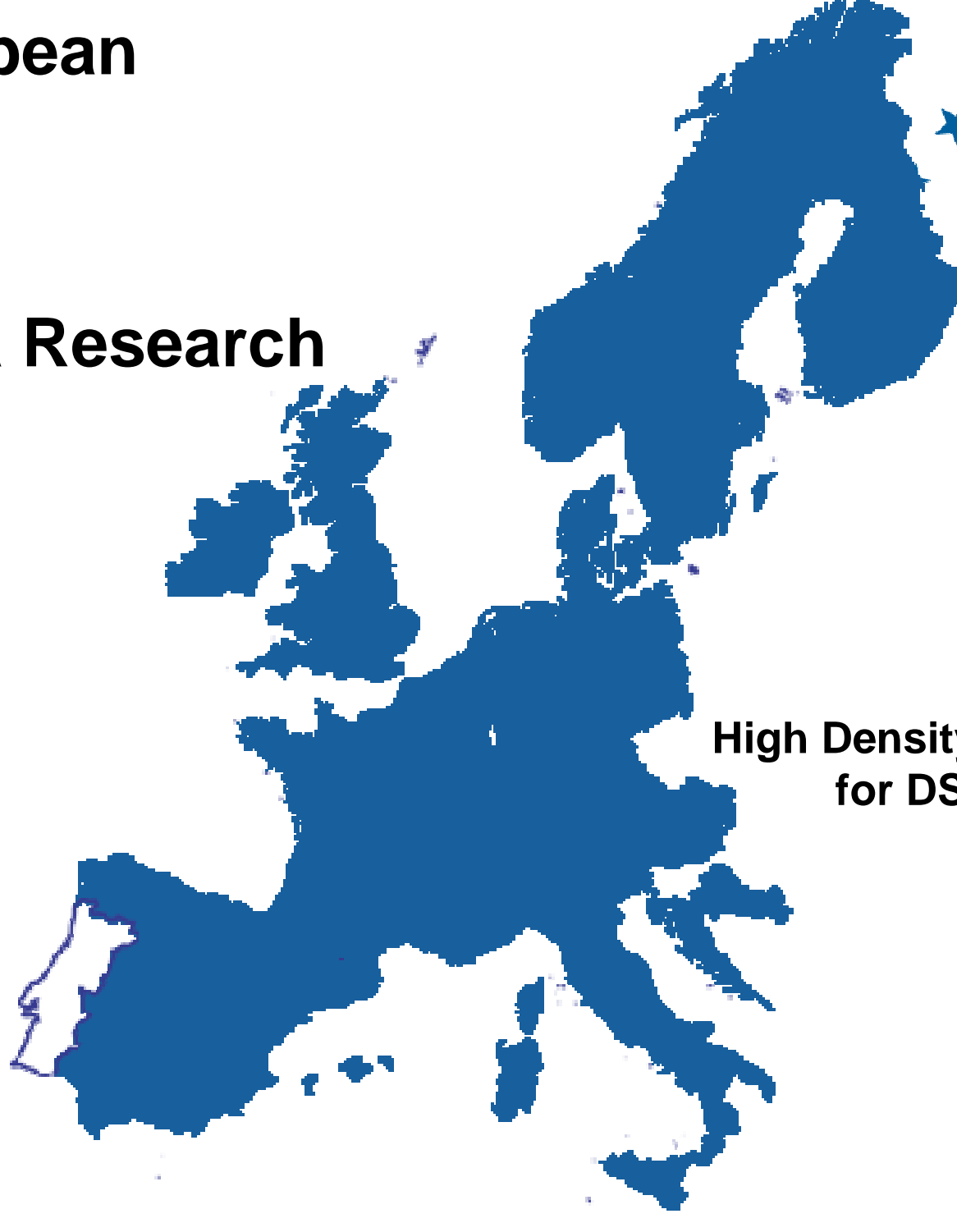


A pan-European Network For Spatial Data Research



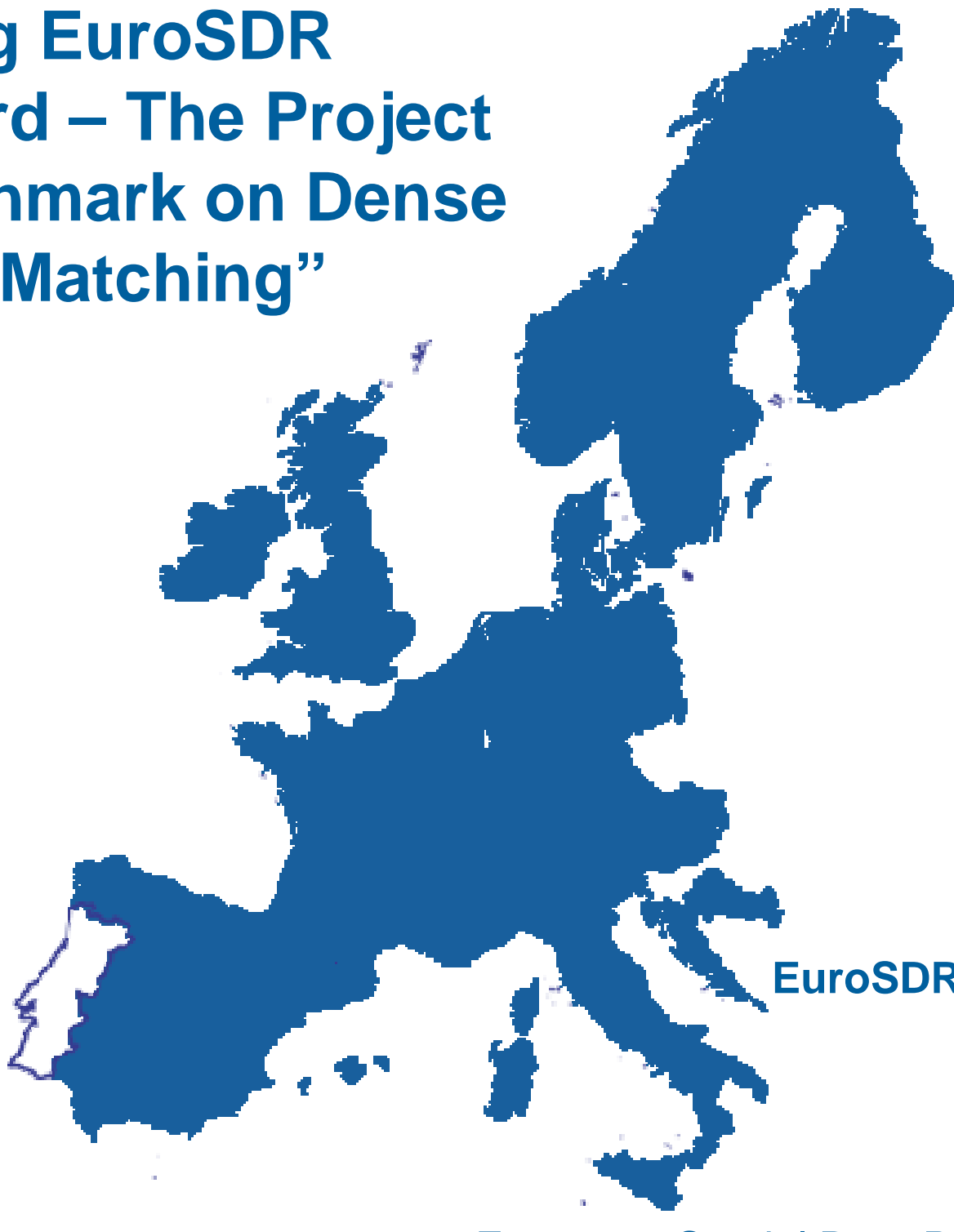
Workshop:

**High Density Image Matching
for DSM Computation II**

11.00-12.30 **Opening Session**

- Welcome Addresses by hosts BEV and by EuroSDR
- D. Fritsch (EuroSDR Vice President):
Moving EuroSDR Forward - The Project "Benchmark on Image Matching" (25 min)
- W. Stößel (LVG Bayern, Germany):
Motivation for a dense image matching benchmark for NMCAs (20 min)
- M. Gruber (Microsoft Photogrammetry, Austria):
Motivation for a dense image matching benchmark for software providers (20 min)

Moving EuroSDR Forward – The Project “Benchmark on Dense Image Matching”



Dieter Fritsch
EuroSDR Vice President Research

Joke of the Day „Opportunities ...“



Joke of the Day: „The Robbery“

A man with a gun goes into a bank and demands their money.

Once he is given the money, he turns to a customer and asks, ‚Did you see me rob this bank?‘

The man replied, ‚Yes Sir I did.‘ The robber then shot him in the head killing him instantly.

He then turned to a couple standing next to him and asked the man, ‚Did you see me rob this bank?‘

The man replied, ‚No Sir, I didn’t, but my wife did!‘

Moral:

When opportunity knocks at the door... MAKE USE OF IT!!!

1. Review Feb 2012 Workshop - Participants



1. Review Feb 2012 Workshop - Statistics



- 79 Participants registered
- 14 Countries represented
- 3 Presentation Sessions
- 14 Presentations from Vendors, Academia, Service Providers & NMCA's
- 2 Breakout Sessions with up to 6 groups

1. Review Feb 2012 Workshop - Publication



- Publication on CD (already published in Summer 2012)
- 2 Participants volunteered to review
 - Paul Marshall (OS Southampton) ü
 - Wolfgang Stoessel (LVG Munich) ü
 - Thanks to the reviewers!

1. Review Feb 2012 Workshop - Outcomes



- Huge response on Dense Image Matching WS
- Interest from NMCAs, Academia, and Industry
- Ad-Hoc academic group compared disparity maps on sample dataset after WS
- EuroSDR project needs continuation

