ifp

University of Stuttgart

SURE

The ifp Software for Dense Image Matching

Konrad Wenzel
Mathias Rothermel
Dieter Fritsch
Norbert Haala

General Workflow

Images
e.g. from mobile phones, DSLRs or aerial cameras

Image Orientation
e.g. from Aerialtriangulation or *Structure from Motion*

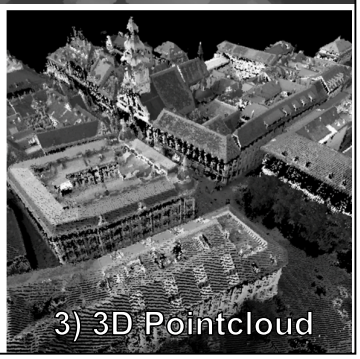
Dense 3D point clouds
using SURE, which derives up to one 3D point per pixel

Pointcloud Derivatives
e.g. meshed surfaces or true orthophotos

University of Stuttgart

Image Matching
pixel correspondence search for depth estimation

1) Find corresponding pixels between images from multiple views
2) Store resulting parallax image
3) Use ray intersection to generate 3D pointcloud



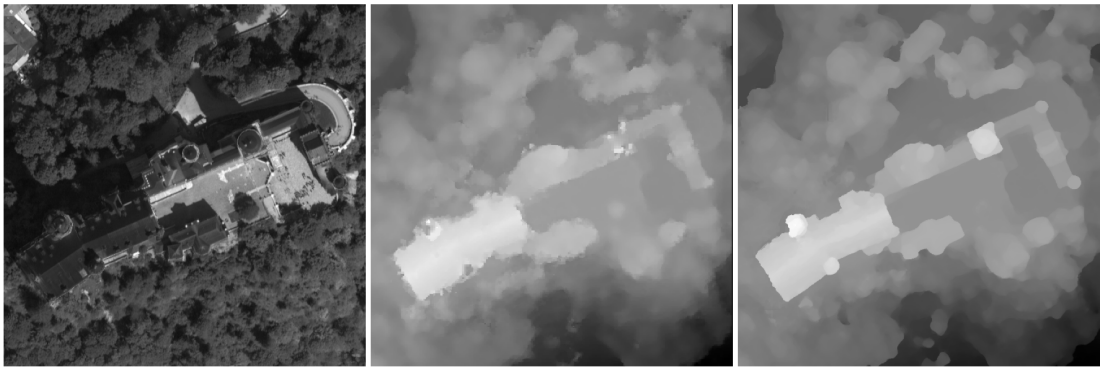
University of Stuttgart

mathias.rothermel@ifp.uni-stuttgart.de / konrad.wenzel@ifp.uni-stuttgart.de

Why Semi Global Matching?

- Matching: dense, intensitybased
- Global: optimization approach using a global model
- Semi: approximation ⇨ fast numerical solution

Intensity image	Disparity image using a correlation matching method	Disparity image using Semi Global Matching



