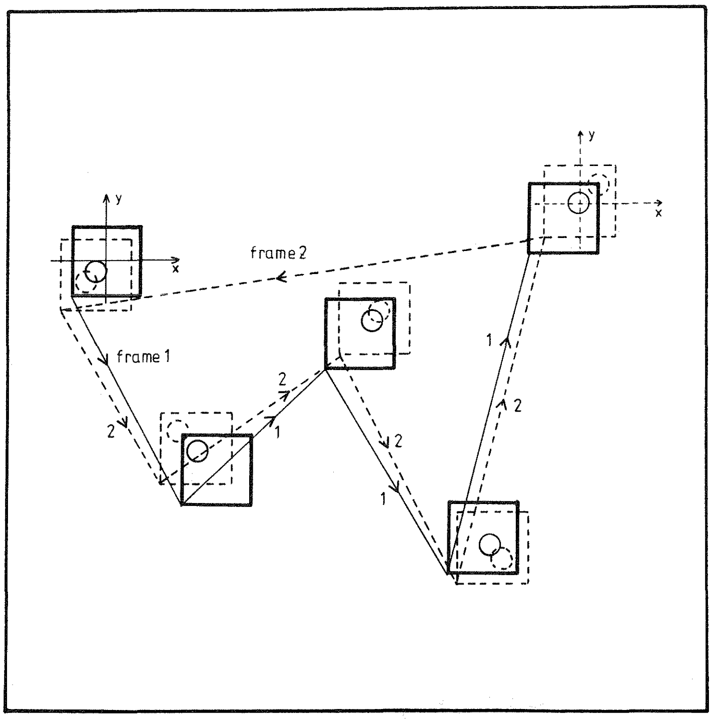
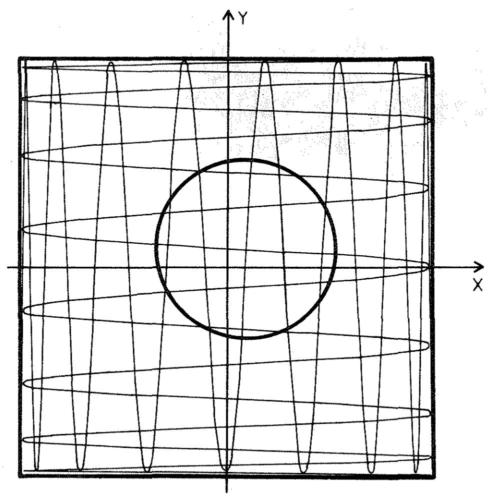


Fig. 1: Principal of random-access video tracking

Fig. 2: Hentschel random-access tracking system HSG 84.30 with Hamamatsu camera C 1181. Halogen lamps for illumination of retro reflecting targets