2. Some Milestones 05/12 Next Steps EuroSDR Project “High DIM4DSM Computation“, Dublin 05/2012



Suggestion from WS organizers

- Decision: continue with new Project Leader/Team
 - at this meeting, please give approval
 - **Proposal: Prof. N. Haala (Stuttgart), W. Stoessel (LVG Munich), Dr. M. Gruber (Vexcel MS Imaging Graz)**
- Reduction of 4 data-sets to 2 only
 - Marseille
 - Vaihingen/Enz (DGPF), later replaced by Munich City
- Preparation of reference data
 - from images
 - from ALS
- Review of project goals by the new management team, to be reported by email to the BoD members (June/July 2012)

2. Some Milestones Time Table for Project “High DIM4DSM Computations“, Dublin 05/2012



Suggestion from WS organizers

- Important decisions at this meeting
 - Project Leader / Team
- Definition / review of project goals in June/July 2012 >>> relaunch benchmark
- Results form participants until October/November 2012
- Final Workshop for summary of results December 2012 / January 2013 (Vienna)
- Publication in spring 2013 (122th meeting)

2. Some Milestones “Preparing EuroSDR for the Future 1“, Dublin 05/2012



- EuroSDR Workshops become more and more attractive!
 - Schema: 2 days, 2 sessions with presenters, 2 breakout sessions with teams of 6-8, wrap-up by every team
 - Successful implementation in Nottingham (1/2012), Vienna (2/2012), Southampton (5/2012)
- EuroSDR Projects should be reorganized: **Shared Lead** – 1 from academia, 1 from NMCA, 1 from industry, the project members should come from across Europe!
 - Will match several and complementary interests: R&D (from academia), operational (from NMCA), performance & applicability (industry)
 - Shares responsibility - the project does not depend on one person only!
 - The Project Management Team meets virtually once a month (by Skype calls etc)
 - The Project Management Team maintains the project web pages, communicates with the project participants
 - The Project Management Team decides about the deliverables: results, workshop, publications, etc.