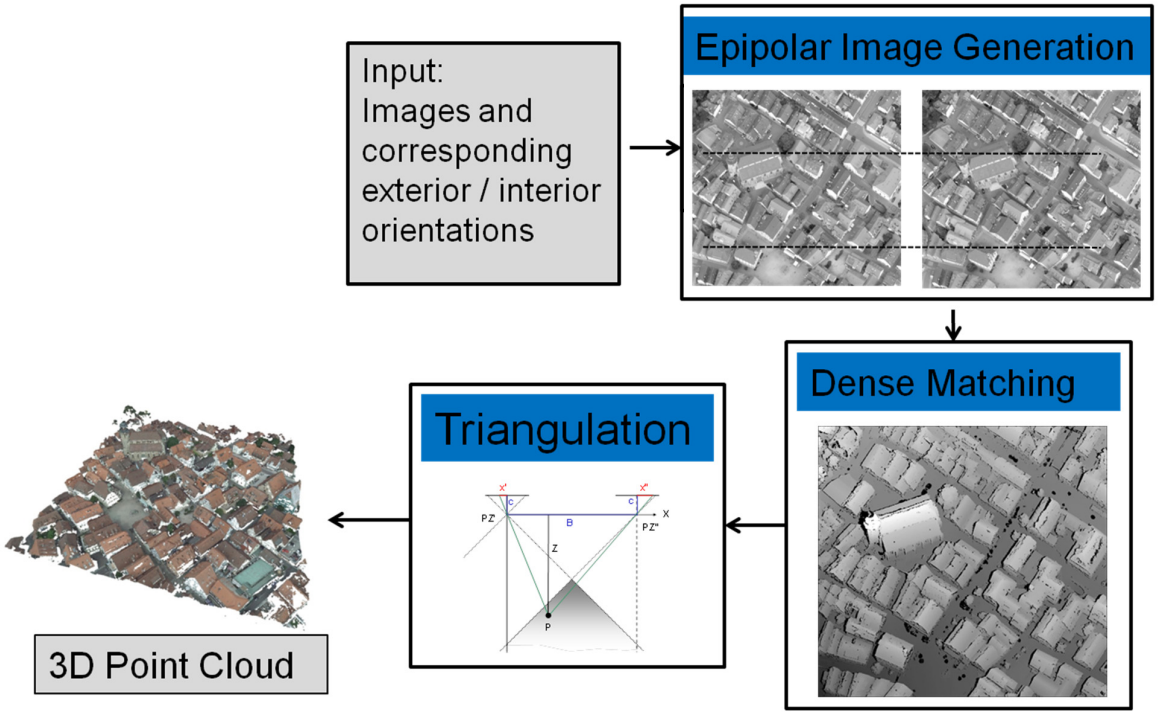
Castle Neuschwanstein, Bavaria, Germany
source: Hirschmüller, Heiko (2005) – Accurate and efficient stereo processing by Semi Global Matching an Mutual Information

mathias.rothermel@ifp.uni-stuttgart.de / konrad.wenzel@ifp.uni-stuttgart.de

University of Stuttgart

ifp

Implemented Reconstruction Pipeline



mathias.rothermel@ifp.uni-stuttgart.de / konrad.wenzel@ifp.uni-stuttgart.de

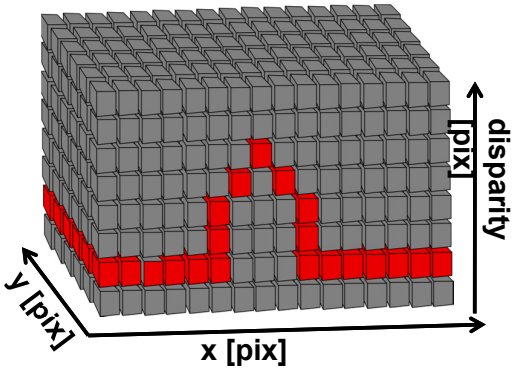
University of Stuttgart

ifp

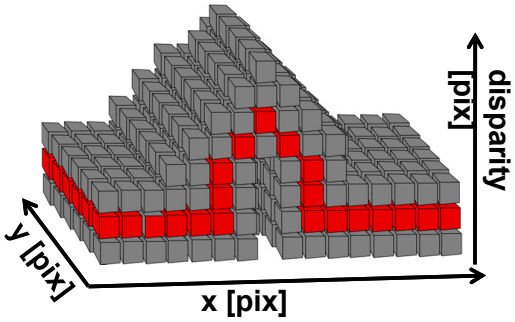
tSGM

- Problem: SGM cost structures require large amount of memory
- Solution: dynamic hierarchical matching cost array
  - ➔ Faster
  - ➔ Less memory requirements

Original SGM



tSGM



mathias.rothermel@ifp.uni-stuttgart.de / konrad.wenzel@ifp.uni-stuttgart.de

University of Stuttgart

Multi-view stereo

Point triangulation using multiple stereo models

- Redundant measurements allow outlier elimination claiming geometric consistency

