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Session 6 - Environmental Systems: Management and Optimisation

Session 7 - New Methods and Technologies for Medicine and Biology

Session 8 - Embedded System Design and Application

Session 9 - Image Processing, Image Analysis and Computer Vision

Session 10 - Mobile Communications

Session 11 - Education in Computer Science and Automation

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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Frank Boochs, Christoph Raab, Rainer Schütze, Jörg Traiser, Holger Wirth

3D contour detection by means of a multi camera system

ABSTRACT

In this paper we show a solution dedicated to measure spatial contours by means of multiple cameras. The contours allow to derive position and orientation, if necessary, of objects which have to be measured very precisely. The use of multiple cameras makes the system very flexible and robust. Set up, processing tasks and results of the system are presented.

SET UP

The system has a solid optical head (cf. fig. 1), to be used as base for cameras and light source. This head can be mounted on a robot arm and then serves as effector which observes objects at predefined positions. This allows fast and flexible measurements of various spatial elements belonging to the object. But in general, the system could also be used in a stationary way, when numerous elements have to be measured under fixed conditions.

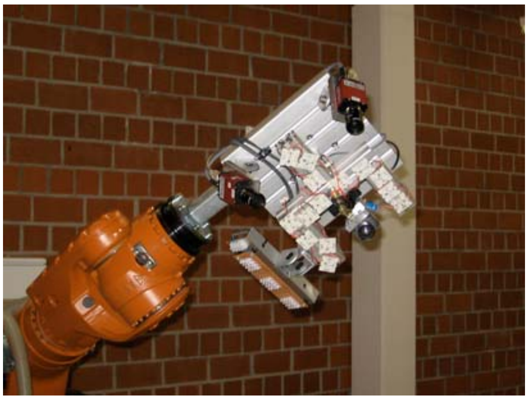

Figure 1 optical head

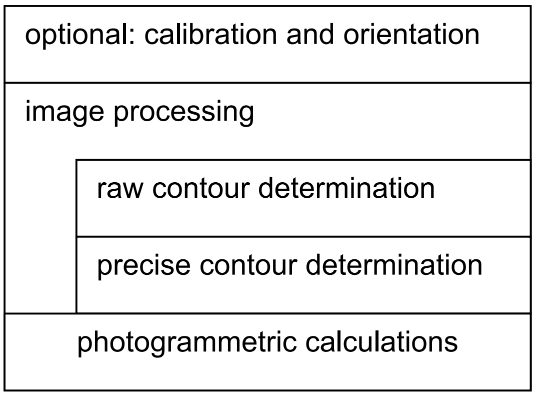

Figure 2 workflow of calculations

On the optical head at least 2 cameras have to be mounted, but this can be simply extended to more sensors, because robustness and accuracy then will profit. In the center of the head a light source is mounted which may project diffuse light but also can use special patterns if necessary to illuminate the object in a characteristic way.

In the first development stage we used 2 cameras in order to have the base for spatial calculations, but 3 cameras are more convenient due to check results more easily against blunder and the impact of viewing directions and provide a higher degree of accuracy.

Processing

As can be seen from fig. 2 the whole process consist of three steps. One of those only has to be used if necessary (calibration) and assures the geometrical quality of the system, the other ones have to be applied onto each image provide the final spatial information for each object observed.

Camera Calibration and Orientation

A geometrical preprocessing of the system is necessary due it's flexibility with respect to the types of cameras used, to their mounting and orientation on the frame, which can be changed if necessary to adopt the configuration to the needs of the application. Furthermore possible forces (movements, thermal environment) may cause changes which have to be checked more or less frequently. The steps to be realized comprise a control of the internal camera geometry (calibration) and a check of the external relations on the frame (orientation).

A camera is calibrated when the focal length (c), the principle point (H') and some distortion parameters (Δr) are known. These parameters describing the camera properties are summarized in literature as the parameters of the interior orientation (IO) [1;2].

The determination of the parameter values for each camera is integrated into the workflow by matter of an automatic calibration procedure. The used calibration method allows a full automatic workflow to determine the IO parameters. Figure 3 shows the procedure of our calibration method.