2. Some Milestones “Preparing EuroSDR for the Future 2, Dublin 05/2012



- EuroSDR Projects will have a different period of time!
 - Some will be finished after 2 years, maybe followed by 1 year of technology transfer
 - Others will kept alive for many years: Camera Calibration (since 1970s), Aerial Traingulation (since 1970s), Image Matching (since 1990s), Pattern Recognition, etc, but have to fulfill milestones after 2-3 years (publications, OpenSource SW etc)
 - **Datasets are offered to a worldwide community: Computer Vision, ISPRS, ICA, etc.**
 - The results gained by scientists using EuroSDR datasets can be compared with existing results
 - **New** interesting results can be **uploaded** to EuroSDR project web pages!

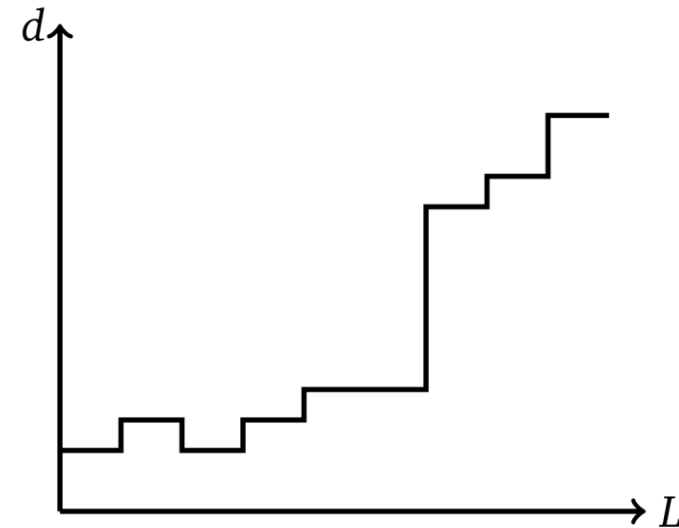
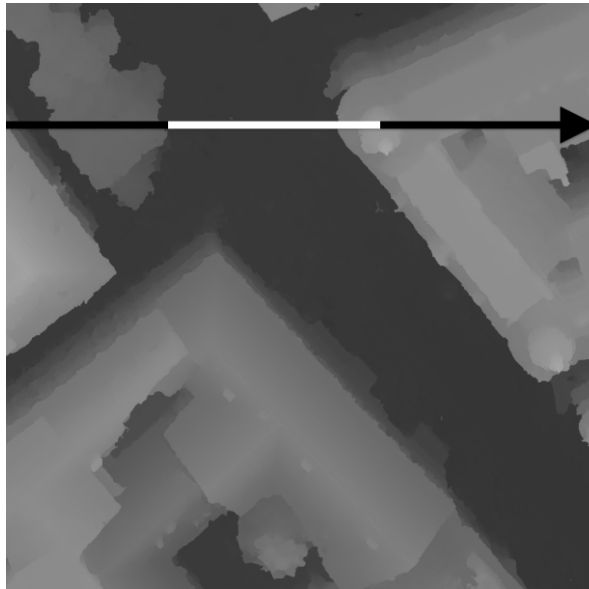
This will give EuroSDR much more visibility and benefits! Young scientists will love EuroSDR and this service!

3. What Happened in Between? Why Dense Image Matching Algorithms?



- Dense Image Matching is complementary/competes with airborne/terrestrial and mobile LiDAR in some respect?
- 53rd Photogrammetric Week, Stuttgart: “Dense Image Matching Meets Advanced LiDAR“ – main conclusions: there is no either or, every technology has its strength & weakness
- SGM/DIM point clouds cover up to 400 points per sqm (GSD 5cm), are therefore superior in quality compared with airborne LiDAR point clouds – they may complement the weakness of static laser scanners
- What about CV OpenSource SW like Bundler, VisualSfM, Autodesk123D Catch, PMVS2,...?

3. What Happended in Between? Basics of Dense Image Matching – Semi Global Matching *Energy minimization on paths*



Disparity along a path L in the image

- SGM Optimization approach: smoothness constraint
disparities similar to neighboring pixels are preferred
- High completeness
 - depth estimation for each pixel
- Low noise surfaces

3. What Happened in Between?

Basics of Dense Image Matching – Semi Global Matching (H. Hirschmüller, 2005)



- Determine the disparities D_p of all pixels subject to a global minimum of the cost function
 - e.g. minimize gray value differences of all matched pixels

$$E(D) = \sum_p C(\mathbf{p}, D_p) \Rightarrow \min \quad C(\mathbf{p}, D_p) = |L(x_p, y_p) - R(x_p - D, y_p)|$$