Stereo

1-fold

Multi-view

> 1-fold

Multi-view

> 2-fold

Multi-view

> 3-fold

University of Stuttgart

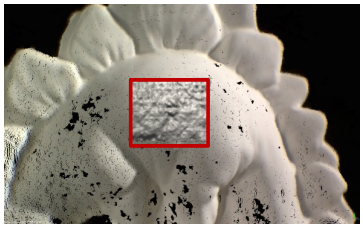
Motivation Multi-view Stereo

Point triangulation using multiple stereo models

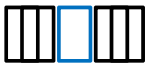
- Improvement of accuracy

Stereo

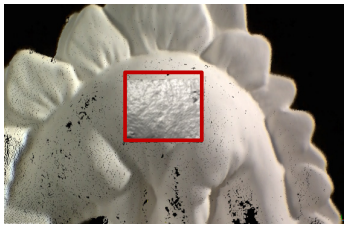
1-fold

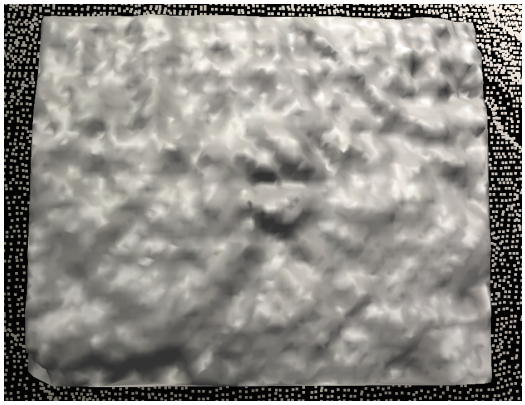


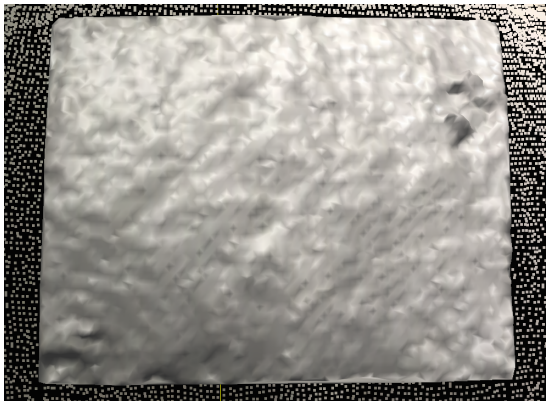
Multi-view



> 1-fold



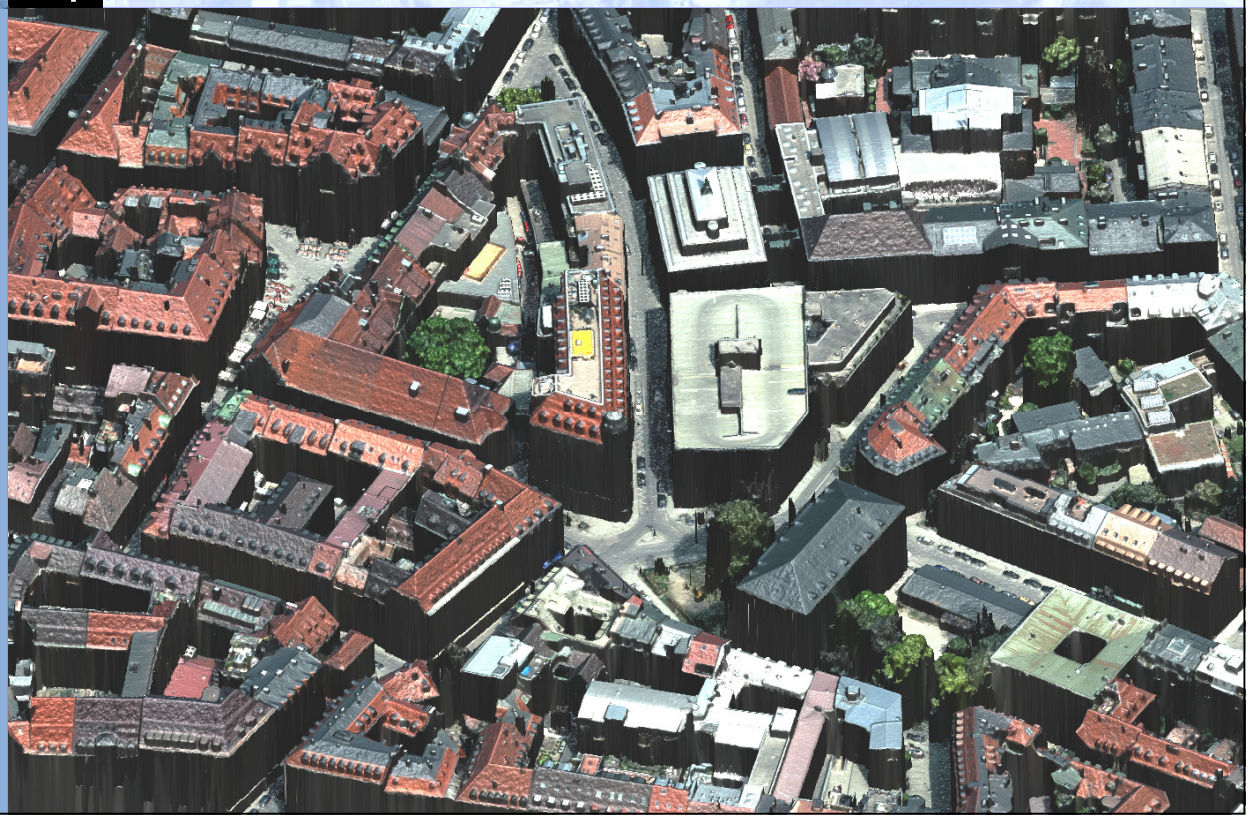




University of Stuttgart

Munich, DMC II, 10cm GSD

EuroSDR Image Matching Test



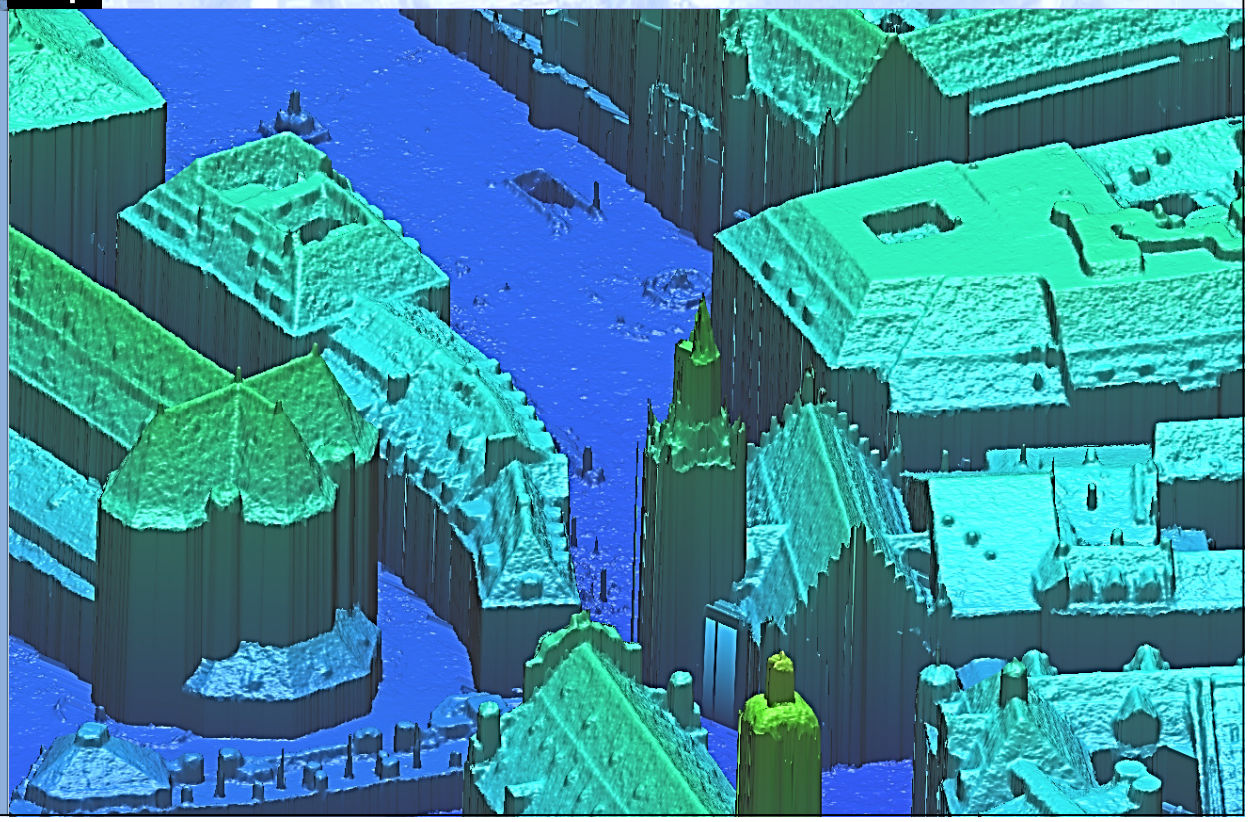
University of Stuttgart

ifp

University of Stuttgart

Munich, DMC II, 10cm GSD

