Some Stuttgart Highlights of Photogrammetry and Remote Sensing

Dieter Fritsch

Keynote - The 55th Photogrammetric Week

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1. Introduction

- April 1, 1966: Fritz Ackermann was appointed Full Professor at the University of Stuttgart and launched the Institute for Photogrammetry
- Excellent contributions in: Analytical photogrammetry (Independent Models, Bundle Block Adjustment, Digital Image Correlation, GPS Photogrammetry, Laser Profiling, automated Aerial Triangulation,..)
- June 1, 1992: Dieter Fritsch was appointed Full Professor at the University of Stuttgart and Director of the Institute for Photogrammetry
- The last 23 years: Contributions to Laser Scanning, ISO, automated 3D City Model Generation, Conflation, 2D & 3D Generalization, Hybrid GIS, Camera Certifications & Calibrations, Dense Image Matching, UAV Photogrammetry, Close-range Photogrammetry, Mobile Mapping (Streets, Rails), SAR Remote Sensing, Optical Remote Sensing, Augmented Reality, 4D Reconstructions, ...


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2.1 Camera Calibration – Intro

- Camera calibration is one essential subject in photogrammetry
  - Self-calibration by using additional parameters (APs)

- Traditional self-calibration APs for analogue (film-based) photogrammetry
  - Physical APs: Brown (1971), Brown (1976)
  - Polynomials APs: Ebner (1976), Grün (1978)
  - They were originated for analogue single-head camera systems

- Do they still work well in digital aerial photogrammetry?

2.1 Camera Calibration - Intro

- Digital Airborne Cameras
  - Most frame cameras employ multi-head, virtual composition techniques

- Integration of GPS/IMU system
  - Direct georeferencing (ISO).
  - What is the impact of the self-calibration approach?

- Some criticisms on traditional APs (Clarke and Fryer, 1998)
  - Some ‘have no foundations based on observable physical phenomena’.
  - High correlations.
2.1 Camera Calibration - Intro
Using extended collinearity equations

- Transformation from Image ➔ Object Space

\[
\begin{align*}
\bar{X} &= \bar{z} \frac{r_{11} \Delta X + r_{21} \Delta Y + r_{31} \Delta Z}{r_{13} \Delta X + r_{23} \Delta Y + r_{33} \Delta Z} + \Delta \bar{x} \\
\bar{Y} &= \bar{z} \frac{r_{12} \Delta X + r_{22} \Delta Y + r_{32} \Delta Z}{r_{13} \Delta X + r_{23} \Delta Y + r_{33} \Delta Z} + \Delta \bar{y}
\end{align*}
\]

with
\[
\begin{align*}
\Delta X &= X - X_0 & \bar{x} &= x - x_0 \\
\Delta Y &= Y - Y_0 & \bar{y} &= y - y_0 \\
\Delta Z &= Z - Z_0 & \bar{z} &= z - z_0 = -c
\end{align*}
\]

- typically the standard model is amended by additional parameters (AP) \( \Delta x, \Delta y \)
- allow for compensation of systematic errors in image space and estimation camera calibration parameters (dependent on block geometry)
- models are functions of reduced image coordinates
- classification of AP sets
  - physical models, obtained from physical interpretable params
  - pure mathematical models without physical meanings
  - combined/mixed models (combination of former two)

2.1 Camera Calibration - Reconsiderations

- Should the traditional APs be continued being used now?
  - If so, why?
  - If not, where are the new ones?

- Some challenges
  - Find the physical or mathematical foundations for APs
  - Decouple multi-corrections
    - Self-calibration APs
    - Misalignments
    - shift/drift effect in DGPS
    - IO parameters
    - EO
    - ...

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2.1 Camera Calibration – Testsite Vaihingen/Enz

- Testsite Vaihingen/Enz, since 1995
- Established for the assessment tests of the Digital Photogrammetric Assembly (DPA) – helped ifp to get worldwide reputation
- Many tests have been supervised by ifp: Film-based (with & without ISO), digital (with/without ISO), …

2.2 Camera Calibration – A Function Approximation Using Polynomials

- Weierstrass Theorem
  - Any univariate function can be approximated with arbitrary accuracy by a polynomial of sufficiently high degree.
    \[ \lim_{n \to \infty} p_n(x) = g(x) \]
- Orthogonal Polynomials
  - Discrete OPs
  - Continuous OPs
- Legendre orthogonal polynomials: continuous OPs
  \[ |L_m(x)| \leq 1, \quad -1 \leq x \leq 1 \]
  \[ \int_{-1}^{1} L_m(x)L_n(x)dx = \begin{cases} 0, & m \neq n \\ 1, & m = n \end{cases} \]
2.2 Camera Calibration – Legendre Polynomials