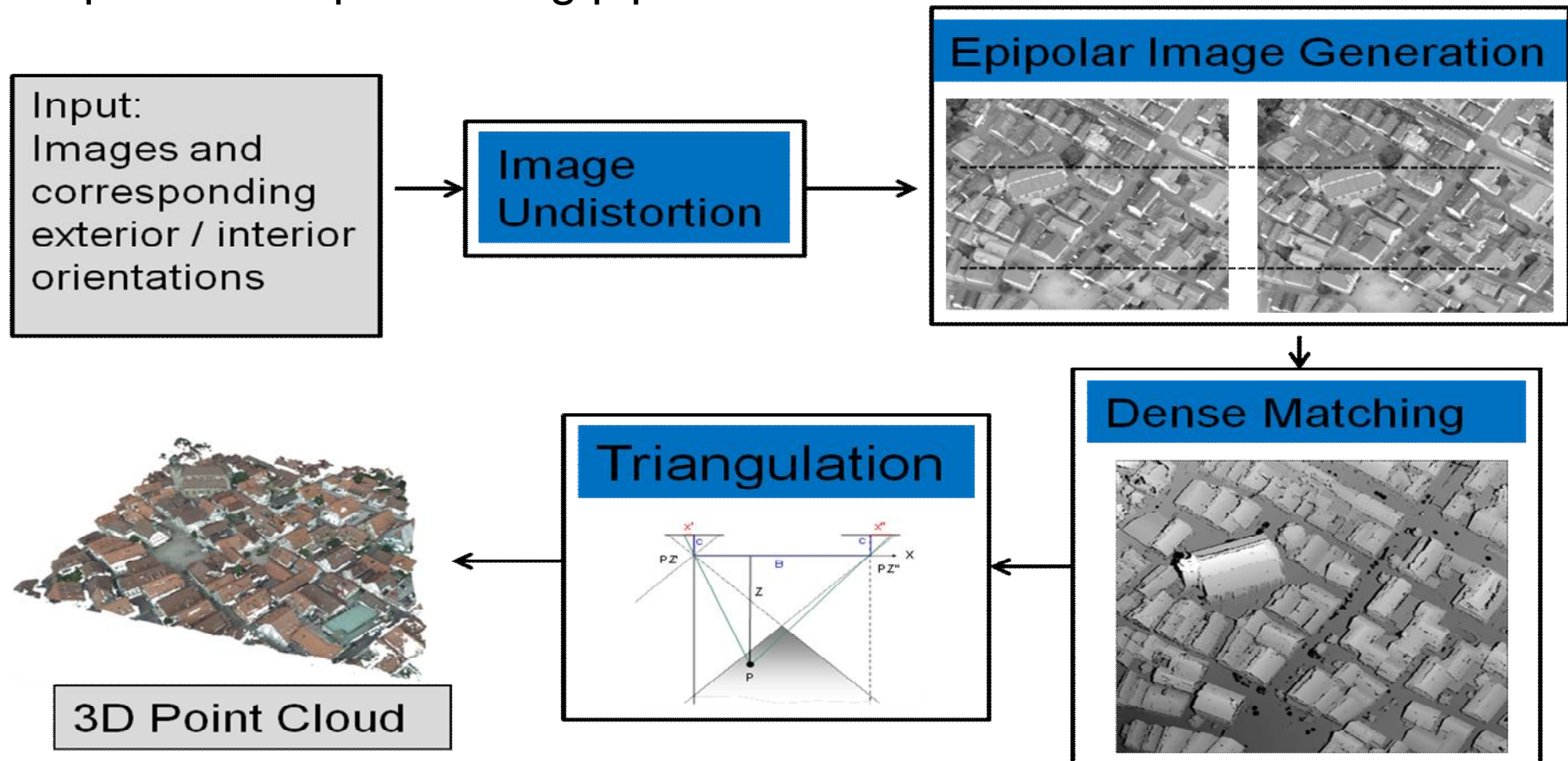
- Large number of identical gray values prevents a unique matching and therefore a stable determination of the cost minimum
- Make use of continuity constraints by advantaging similar parallaxes for neighboring pixels
 - Additional costs for changes in disparities of neighboring pixels
 - q is pixel in neighborhood N of p
 - e.g. Different costs (penalty) for small (=1) and large changes (>1) of the parallaxe/disparity

$$PT[D_p \neq D_q]$$

$$E(D) = \sum_p C(\mathbf{p}, D_p) + \sum_{q=N_p} P_1 T[|D_p - D_q| = 1] + \sum_{q=N_p} P_2 T[|D_p - D_q| > 1] \Rightarrow \min$$

3. What Happened in Between? Basics of Dense Image Matching – Processing Pipeline SURE@ifp

- Goal: 3D structure extraction
- Implemented processing pipeline:

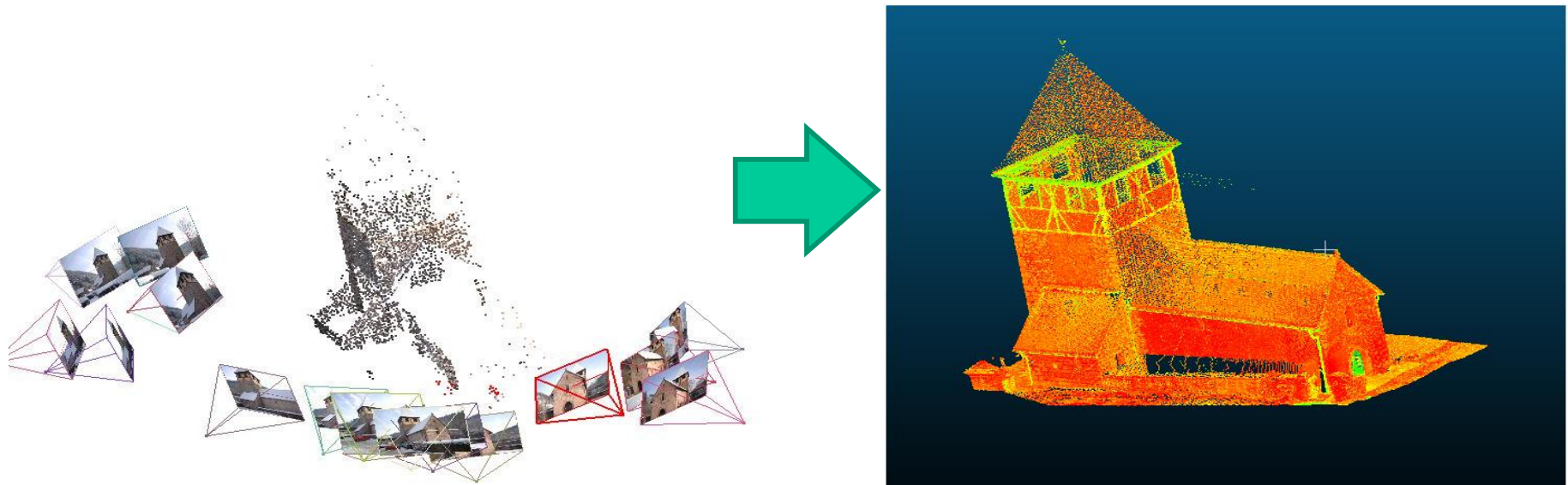


3. What Happened in Between?

OpenSource for Dense Image Matching – MicMac@IGN France, SURE@ifp, PMVS2,...



- Goal: Make DIM even more popular, in photogrammetry and computer vision
- e.g. Match AT or VisualSfM provide image orientations



- MicMac: www.ign.fr/software
- SURE: www.ifp.uni-stuttgart/publications/software
- Ref: Rothermel, M., Wenzel, K., Fritsch, D.&Hala, N. (2012):**SURE: Photogrammetric Surface Reconstruction from Imagery. Paper LC3D Conf, Berlin.**

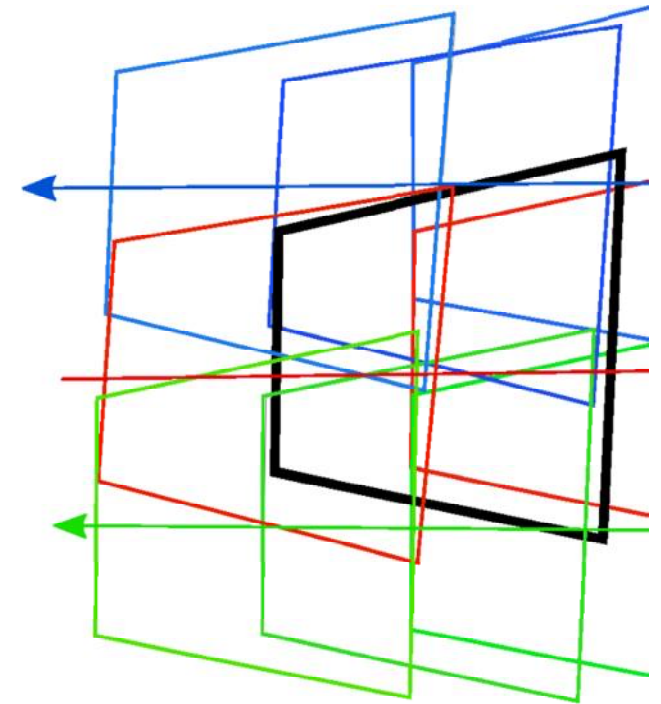


3. What Happened in Between? Point Clouds from Oblique Airborne Photography

The IGI Luenen Dataset, Germany



- Benefits
 - Reconstruction of building facades
 - High completeness
 - High redundancy
- Challenges
 - Large amount of images
 - Large variations in ground sampling
 - Large perspective distortions



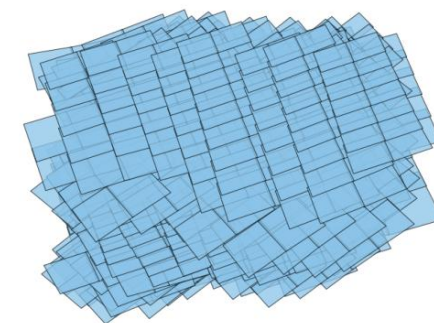
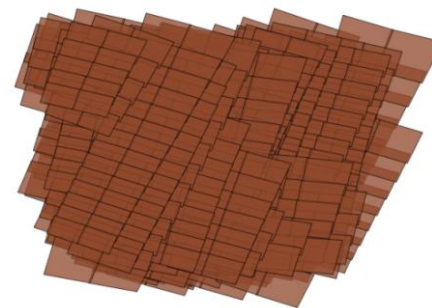
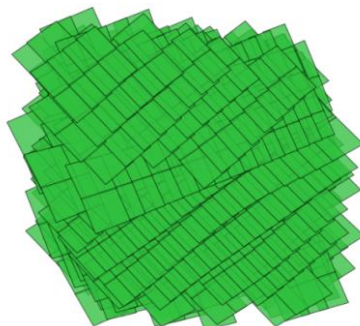
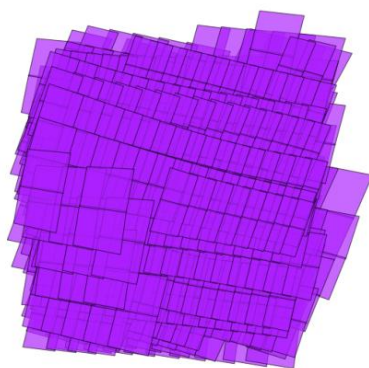
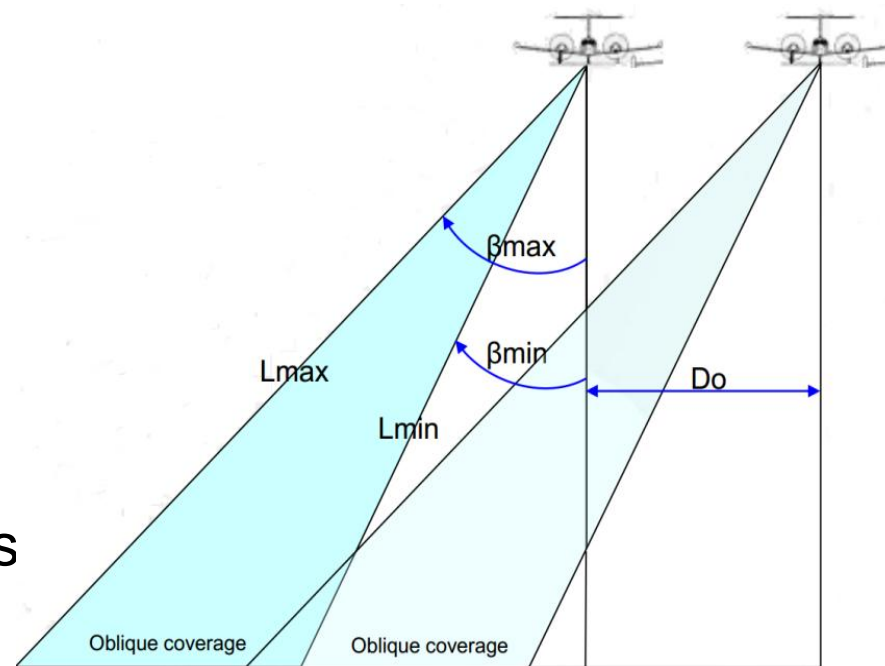
è Solution: **Hierarchical Multi-View SGM**