EuroSDR Image Matching Test



ifp

University of Stuttgart

Munich, DMC II, 10cm GSD

EuroSDR Image Matching Test

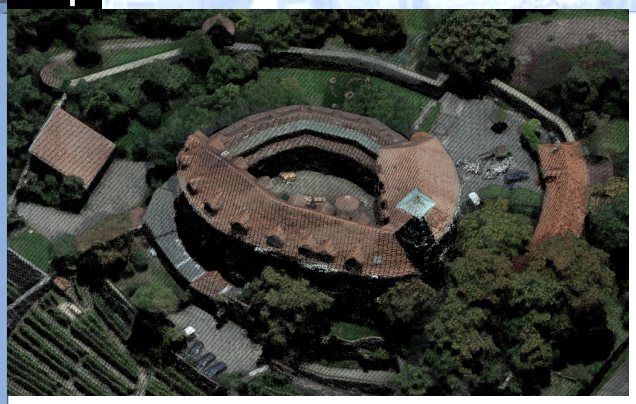
Further talk about the EuroSDR Matching Test:

Norbert Haala:

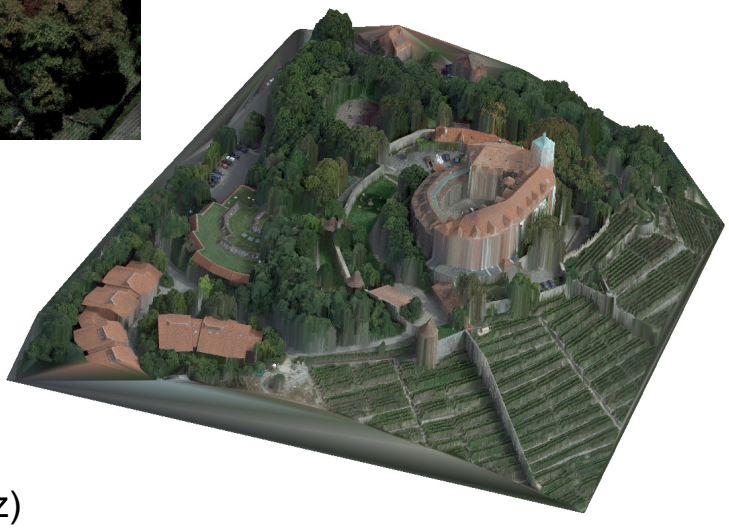
The Landscape of
Dense Image Matching Algorithms

Thursday, 9:00

Aerial Dataset (UltraCamX)