- Legendre polynomials possess the optimal approximation in the least-squares sense (Mason & Handscomb, 2002).

\[
\begin{align*}
L_0(x) &= 1 \\
L_1(x) &= x \\
L_2(x) &= \frac{1}{2} (3x^2 - 1) \\
L_3(x) &= \frac{1}{2} (5x^3 - 3x) \\
L_4(x) &= \frac{1}{8} (35x^4 - 30x^2 + 3) \\
L_5(x) &= \frac{1}{8} (63x^5 - 70x^3 + 15x) \\
L_6(x) &= \frac{1}{16} (231x^6 - 315x^4 + 105x^2 - 5)
\end{align*}
\]

- Development of Legendre self-calibration APs

- Width and length of images: \(2b_x, 2b_y\)

\[
\begin{align*}
l_m(x, b_x) &= L_m\left(\frac{x}{b_x}\right) \\
l_n(y, b_y) &= L_n\left(\frac{y}{b_y}\right) \\
F_{m,n} &= \int \int f_{m,n}(x, y; b_x, b_y) \, dx \, dy = l_m(x, b_x) l_n(y, b_y) \\
P_{m,n} &= 10^{-4} F_{m,n}, \quad |p_{m,n}| \leq 10^{-4}
\end{align*}
\]

\[
\int \int p_{i,j} p_{m,n} \, dx \, dy = 0 \quad \text{if} \quad i \neq m \quad \text{or} \quad j \neq n
\]

- Each distortion term is approximated by the combinations of

\[
\{p_{m,n}\}_{m,n}
\]
2.2 Camera Calibration – Legendre Polynomials

- Selecting M and N
  \[ m = 0,1,\ldots,M, \quad n = 0,1,2,\ldots,N \]
- Eliminating two constant terms and four highly correlated terms.
- The number of Legendre APs
  \[ L_{AP} = 2(M + 1)(N + 1) - 6 \]
  \[ M = N = 2, \quad L_{AP} = 12 \]
  \[ M = N = 3, \quad L_{AP} = 26 \]
  \[ M = N = 4, \quad L_{AP} = 44 \]
  \[ M = N = 5, \quad L_{AP} = 66 \]
  ...
  \[ M = 3, N = 4, \quad L_{AP} = 34 \]
- So far, Legendre APs are successfully constructed.

2.2 Camera Calibration - Fourier Series

- Fourier series are also optimal base function for developing self-calibration APs
- Laplace’s Equation and Fourier Theorem
- Construction of bi-variate Fourier APs

\[ \cos(mx \pm ny), \sin(mx \pm ny), \quad m, n = 0, \pm 1, \pm 2, \ldots \]
\[ u = \frac{x}{b_x}, \quad v = \frac{y}{b_y}, \quad u \in [-\pi, \pi], v \in [-\pi, \pi] \]
\[ c_{m,n} = 10^{-6} \cos(mu + nv), \quad s_{m,n} = 10^{-6} \sin(mu + nv) \]
\[ \Delta x = \sum_{m=1}^{M} \sum_{n=-N}^{N} (a_{m,n} c_{m,n} + b_{m,n} s_{m,n}) + \sum_{n=1}^{N} (a'_{0,n} c_{0,n} + b'_{0,n} s_{0,n}) \]
\[ \Delta y = \sum_{m=1}^{M} \sum_{n=-N}^{N} (a'_{m,n} c_{m,n} + b'_{m,n} s_{m,n}) + \sum_{n=1}^{N} (a'_{0,n} c_{0,n} + b'_{0,n} s_{0,n}) \]
2.3 Camera Calibration – The Novel Approach

Practical Tests

- Test datasets
  - It was carried out using flights over the Vaihingen/Enz testfield

Tests on DMC and UltracamX Cameras

- Block overview
  - Two cameras: DMC and UltracamX
  - Two fly heights: GSD 20cm and GSD 8cm
  - Two block configurations
    - Dense GCPs and high side-overlap (60%)
    - Sparse GCPs and low side-overlap (20%)