3. What Happened in Between? Point Clouds from Oblique Airborne Photography –

The VisionMap A3 Tel Aviv Dataset, Israel

A3 Flight Parameters

- § Sweeping frame system
- § GSD Nadir 6cm
- § Flight height 2000m
- § Forward/Side Laps 55%/44%
- § Oblique viewing angle 25.0 - 44.98 deg
- § Airplane equipped with 4 cameras (mounted 45° , -45° , 135° , -135° , w.r.t flight direction)



3. What Happened in Between? Point Clouds from Oblique Airborne Photography - The VisionMap A3 Tel Aviv Dataset

- One base image was matched against 41 proximate match images
- Resulting 41 disparity maps were fused



Base image

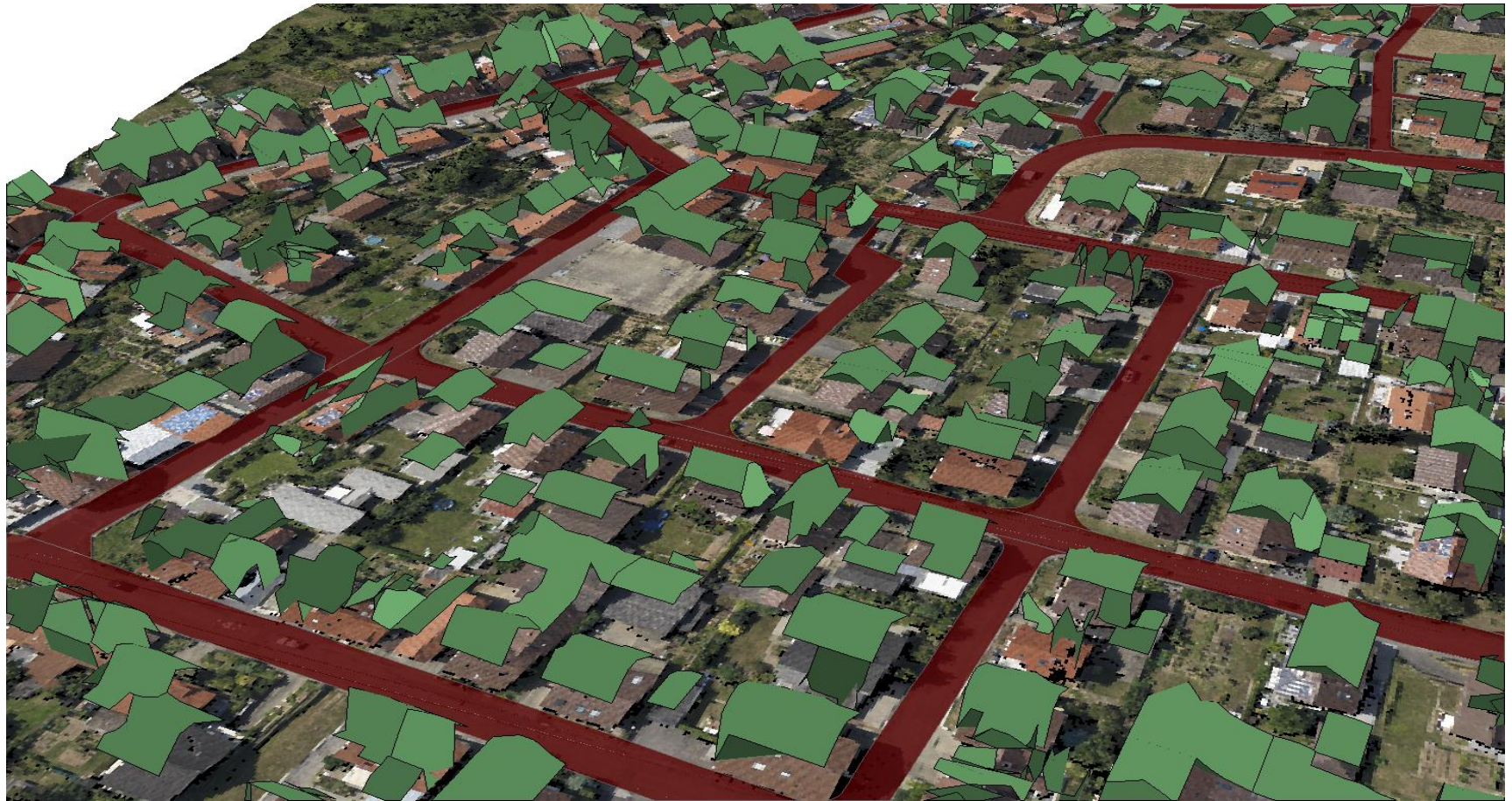


Match images

3. What Happened in Between? Automatic Building Database Update



- Input: DSM of Dense Image Matching, bulding footprints from cadastre
- DTM computation using DSM and morphological „opening“