- Overlap 80/60%
- GSD 8cm
- Matching 4 neighbourhood



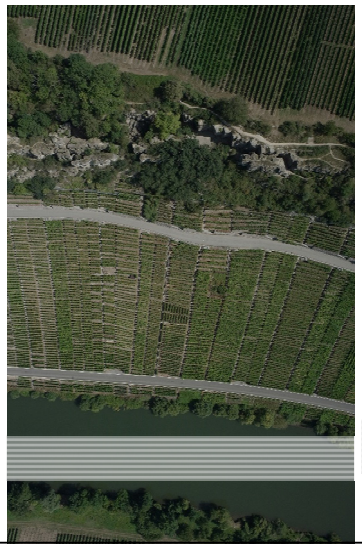
- Bundle Adjustment: Trimble/Inpho Match-AT
- Matching time: <5 min per stereo pair (i7-3.4GHz)

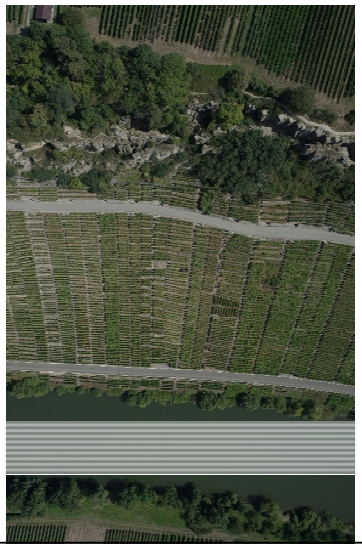
mathias.rothermel@ifp.uni-stuttgart.de / konrad.wenzel@ifp.uni-stuttgart.de

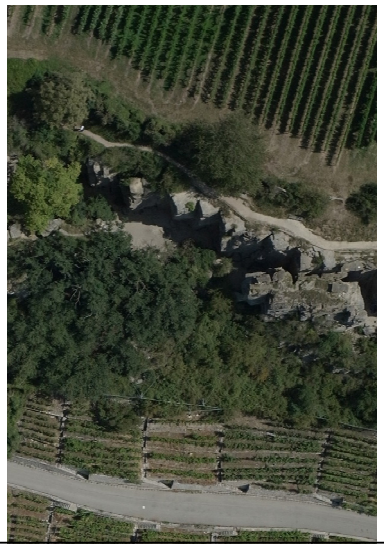
Example: UAV flight - Hessigheim, Germany

- Block of 190 images, acquired over Hessigheim Germany
- Fixed wing UAV
- Ricoh GXR with 21 mm Zeiss Biogon lens