<table>
<thead>
<tr>
<th>Context</th>
<th>In-situ calibration</th>
<th>Operational project</th>
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<tr>
<td>Sensor orientation</td>
<td>ISO</td>
<td>ISO</td>
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<tr>
<td>Forward overlap (p)</td>
<td>60% – 70%</td>
<td>60% – 70%</td>
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<tr>
<td>Cross strip</td>
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<td>NO</td>
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<tr>
<td>Side overlap (q)</td>
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<td>20%</td>
</tr>
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<td>Image number</td>
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<td></td>
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<tr>
<td>DMC (GSD 20cm)</td>
<td>3 lines × 14/line = 42</td>
<td>2 lines × 14/line = 28</td>
</tr>
<tr>
<td>Ultracam-X (GSD 20cm)</td>
<td>3 lines × 12/line = 36</td>
<td>2 lines × 12/line = 24</td>
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<tr>
<td>DMC (GSD 8cm)</td>
<td>5 lines × 22/line = 110</td>
<td>3 lines × 22/line = 66</td>
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<td>Ultracam-X (GSD 8cm)</td>
<td>5 lines × 35/line = 175</td>
<td>3 lines × 35/line = 105</td>
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<td>GCP/ChP distribution</td>
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<td></td>
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<tr>
<td>DMC (GSD 20cm)</td>
<td>47 GCPs /138ChPs</td>
<td>4GCPs/181ChPs</td>
</tr>
<tr>
<td>Ultracam-X (GSD 20cm)</td>
<td>47 GCPs /138ChPs</td>
<td>4GCPs/181ChPs</td>
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<td>DMC (GSD 8cm)</td>
<td>49 GCPs /69ChPs</td>
<td>4GCPs/114ChPs</td>
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<tr>
<td>Ultracam-X (GSD 8cm)</td>
<td>48 GCPs /68ChPs</td>
<td>4GCPs/112ChPs</td>
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</table>
2.3 Camera Calibration – Practical Tests

- Two examples of Legendre APs

  \[ \Delta x = a_1 p_{x,0} + a_2 p_{x,2} + a_3 p_{x,4} + a_4 p_{x,6} + a_5 p_{x,8} \]
  \[ + a_6 p_{x,10} + a_7 p_{x,12} + a_8 p_{x,14} + a_9 p_{x,16} + a_{10} p_{x,18} \]
  \[ + a_{11} p_{x,20} + a_{12} p_{x,22} + a_{13} p_{x,24} + a_{14} p_{x,26} + a_{15} p_{x,28} \]
  \[ + a_{16} p_{x,30} + a_{17} p_{x,32} + a_{18} p_{x,34} + a_{19} p_{x,36} + a_{20} p_{x,38} \]
  \[ + a_{21} p_{x,40} + a_{22} p_{x,42} + a_{23} p_{x,44} + a_{24} p_{x,46} + a_{25} p_{x,48} \]
  \[ + a_{26} p_{x,50} + a_{27} p_{x,52} + a_{28} p_{x,54} + a_{29} p_{x,56} + a_{30} p_{x,58} \]

  \[ \Delta y = a_1 p_{y,0} + a_2 p_{y,2} + a_3 p_{y,4} + a_4 p_{y,6} + a_5 p_{y,8} \]
  \[ + a_6 p_{y,10} + a_7 p_{y,12} + a_8 p_{y,14} + a_9 p_{y,16} + a_{10} p_{y,18} \]
  \[ + a_{11} p_{y,20} + a_{12} p_{y,22} + a_{13} p_{y,24} + a_{14} p_{y,26} + a_{15} p_{y,28} \]
  \[ + a_{16} p_{y,30} + a_{17} p_{y,32} + a_{18} p_{y,34} + a_{19} p_{y,36} + a_{20} p_{y,38} \]
  \[ + a_{21} p_{y,40} + a_{22} p_{y,42} + a_{23} p_{y,44} + a_{24} p_{y,46} + a_{25} p_{y,48} \]

For practical tests:

- Fourier APs, 16 params (maximum degree 1)

  \[ \Delta x = a_1 c_{1,0} + a_2 c_{1,1} + a_3 c_{1,2} + a_4 c_{1,3} \]
  \[ + a_5 c_{1,4} + a_6 c_{1,5} + a_7 c_{1,6} + a_8 c_{1,7}, \]

  \[ \Delta y = a_1 s_{1,0} + a_2 s_{1,1} + a_3 s_{1,2} + a_4 s_{1,3} \]
  \[ + a_5 s_{1,4} + a_6 s_{1,5} + a_7 s_{1,6} + a_8 s_{1,7}, \]

