EuroSDR network

Digital Camera Calibration

Initial Meeting

Photogrammetric Week 2003
Stuttgart, Germany, September 4th
14.00 – 15.30 h

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Universität Stuttgart

EuroSDR

from OEEPE
European Organization for Experimental Photogrammetric Research

to EuroSDR
European Spatial Data Research

www.eurosdr.org & www.oeepe.org

Mission of EuroSDR

- Aim of EuroSDR is to develop and improve methods, systems and standards for processing, production, maintenance and dissemination of core geospatial information and to promote applications of such data.
- Special emphasis is put on further development of airborne and spaceborne methods for data acquisition, on methods for information extraction from these sources and on the integration of this information with information from other sources.
- Encourage interaction between research organisations and the public and private sector to exchange ideas about relevant research problems and to transfer research results obtained to geoinformation production organisations.

50th Anniversary Seminar of Honour

"50 years of European spatial data research and beyond"

October 16th, 2003, Munich, Germany

Network Digital Camera Calibration

Motivation

- Initiative to investigate future of digital camera calibration driven by following facts
  - availability and growing use of digital camera in production environment
  - no equivalent procedure available compared to standard analogue camera calibration protocol
  - knowledge deficit on users side & mapping agencies
- Core network established by EuroSDR steering committee
  - initiation of this first meeting
  - incorporate of camera producers from first project stage
- Focus on
  - technical background of calibration procedures for digital cameras
  - not to go into legal aspects

Addressed organizations

#	Organization	Camera system (concept)
1	Leica Geosystems	ADS 40 (line)
2	ZI-Imaging	DMC (frame, multi-head)
3	Vexcel	UltraCam (frame, multi-head)
4	Applanix/Emerge	DSS (frame)
5	Cicade	DIMAC (frame)
6	Ohio State University	AIMS (frame)
7	ETH Zurich	TLS (line)
8	IGN	IGN (frame)

Private companies

Academic sector

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Agenda

1 – Status of camera calibration

2 – Concepts for calibration procedures

3 – Experimental research

4 – Miscellaneous & further activities

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Camera calibration
Manual of photogrammetry

- Camera calibration is the process whereby the geometric aspects of an individual mapping camera are determined.
- It is performed in the order that the photo obtained with the camera is used to produce accurate maps, to allow measurements, whereby ground distances or elevations can be obtained and to make orthophotos.
- It is possible to perform calibration to some order on any camera, but the cameras used to obtain the most accurate geometric data are specially designed for that purpose.
- Calibration assumes, that the thing being calibrated is stable between calibrations.
- Calibrated values and their accuracy are reported in a camera calibration certificate with tables and graphs.

Calibration methods
Manual of photogrammetry

Method 1

- Present an array of targets at known angles to a camera which records their images.
- Targets may be optical or terrain targets photographed from towers, aircrafts or ground.
- Recorded images are measured and the data reduced from measurements provide the elements of interior orientation.
- Many physical controls are essential.

Field calibration

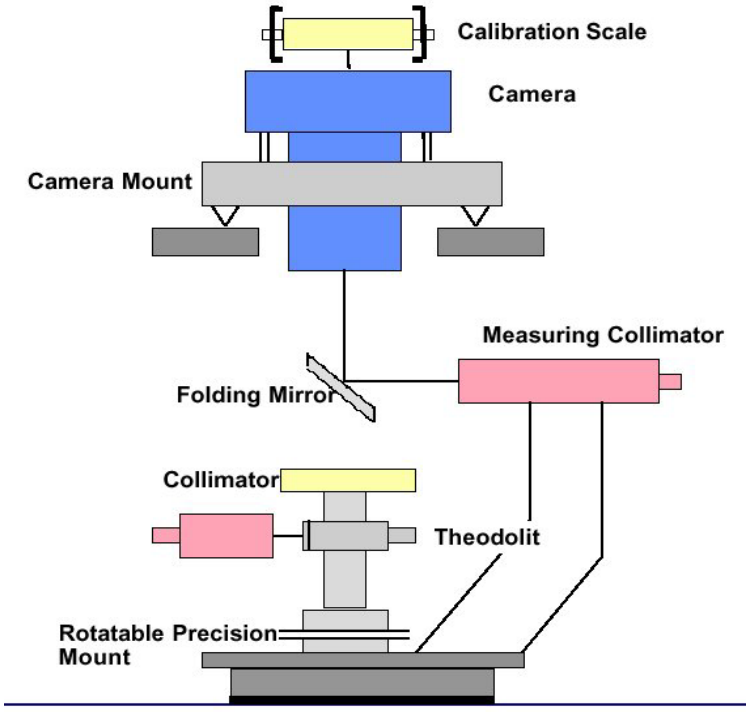
Calibration methods
Manual of photogrammetry