3. What Happened in Between? Automatic Building Database Update



- Input: DSM from Dense Image Matching, building footprints from cadastre
- DTM computation by morphological „Opening“
- Subtract DTM from DSM
- Check for areas higher than 3m and not in cadastral database



4. Expectations June 2013 Workshop - Parties



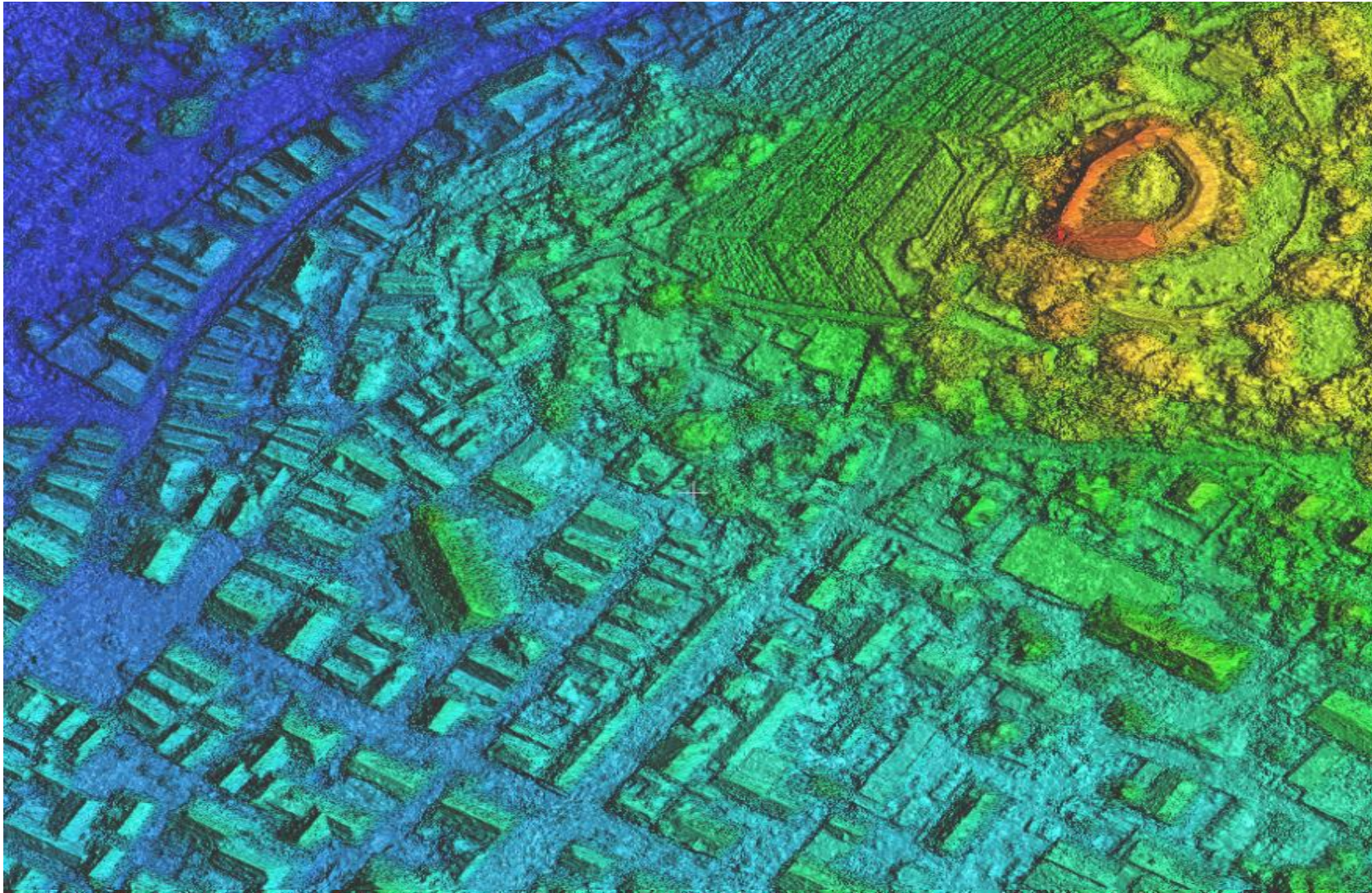
- Participants

- C. Ginzler (WSL - Swiss Federal Institute for Forest, Snow and Landscape Research)
- B. Brunner (FMM - Forest Mapping and Management, Salzburg)
- R. Schneider (Digital Photogrammetry GEOSYSTEMS GmbH, Germany)
- P. Nonin (GEO-Information Services Astrium Services)
- C. Ressler (GEO TU Wien, Vienna)
- M. Idrissa (Royal Military Academy, Brussels)
- K. Gutjahr (Joanneum Research, Graz)
- M. Pierrot-Deseilligny (IGN France)
- M. Rothermel (ifp, University of Stuttgart)
- H. Hirschmüller German Aerospace Center (DLR)
- K. Legat (AVT Photogrammetrie und Bildflug)
- J. Gonçalves (University of Porto)