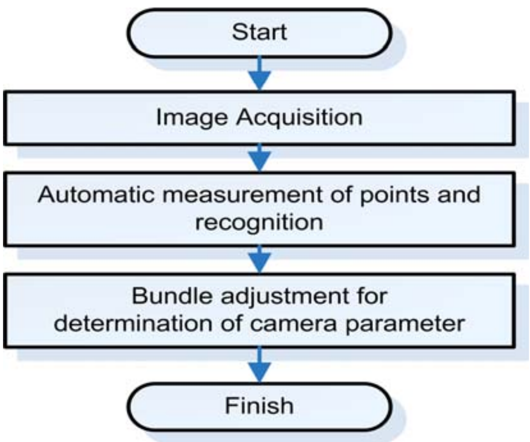

Figure 3 Procedure of the used calibration method

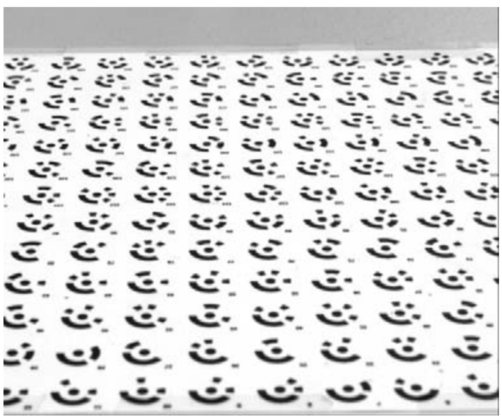

Figure 4 view onto point field used for calibration

About 32 images are acquired of the calibration panel (cf. Fig. 4) from different directions, inclinations and rotations of the camera around the optical axis. Within each image the center of all points are automatically measured, using the center of gravity (COG) method together with an analysis of the code ring [3] providing the point ID.

The measured image coordinates, the approximated object coordinates and the estimated exterior orientation [4] are brought together to calculated the parameters of the interior orientation with an adjustment library (AxOri [5]). The adjustment is free supported by the picture coordinates, the EO and the IO, whereas the object coordinates set the date (scale, rotation and translation) of the system.

In order to give an estimate of the geometrical quality of a calibration step Table 1 summarizes the root mean square values (RMS) of the object coordinates, the standard deviations of the EO and of course the standard deviations of the IO, for three *AVT Marlin F-046B (b/w)* cameras (pixel size 8.3 x 8.3 μm, 16mm objective). As can be seen, the results are sufficient to achieve precise results during the later measuring process.

	Camera (μm)			Image points (μm)		Object points (μm)		
	c	xH’	yH’	X	y	X	Y	Z
Cam. A – C	1.8 – 2.1	4.6 – 5.2	3.3 – 3.8	0.1 – 0.2	0.1 – 0.4	1.0	1.0	1.1

Table 1 Root mean squares of significant parameter of the IO bundle ([μm])

A calibration only should be necessary when cameras have been exchanged or modified, or other reasons for a change of their internal set up exist.

More often the external configuration might be changed, what then needs to check the geometrical configuration between the cameras or, if existing, in relation to an external coordinate system. This task uses the same strategy as with calibration, but allows a reduced number of images to be taken. Results of an orientation are show below:

	Image points (μm)		Object points (μm)		
	X	y	X	Y	Z
Cam. A-C	0.1 – 0.2	0.1 – 0.2	1.0	2.5	3.6

Table 2 Root mean squares of significant parameter of the EO bundle ([μm])

Contour Detection

The calculation of the spatial contour is based on all images taken by a simultaneous shot of all cameras. These images are then individually processed in order to detect the 2D-contours of the object and are then combined in a photogrammetric calculation, which results in a spatial description of the object. Redundancy due to multiple images allows to check the results and to eliminate blunder or regions where the contour is damaged.

For the 2D-contours it is assumed, that there exists a mathematical model, which can be used for a fitting process. This allows to process all contour elements with respect to this model giving a higher degree of accuracy. Actually elliptical contours are realized, but this can easily be substituted in case of other geometrical objects. The process of fitting is splitted in two parts. A raw determination of the 2D-contour (cf. Fig. 4) and a following exact determination by analyzing the gray scale value-profiles along the normal vectors of the contour (cf. Fig. 5).

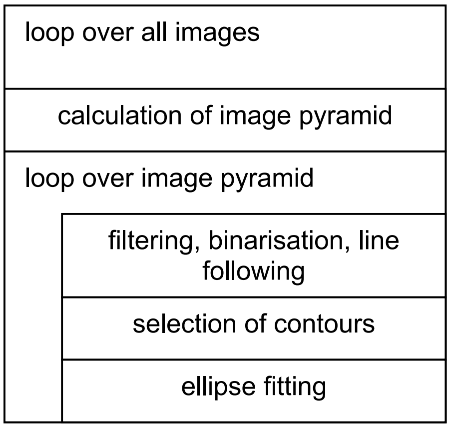

Figure 4 image processing (part1)

The **raw determination** consists of an edge detection by filtering, binarisation and line following process. The contours found during edge detection are evaluated and selected by means of geometric properties. All segments retained are used for an ellipse fitting. This process loops over an image pyramid allowing to reduce the impact of parasitic image elements appearing in the edge detection and increases the robustness.

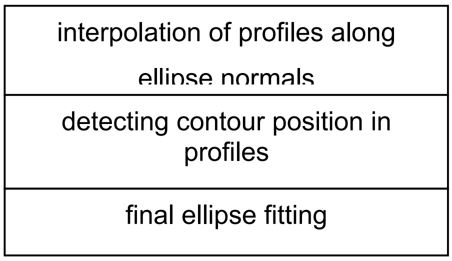

Figure 5 image processing (part2)

The **precise** contour **determination** happens only on the level of highest resolution. First, discrete gray scale values along local profiles normal to the contour are generated, in order to give a detailed local description of the transition from regions inside the contour to outside. In each profile the position of the maximal gradient close to the preliminary contour is determined, checked for plausibility and compared to the results of the neighborhood. The peaks found in all profiles are then used for a repeated ellipse fitting. The adjustment includes a blunder detection and finally provides the parameters of the elliptic contour in the image coordinate system.