- Fourier APs, 48 params (maximum degree 2)

  \[ \Delta x = a_1 c_{2,0} + a_2 c_{2,1} + a_3 c_{2,2} + a_4 c_{2,3} + a_5 c_{2,4} + a_6 c_{2,5} \]
  \[ + a_7 c_{2,6} + a_8 c_{2,7} + a_9 c_{2,8} + a_{10} c_{2,9} + a_{11} c_{2,10} + a_{12} c_{2,12} \]
  \[ + a_{13} c_{2,13} + a_{14} c_{2,14} + a_{15} c_{2,15} + a_{16} c_{2,16} + a_{17} c_{2,17} + a_{18} c_{2,18} \]
  \[ + a_{19} c_{2,19} + a_{20} c_{2,20} + a_{21} c_{2,21} + a_{22} c_{2,22} + a_{23} c_{2,23} + a_{24} c_{2,24} \]

  \[ \Delta y = a_1 s_{2,0} + a_2 s_{2,1} + a_3 s_{2,2} + a_4 s_{2,3} + a_5 s_{2,4} + a_6 s_{2,5} + a_7 s_{2,6} + a_8 s_{2,7} + a_9 s_{2,8} + a_{10} s_{2,9} + a_{11} s_{2,10} + a_{12} s_{2,11} + a_{13} s_{2,12} \]
2.3 Camera Calibration – In-situ Scenario

- Dense GCPs and 60% side-overlap

![Graphs showing camera calibration results with dense GCPs](image)

- 4 GCPs and 20% side-overlap

![Graphs showing camera calibration results with 4 GCPs](image)

---

2.3 Camera Calibration – The Novel Approach

**Operational Project Scenario**

- 4 GCPs and 20% side-overlap

![Graphs showing camera calibration results with the novel approach](image)
### 2.3 Camera Calibration – The Novel Approach

**Accuracy Comparisons**

#### Correlation Analyses

<table>
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<th>APs</th>
<th>corr.</th>
<th>EO</th>
<th>IO</th>
<th>IMU</th>
<th>Intra-corr</th>
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<td>78%</td>
<td>86%</td>
<td>78%</td>
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<td>88%</td>
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<td>(44)</td>
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<td>0.73</td>
<td>0.53</td>
<td>0.93</td>
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<td>Legendre APs</td>
<td>&lt; 0.1</td>
<td>100%</td>
<td>97%</td>
<td>100%</td>
<td>96%</td>
</tr>
<tr>
<td>(66)</td>
<td>max</td>
<td>---</td>
<td>0.44</td>
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<td>0.57</td>
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<td>Fourier APs</td>
<td>&lt; 0.1</td>
<td>100%</td>
<td>89%</td>
<td>92%</td>
<td>92%</td>
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<td>(16)</td>
<td>max</td>
<td>---</td>
<td>0.45</td>
<td>0.20</td>
<td>0.53</td>
</tr>
</tbody>
</table>

- Legendre APs and Fourier APs perform similarly best.
2.3 Camera Calibration – The Novel Approach

### Distortion Determination

- **DMC (GSD 20cm)**

2.4 Summary

The new families of Legendre and Fourier self-calibration APs are excellent:

- Use mathematical base functions to approximate the unknown distortion function
- Fourier APs are rigorous, flexible and use a lower number of additional parameters – just 16 are sufficient!
  - Many other datasets were tested with DMC II, UltracamXp, DigiCAM cameras in different test fields.
- Fourier APs vs Polynomial APs
  - Fourier APs are theoretically preferable
  - Fourier APs are more efficient (less APs)
  - Fourier APs obtain more realistic distortion results

Fourier APs should be integrated in every Bundle Block Adjustment software!
2.5 References


3.1 SURE History – SUrface REconstruction

- 10/2009: After PhoWo’09 Interests of Vexcel Imaging GmbH on Study “Multiray Photogrammetry”
- 11/2009: Fritsch’ offer to Mathias Rothermel for PhD studies at ifp, started Jan 15, 2010, pilot programming of SGM algorithms
- 03/2010 Interests of LVG Munich on SGM, user of first ifp SGM pilot software, end 2010
- 05/2010: Kick-off meeting with Vexcel Imaging, study delivered Jan 12, 2011
- 04-12/2010: Master’s Thesis Konrad Wenzel in cooperation with Trimble inpho
3.1 SURE History – SUrface REconstruction