Method 2

- Clamp a master grid at the focal plane.
- Measure the observed angles in object space.
- Distortion is computed from the focal length and the difference between the image and object angles.

Laboratory calibration

Lab calibration
Principle sketch of Goniometer



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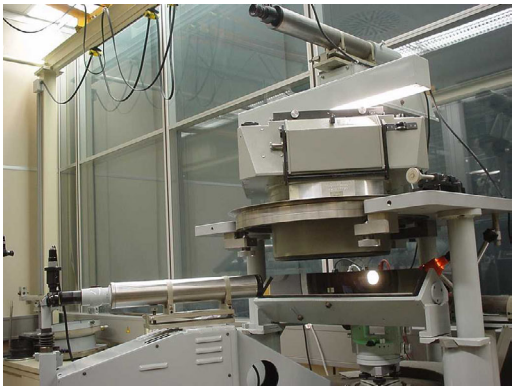
Lab calibration

Calibration facility at Carl Zeiss, Oberkochen



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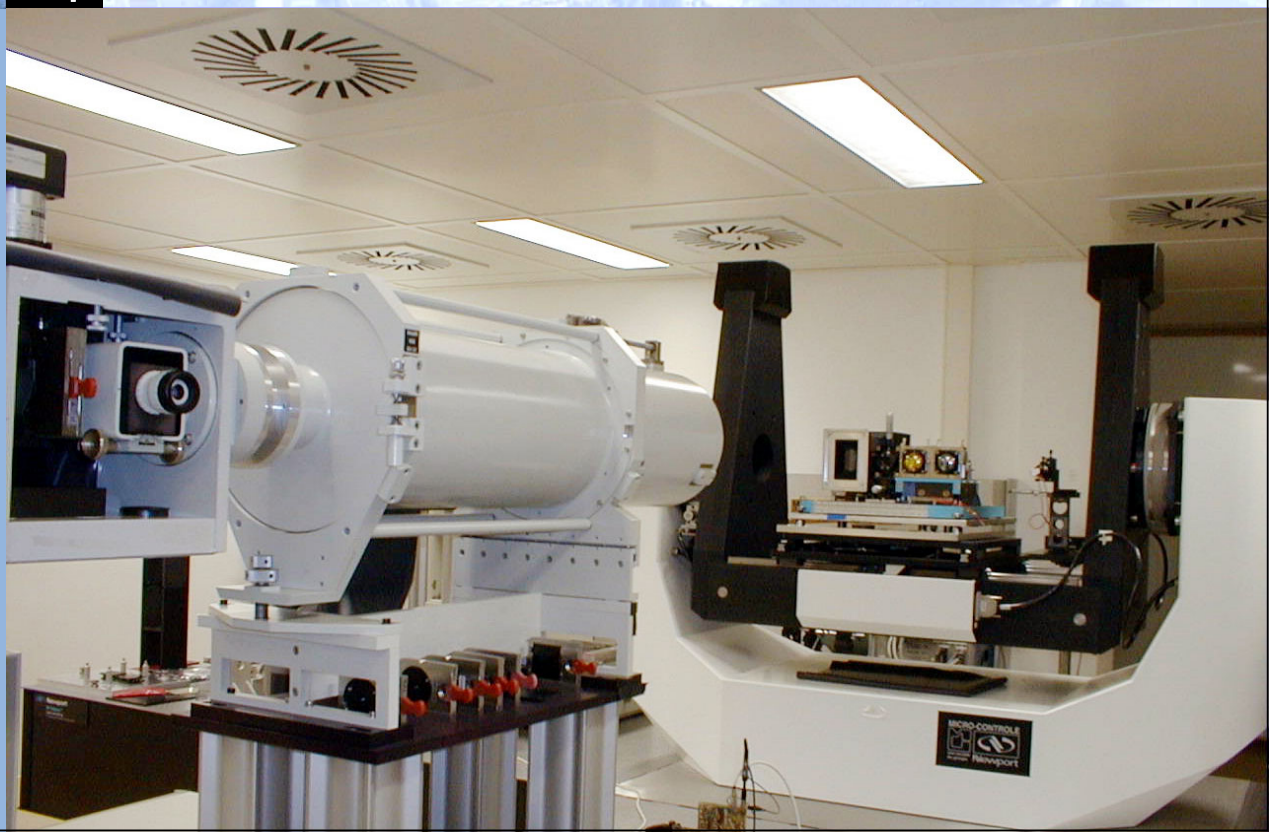
Lab calibration