a) multipoint random-access scanning in the field of view



b) high frequency sinus scanning inside a window

Fig. 3: Random-access window scanning

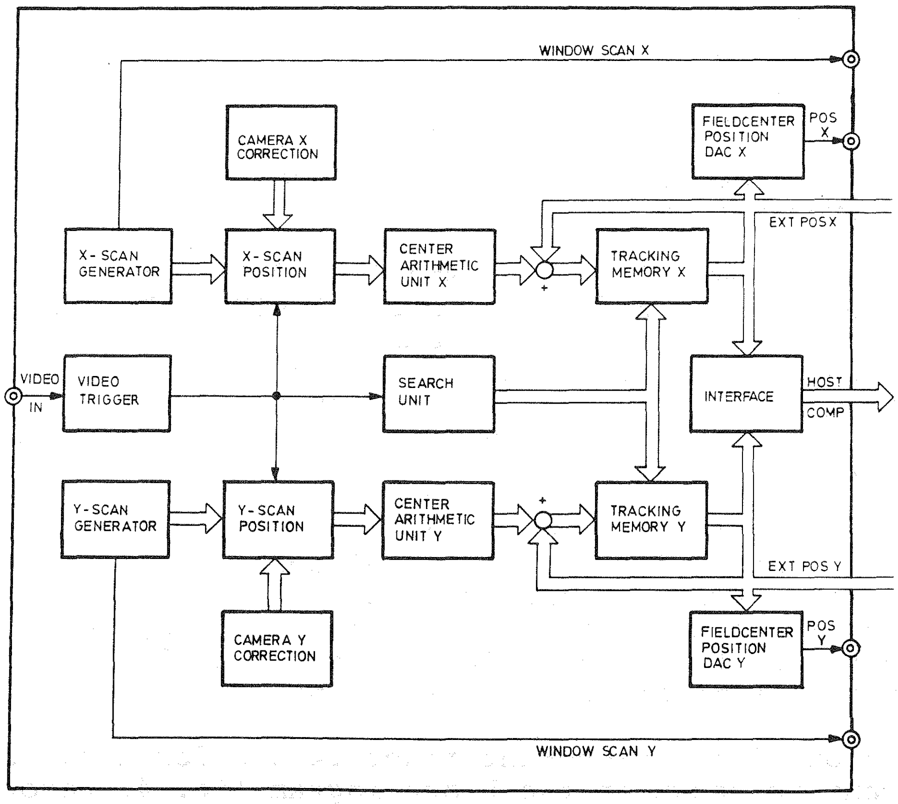


Fig. 4: Blockdiagram of video-interface 84.330

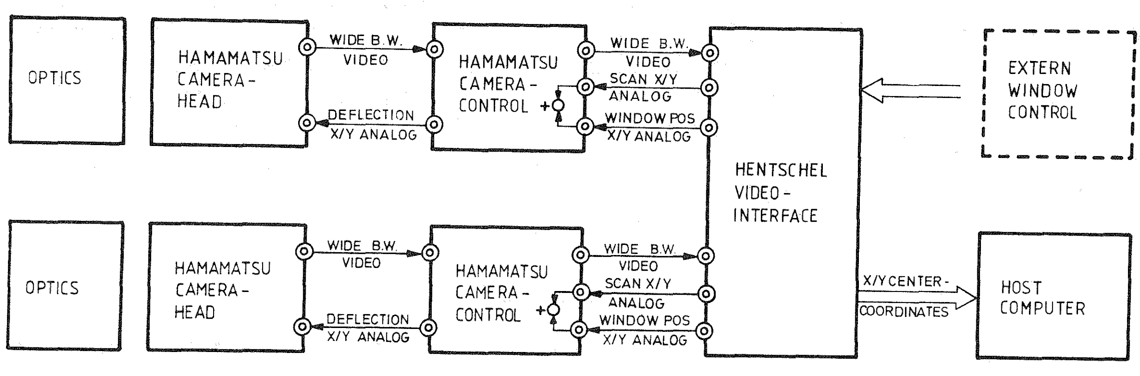


Fig. 5: Blockdiagram of random-access tracking system HSG

The random-access tracking system HSG 84.30 from Hentschel System allows high speed and high resolution multi-point tracking (Zamzow 1988)(fig. 2). This system uses random-access cameras C 1181 from Hamamatsu Photonics with an image dissector. In contrast to conventional video cameras with normal TV scanning its scanning mode is not limited by synchronizing signals. This allows a free extern deflection.

By setting windows (fig. 3) instead of full screen mode with comparable absolute deflection speed inside, the sampling rate can be extremely increased. Because the image dissector has no lag, the camera can access any point in the field with an access time under 15 microseconds. Thus, sampling rates up to 7,5 kHz are possible. The picture frequency depends on the number of windows, which is variable.

The resolution of the camera system is 8192 x 8192 pixels. With reduced dimension of the tracking windows - smaller then 1% x 1% of the field - even a higher resolution is possible. The noise is less then +/-4 pixels at 7,5 kHz sampling rate, small windows and best light conditions. By reducing the variable sampling rate, a longer access time and a finer scanning will improve this value.

The function of the video-interface 84.330 for a two dimensional measurement is shown in the blockdiagram fig. 4. Before tracking is started, the positions of the points are automatically detected in a special search line mode and stored in the tracking memory. After change-over to tracking mode, the marks are surrounded by windows (fig. 3a). The high speed deflection signals (fig. 3b) are digitally generated by the x/y scan generators. The video-signals of the camera allow to detect the peripheral coordinates inside the window with a resolution of 8 bits. A fast hardware arithmetic unit computes the centers of the points. The addition of the window position and the center position inside the window delivers the point position in the field of view. The x/y-coordinates are stored in the tracking memory and used for window placing in the next frame (fig. 3a). The extremely reduced quantity of data allows a simultaneous on-line data transfer to a host computer even at highest sampling rates. Variable sampling rate, window dimensions and number of windows enable the user to optimize the system to different problems of measurement. The video-interface 84.330 allows multi-camera tracking with synchronous control for 3-D motion analysis and on-line data transfer to a computer (fig. 5).