As result of this process a parametric description of all contours is available and can be used for the final photogrammetric treatment of the data.

This is founded on the knowledge about the geometrical relationships between the images coming from the preceding calibration and

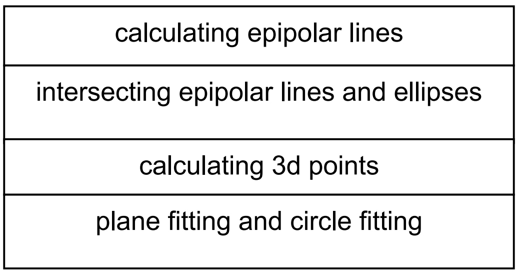

Figure 6 photogrammetric calculation

orientations steps. As the contours don't provide individual points to be used as input for spatial calculations these points are generated artificially using epipolar constraints. Starting with a first image pair, each contour is intersected with a number of epipolar lines for the respective image. In case of multiple images the points generated in one image are used to extend this process to all other contours. Each artificial point then has a number of counterparts – at least one – which then can be used to intersect the corresponding rays yielding a 3D point.

As matter of control all 3D-contour points are fitted into a plane, in order to check for deviations in the 2D-contours. If they are displaced, this results in changes of the distance to the spatial contour, what can be identified in the residuals of the plane. These residuals can be used to analyze erroneous contour parts and to reject points if necessary. As long as the plane gives acceptable results the spatial contour points can be fitted into the appropriate mathematical model, providing the final result.

RESULTS

At the moment the processing chain is completely realized for the use of 2 images. Some minor steps concerning data control and blunder detection in case of more than two images have still to be implemented. We therefore present results of a two image situation.

Figure 7 test object shown in image A

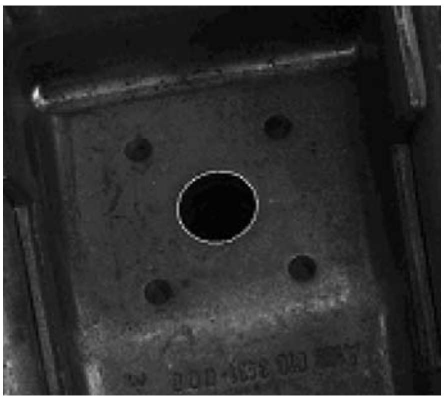

Figure 8 detected contour plotted in image B

Figure 7 shows the object measured, Figure 8 displays the contour detected and Table 3 gives an idea of the quality. The example belongs to a car body and shows a hole used to fix a seat of a carriage.

From table 3 it can be deduced, that the quality achieved is satisfying. In relation to the size of an individual pixel the center of the contour object has been determined with a 40th of an image element, what is a satisfactory value.

2D	σ_0 ellipse of image A		σ_0 ellipse of image B		Cell size
	0.003		0.003		0.0083
3D	σ_0 plane	σ_0 circle	σ center x	σ center y	Pixel in space
	0.032	0.021	0.003	0.004	0.130

Table 3 standard deviations of one camera combination (images A and B); all values in mm

After integration of the remaining analysis steps concerning more than two cameras the system may serve as base for a flexible and reliable tool for the determination of spatial contours and their position and orientation in space.

References:

[1] Luhmann T. (2003), “Nahbereichsphotogrammetrie - Grundlagen, Methoden und Anwendungen“, 2nd Edition, Wichmann Verlag, Heidelberg, Germany, ISBN 3-87907-398-8

[2] Remondino, F., Fraser, C. (2006), “Digital camera calibration methods: considerations and comparisons”, International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVI, part 5, pp. 266-272. ISPRS Commission V Symposium, Dresden, Germany

[3] Niederöst, M., Maas, H.-G. (1997), “Entwurf und Erkennung von codierten Zielmarken”, Tagungsband der 16. Wissenschaftlich-Technischen Jahrestagung der Deutschen Gesellschaft für Photogrammetrie und Fernerkundung, Oldenburg 1996, Germany

[4] Wrobel, B. (1999), “Minimum Solutions for Orientation” in “Calibration and Orientation of Cameras in Computer Vision”, Editors Th. Huang/A. Gruen, Springer-Verlag

[5] axios3d (2007), “Ax.Ori - Photogrammetrischen Bündelblockausgleichung”, http://www.axios3d.de/produkte/ori/ (Status 04-06-2007)

[6] Demant, Streicher-Abel, Waszkewitz: Industrielle Bildverarbeitung: Wie optische Qualitätskontrolle wirklich funktioniert. Springer 2002

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