Calibration facility at DLR, Berlin



Camera calibration
Interior orientation parameters

- IO of camera refers to perspective geometry of camera
- Parameters
  - calibrated focal length
  - position of principal point in image plane
  - geometric distortion characteristics of lens system, i.e.
    - radial distortions
    - tangential distortions
  - different models for additional parameters
    - physical models
    - mathematical models, i.e.
      - polynomials
      - orthogonal polynomials

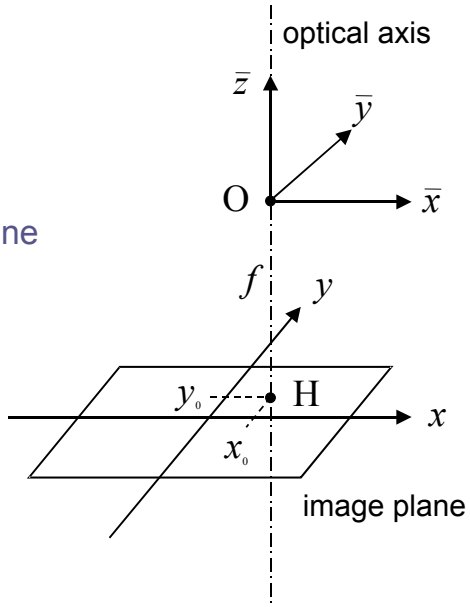


image coordinate system

Camera calibration
Calibration certificate

DEUTSCHER KALIBRIERDIENST (DKD)
Page 2 of the certificate dated 22.01.98

0536 DKD-K-05202 98-01

CAMERA TYPE: RMK TOP 15 SERIAL NO. 142829
LENS TYPE: PLEOGON A3 SERIAL NO. 142820
MAX.APERTURE: F/4 NOM. FOCAL LENGTH: 153 MM

1) CALIBRATED FOCAL LENGTH = 153.179 MM

2) DISTORTION /0.001 MM, REFERRING TO P.P. OF SYMMETRY PPS

S/MM=	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
5	0	0	-1	-2	-2	-1	1	-1	-1	0	-2	-3	-1	1	2	4
6	0	-1	-2	-2	-2	-1	-2	-1	-1	-2	-1	-2	-1	0	3	3
7	0	-1	-1	-1	-1	-1	0	1	-1	-1	-1	-3	-1	0	3	4
8	0	-1	-2	-2	-2	-1	-1	-1	0	-3	-3	-3	-1	0	3	6
AV.	0	-1	-1	-2	-2	-1	0	0	-1	-1	-2	-3	-1	0	3	4

3) P.P. OF AUTOCOLLIMATION AND FIDUCIAL CENTRE, REFERRING TO PPS

P.P. OF AUTOCOLLIMATION PPA X= .002 Y= .001 MM
FIDUCIAL CENTRE FC X= .014 Y= -.006 MM
CORNER FIDUCIAL CENTRE FCC X= .010 Y= -.003 MM