Photogrammetric application - First experiences

By means of a multi-image test field triangulation the geometric quality of the random-access video system was investigated. The test field, consisting of 25 points equipped with retro-reflecting targets, was recorded by 10 images according to fig. 6.The illimination was realized by halogen lamps, arranged as shown in fig. 2. A bundle triangulation, carried out as a free net adjustment, led to the following results:

σ_o : ± 7 pixel

relative accuracy in object space $\leq 10^{-3}$

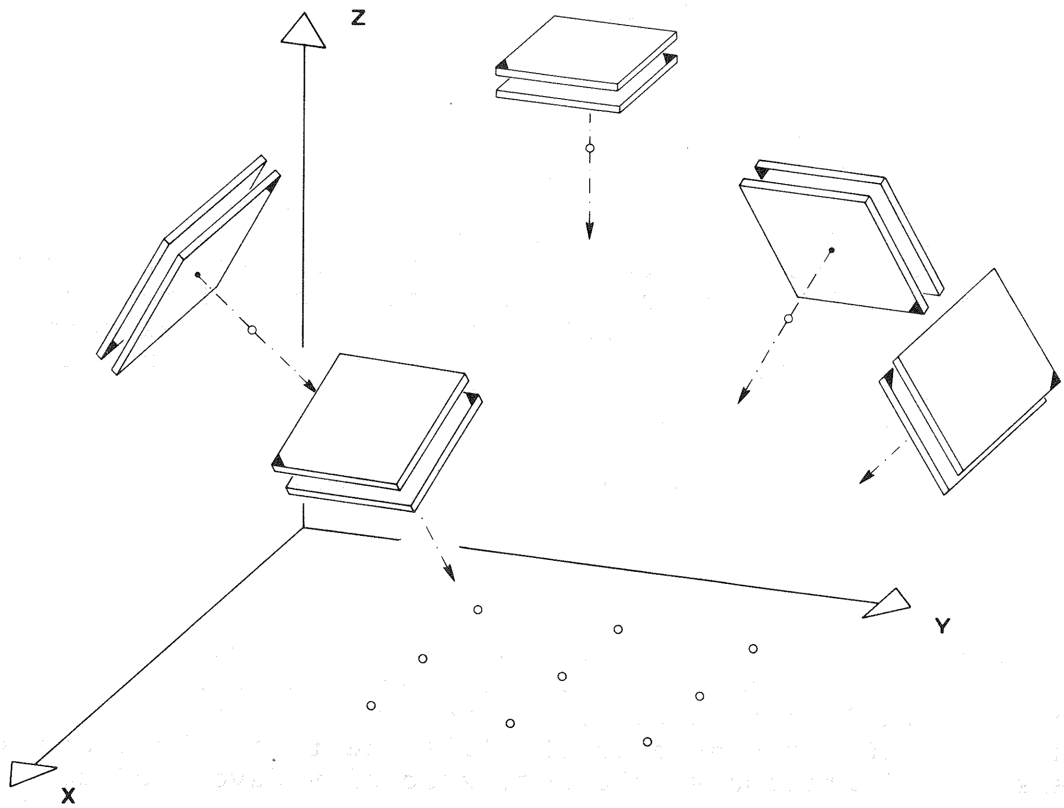


Fig. 6: Test field triangulation

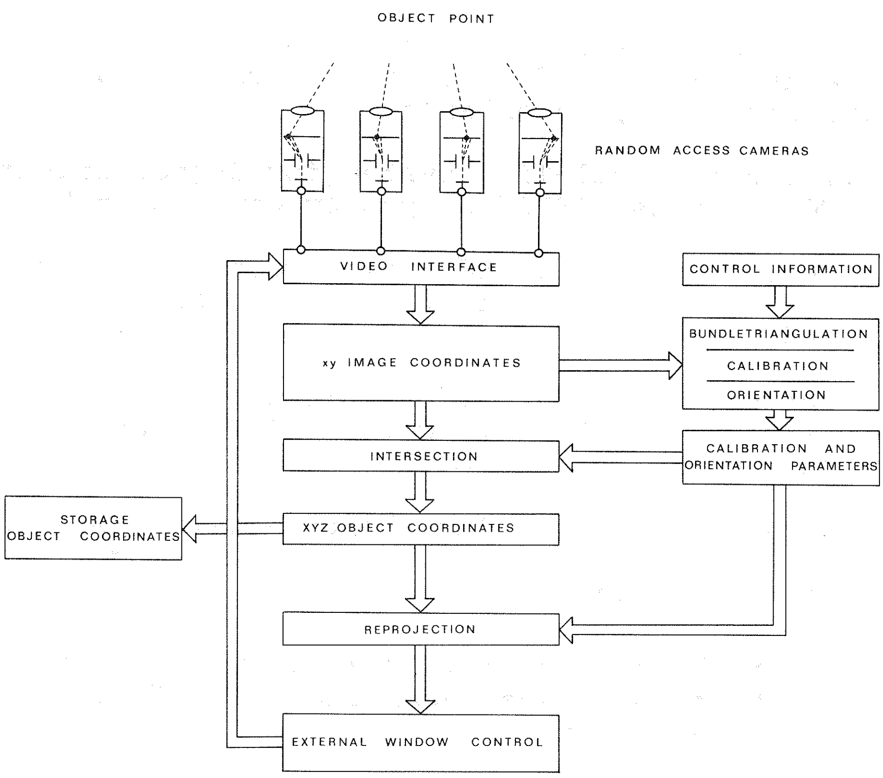


Fig. 7: Integrated system for photogrammetric multi-camera random-access point tracking

Block invariant additional parameters were introduced for affine and radial-symmetric distortion.

The accuracy may be encreased by means of additional parameters, specially designed in order to describe the image deformations of random-access video. This requires a suitable strategy for system calibration. Fig. 7 shows a proposal for an integrated photogrammetric multi-camera random-access tracking system: The cameras can be calibrated within bundle adjustment. Recording the control information in real-time, the calibration intervals may be choosen according to the instrumental conditions and the accuracy demands. Further more the scheme in fig. 7 allows to support the real-time point tracking by means of response from the object, reprojecting the determined object points numerically into the image systems. This allows to recatch a point, when the tracking had been interupted in a camera.