➔ Extract of 12 images

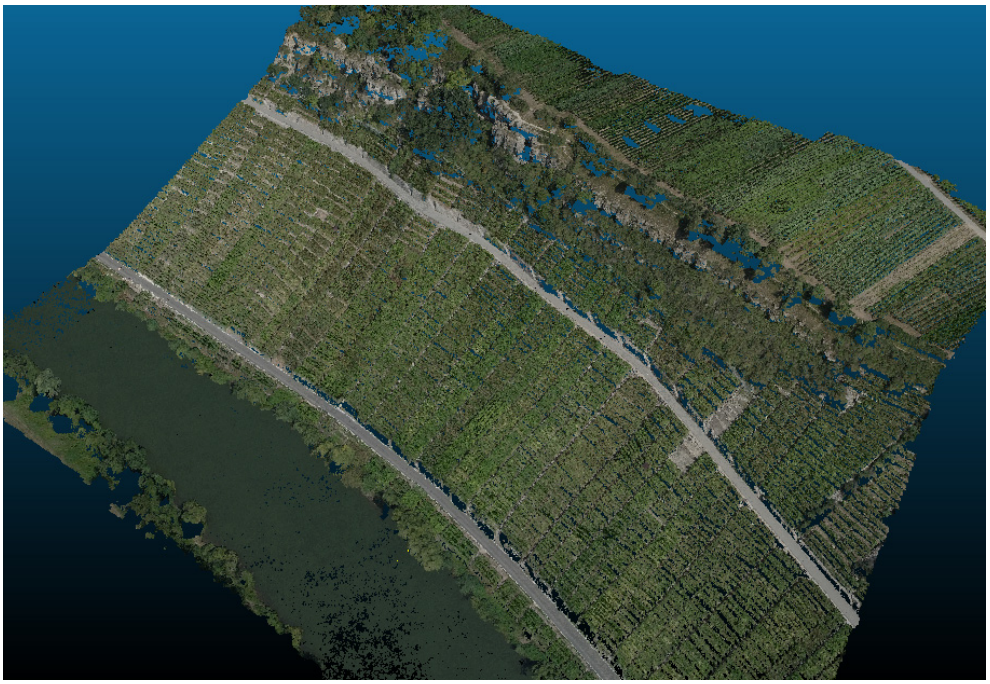






Example: UAV flight - Hessigheim, Germany

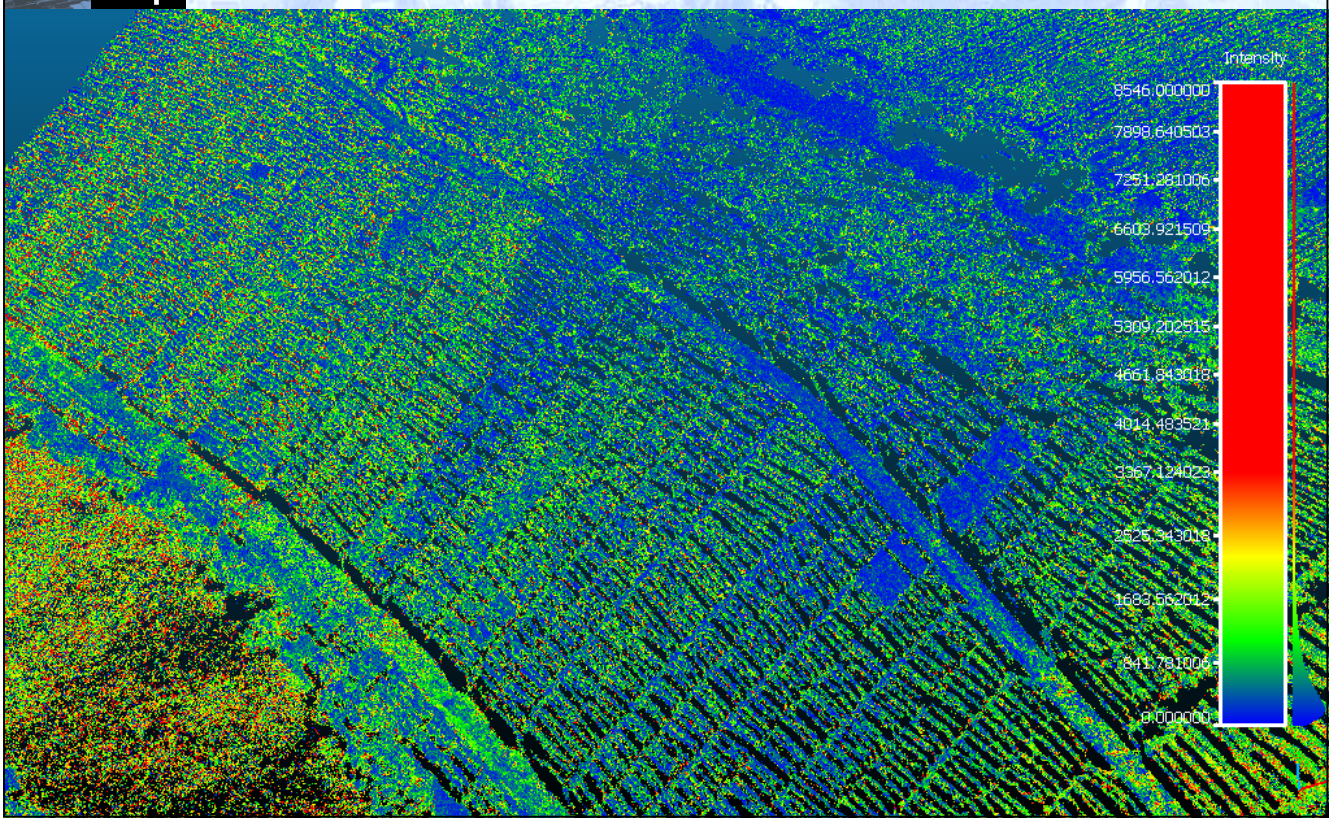
- Point cloud from SURE using extract of 12 images