4) FIDUCIAL MARKS, REFERRING TO PPS

X1= 113.016 X2=-112.986 X3= .017 X4= .011 MM
Y1= -.003 Y2= -.009 Y3= 113.008 Y4=-113.006 MM
DISTANCES 1-2= 226.002 3-4= 226.014 MM
X5= 113.017 X6=-112.994 X7=-112.985 X8= 113.015 MM
Y5= 113.002 Y6=-113.004 Y7= 112.984 Y8=-113.000 MM

5) PHOTOGRAPHIC RESOLVING POWER, IN CYCLES PER MM
(AS PER DEFINITION, R. P. IS NOT A CALIBRATED DATUM)
AREA WEIGHTED AVERAGE RESOLUTION=104

FIELD ANGLE /DEG = 0 7 14 21 28 35 42

RADIAL LINES 163 145 141 136 115 106 86
TANGENTIAL LINES 163 144 122 113 101 87 45

FILM: KODAK PANATOMIC X 3412 SPEED 40 ASA
DEVELOPED IN AGFA G 74 C AVIPHOT

6) Filter

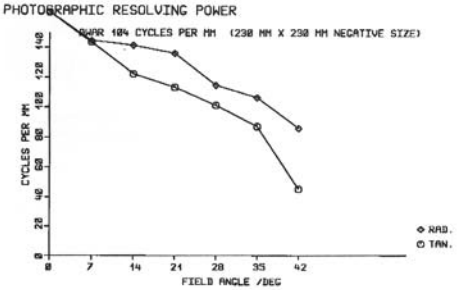
7) Magazine
CC 24 No.: 136 375
T-MC No.: 145 761

DEUTSCHER KALIBRIERDIENST (DKD)
Page 4 of the certificate dated 22.01.98

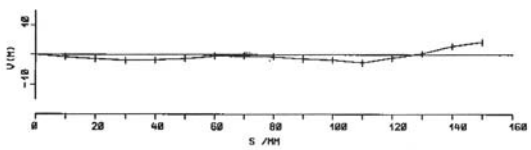
0536 DKD-K-05202 98-01

RMK TOP 15 NO. 142829

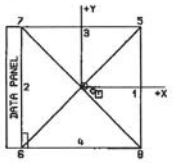
PHOTOGRAPHIC RESOLVING POWER



DEPARTURE OF AVERAGE DISTORTION FROM ZERO REFERENCE



PRINCIPAL POINT(PPA, PPS) AND FIDUCIAL CENTRE (FC)



COORDINATES, REFERRING TO PPS

	X /MM	Y /MM
PPA	0.002	0.001
FC	0.014	-0.006
FCC (CORNER FIDUCIAL CENTRE)	0.010	-0.003

0.01 MM, X-AXIS AS DEFINED BY FIDUCIAL MARK COORDINATES
α(G)= 0.0° α(B)= α(G)+90°

Agenda

1 – Status of camera calibration

- What is the general status of digital camera calibration procedures?
- What do other organizations do?
  - ISO, ISPRS, ASPRS, CEO, EUROGI, ….
- How is calibration performed by the camera producers?

Agenda

2 – Concepts for calibration procedures

- What is is expected from digital camera calibration?
- Is the calibration restricted on the optic parts only or should additional sensors like GPS/inertial components being involved?
- Is there a need for laboratory and/or test field calibration?
- Does calibration include only the geometric part or should radiometry be covered also?
- Is there a realistic chance to design an accepted and practicable camera calibration strategy, which could be recommended for future digital cameras?
- What about stability, reliability, validity aspects of calibration parameters?

Agenda

3 – Experimental research

- Should EuroSDR go into experimental testing of digital camera calibration?
- What are the project goals?
- If so, who is interested in participating such tests and who could provide the appropriate test facilities (laboratory equipment, test site) and human power?
- Will camera producers support such test campaigns providing their digital systems?
- Are there any general recommendations on test design and procedures?
- Which software modules are available for processing?