Conclusions

The presented random-access video system allows point tracking with a frequency of about 7 KHz. The geometric quality of the images is suitable for photogrammetric applications. The accuracy of $\leq 10^{-3}$ achieved in the first tests may be encreased by means of calibration strategies, specially developed for random-access video.

References

Beyer, H.A., 1987: Some Aspects of the Geometric Calibration of CCD-Cameras. ISPRS Conference "Fast Processing of Photogrammetric Data", Interlaken.

El-Hakim, S.F., 1986: A Real-Time System for Object Measurement with CCD-Cameras, ISPRS Symposium Commission V, Ottawa.

Fraser, C., Brown, D.C., 1986: Industrial Photogrammetry-New Developments and Recent Applications. The Photogrammetric Record 12 (68).

Gottwald, R., Berner, W., 1987: Electronic Theodolites-Sensor-Systems for Real-Time-Photogrammetry ? ISPRS Conferences "Fast Processing of Photogrammetric Data", Interlaken.

Haggreen, H., 1987: Mapvision - The Photogrammetric Machine Vision System. ISPRS Conference "Fast Processing of Photogrammetric Data", Interlaken.

Luhmann, T., Wester-Ebbinghaus, W., 1987: Digital Image Processing by Means of Reséau-Scanning. 41st Photogrammetric Week, Stuttgart.

Wester-Ebbinghaus, W., 1988: Trends in Non-Topographic Photogrammetry Systems. In: Karara, S. (Editor): Handbook of Non-Topographic Photogrammetry, 2nd edition, ASPRS.

Zamzow, H., 1988: Schnelle Bewegungen in Echtzeit erfassen. Elektronik, 4/88.