- 10/2010: Contact with IB Christofori to reconstruct the 2 Tympana of the Amsterdam Royal Palace by Dense Image Matching using Close Range photogrammetry
- 11/2010: Fritsch’ offer to Konrad Wenzel for PhD studies at ifp, started Jan 01, 2011, pilot programming of SGM algorithms
- 03/2011: Data collection in Amsterdam
- 10/2011: Delivery of dense point cloud to IB Christofori
- During period of data processing ifp developed own strategy for Structure-from-Motion and tSGM

3.1 SURE History – The Amsterdam Project

**West Façade**

- Multi-Camera System
  - 5 industrial cameras
- About 4000 images
- 6 Clusters
- Global Adjustment
  - 1.1 Million points
  - RMS: 0.5 pixels
- Dense Matching (SGM): 1.1 Billion points
Reconstruction of the Akhenaten Temple in Heliopolis/Cairo (Joint Project of Univ Leipzig, Univ Stuttgart and German University in Cairo)

- First explorations/excavations 2011 & 2012
- Pilots for 3D reconstructions using laser scanning & photogrammetry
- Bundle Adjustment: Visual SFM, bundler
- 34 images, Nikon DX2, 14MPix, c=24mm
- Dense Image Matching: SURE > 5.5 million points

Laser scan, 1.4 Mio points
GSD 1-2mm

DIM@SURE, 5.5 Mio points
GSD 0.5mm
3.1 SURE History– SUrface REconstruction

- 03-06/2012: Feasibility study for IGI with Oblique Imagery
- 05/2012-10/2012: Merger of two DIM software packages to one: SURE
- 06/2013: Decision to outsource further developments of SURE to nFrames, a TGU within the incubator TTI GmbH, Stuttgart
- 01/2015: All rights of SURE to nFrames GmbH, Stuttgart

3.2 SURE Update - Processing Pipeline Overview

- Structure of the dense matching pipeline
3.2 SURE Update – DSM Mesh

- Adaptive triangle size

3.2 SURE Update – True Ortho Generation

- Sharp edges
3. SURE Update – True Orthophotos

3. SURE Update – DSM Mesh

DSM edge refinement

Automatic seam leveling
3.2 SURE Update – 3D Mesh

Photorealistic texturing

Each face is seen in multiple views, how to select texture?
- Blending texture from multiple views
- Visible seams due to inaccurate orientation
- Differences in image scale: blurred textures
- Select texture from best view
  - Criterion for best view, for example nearest non-blurred view
  - To avoid seams: neighboring faces should be textured from the same image
- Cast as global optimization problem

$$E(l) = \sum_{F_i \in \text{Faces}} E_{\text{data}}(F_i, l_i) + \sum_{(F_i, F_j) \in \text{Edges}} E_{\text{smooth}}(F_i, F_j, l_i, l_j)$$

3.2 SURE – Texture Mapping
Example Nadir Flight (80/80, 10cm GSD)

3.3 Summary
Key features SURE

- Scalability to large data sets - e.g. city scale projects
- Completely automatic and configurable
- Supports all frame cameras in nadir or oblique configuration
- 8 Bit and 16 Bit multispectral imagery support
- Generation of georeferenced DSM tiles
- Automatic True Ortho generation and refinement
- Automatic 2.5D and 3D texturized meshes
- Orientation interfaces for Match-AT, VSFM, Photoscan, Pix4D and many more
- Multi-core implementation & graphics card support
- Distributed processing
- Multiple interfaces – graphical, command line or APIs
3.4 References SURE (2012 only)


4.1 Geometric Processing of WorldView-2

The Munich Stereo Images – Example 1

Copyright: DigitalGlobe

4.1 Geometric Processing of WV-2 Imagery

Rational Polynomial Coefficients

- Usually, satellite imagery does not provide the interior and exterior elements, but Rational Polynomial Coefficients (RPCs).

\[ y = \frac{\text{Num}_L(B, L, H)}{\text{Den}_L(B, L, H)} \]
\[ x = \frac{\text{Num}_S(B, L, H)}{\text{Den}_S(B, L, H)} \]

- For NumL, DenL, Nums and Dens, each one is a function of normalized latitude, longitude and elevation with 20 coefficients. So 80 coefficients for all.