4. Expectations June 2013 Workshop - Dataset VaihingenEnz



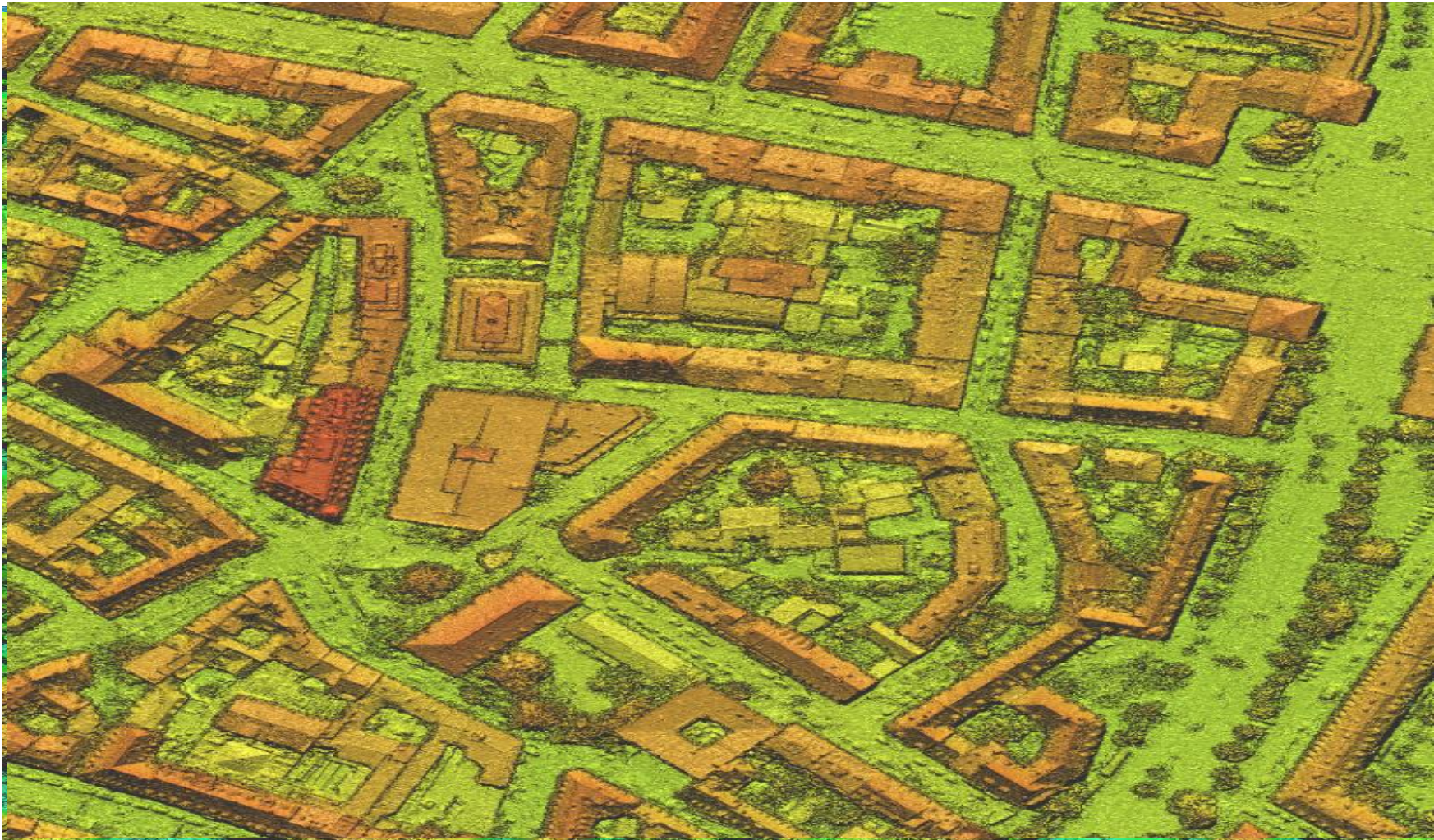
- Differences between the DSMs



4. Expectations June 2013 Workshop - Dataset Munich



- Differences between the DSMs



4. Expectations June 2013 Workshop



Academia (NMCA: W. Stoessel, Private Sector: M. Gruber)

- To learn from each other
- Computing time when using several IT infrastructures
- Performance of algorithms in DSM detail reproduction
- Geometric accuracies of DSMs
- ...
- **But:** No ranking at all amongst the groups/parties
- No “good“ or “bad“ statements to disqualify some work

5. Conclusions



- Dense Image Matching remains a hot topic for EuroSDR for the years to come (incremental update of databases etc)
- This project will be closed at the Gaevle BoD Meeting, Oct. 2013
- 2 Reviewers are needed to review the publication material (for the workshop CD ROM & for a booklet which will appear in 2014)
- Existing software (MicMac, SURE,...) will be made available (links etc) at the EuroSDR App Store
- Results of 1st image matching benchmark (Year 2000) and this benchmark (Year 2013) will be made available at the new EuroSDR Web Pages
- Data & Results of this workshop might be maintained for further testing (by photogrammetrists & computer vision people) – not decided yet!

Program II.



13:30-15:15 **A Users Point of View**

- H. Lehner (City Administration, Vienna):
“Exploiting the DSM in city areas: example from a municipality”
- K. Schadauer (Austrian Research Center for Forest, Vienna)
“Exploiting the DSM for vegetation analysis: examples from forestry”
- G. Bronner (Umweltdata, Lower Austria):
“DSM’s for Forestry (Requirements in operational Forest Management, Planning and Monitoring)”

15.15-15.45 Coffee Break

15.45-17.30 Break-out session:

Expectations on Image Matching for DSM Generation

Group Discussion & Wrap-up