\[
\begin{align*}
  B &= \frac{\text{lat} - \text{lat}_\text{off}}{\text{lat}_\text{scale}} \\
  L &= \frac{\text{lon} - \text{long}_\text{off}}{\text{long}_\text{scale}} \\
  H &= \frac{\text{height} - \text{height}_\text{off}}{\text{height}_\text{scale}} \\
  y &= \frac{j - \text{line}_\text{off}}{\text{line}_\text{scale}} \\
  x &= \frac{i - \text{sample}_\text{off}}{\text{sample}_\text{scale}}
\end{align*}
\]
**4.1 Geometric processing of WV-2 Imagery**

**Challenges**

- Airborne imagery
  - GSD: \(\sim10\) cm
  - Covering area: \(<5\) sqkm

- Satellite imagery
  - GSD: \(\sim50\) cm
  - Covering area: \(>10\) sqkm

**Bundle Block Adjustment**

**Dense Image Matching**

**Very Dense DSM**

**4.2 Geometric Processing of WV-2 Imagery**

**Bias-Compensation**

- With RPCs a bundle block adjustment can be done, but the accuracy of RPCs provided by satellite data provider is low. Therefore, often an affine model is used to compensate the bias.

  \[
  \Delta p^{(j)} = a_0^{(j)} + a_s^{(j)} \cdot sample_i^{(j)} + a_L^{(j)} \cdot line_i^{(j)}
  \]

  \[
  \Delta r^{(j)} = b_0^{(j)} + b_s^{(j)} \cdot sample_i^{(j)} + b_L^{(j)} \cdot line_i^{(j)}
  \]

- For each point \(i\) on image \(j\) the RPC bundle block adjustment observation equations are:

  \[
  F_{Li} = -line_i^{(j)} + p^{(j)}(\phi_k, \lambda_k, h_k) + \epsilon_{Li} + \Delta p^{(j)} = 0
  \]

  \[
  F_{Si} = -sample_i^{(j)} + r^{(j)}(\phi_k, \lambda_k, h_k) + \epsilon_{Si} + \Delta r^{(j)} = 0
  \]
4.3 Geometric Processing of WV-2 Imagery  
*Epipolar Image Generation*

- Epipolar images are images without any vertical parallax or disparity.

- For traditional frame imagery, the perspective centre is fixed, the epipolar line is the intersection between the epipolar plane and the image plane.

- For push-broom sensors, the perspective centre is changing (as a function of time).

- How to solve the problem? With the projection trajectory method based on RPCs.

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4.2 Geometric Processing of WorldView-2  
*Epipolar Image*
4.3 Geometric processing of WV-2 Imagery

Disparity Image and DSM

Vertical difference at check points from airborne LiDAR

rms = 1.9989 m

DSM airborne images
(from DMC camera)

DSM WV-2 images

Part II – Research Projects

Universität Stuttgart
4.3 Geometric Processing of WV-2 Imagery
DSM Accuracy Analysis

Vertical difference at check points from airborne LiDAR

Vertical profiles DSM from DMC versus DSM from WV-2

- P1: 20 ChP DMC vs WV-2: RMS 1.41m
- P2: 20 ChP DMC vs WV-2: RMS 2.09m

4.4 Summary

- QuickBird and WV-2 images have been processed using an affine distortion model.
- Epipolar image generation using RCP trajectories
- Dense Image Matching with SURE delivers reasonable results: along roofs 1.4m RMS, along terrain 2.1m RMS
- Not yet all optimizations explored, we just started!
- Will continue with WV-3 imagery
5. Conclusions

- The Institute for Photogrammetry of the University of Stuttgart continued with the tradition to make an impact to R&D in photogrammetry, remote sensing and geoinformatics.
- Excellent staff members contributed to these developments in the last 5 decades
- **Remember the date: April 8, 2016 – 50th Anniversary of ifp, Stuttgart**
- Teaching is video-casted since 2006 – worldwide recognition!
- Exports of Teaching to GUC, Cairo and Berlin
- Exports of Teaching to SUSTECH, Khartoum, Sudan
- The Photogrammetric Week Series got a new profile in 2003 – open for all participants, open for Open PhoWo Partners!


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Thank you all for your strong support – you made an impact!
Thank you for Participating the 55th Photogrammetric Week.

… when it started at the 44th Photogrammetric Week 1993