University of Stuttgart

Example: UAV flight - Hessigheim, Germany

Depth precision for each point

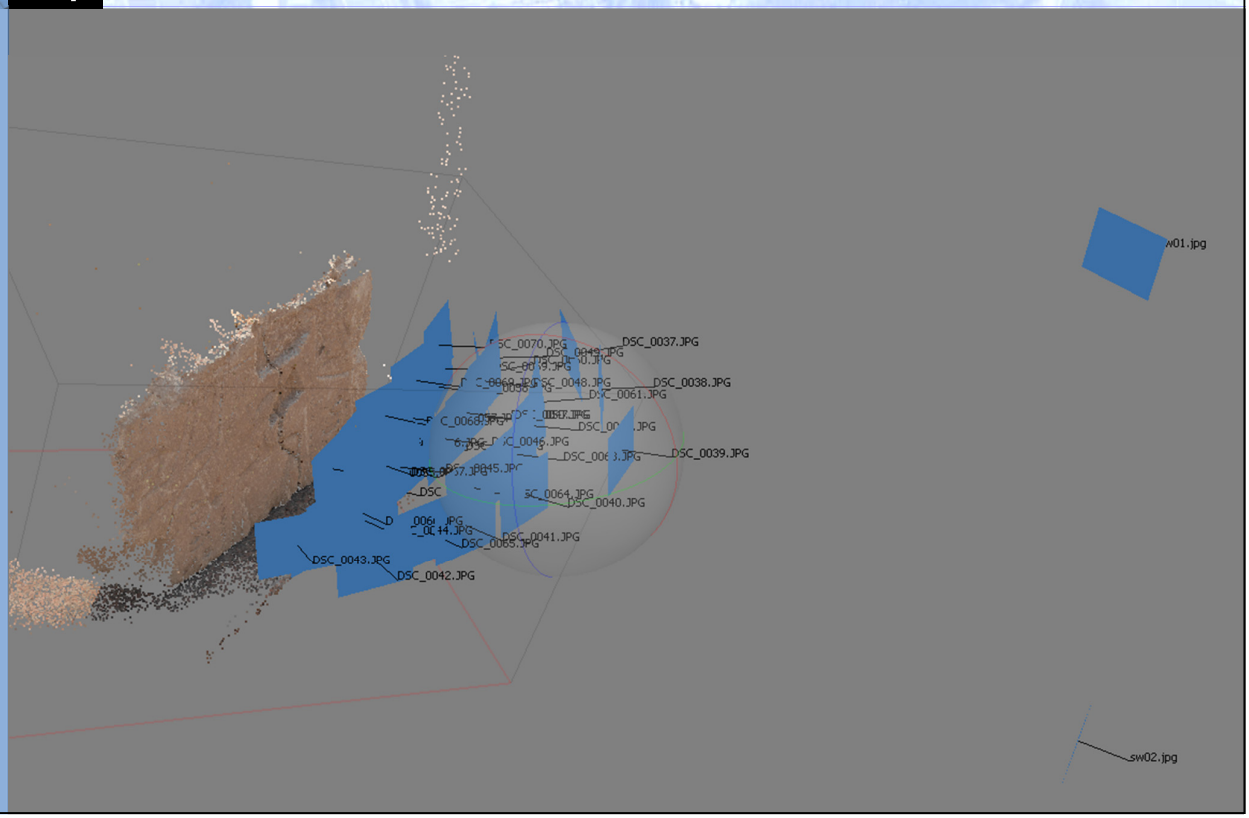


ifp

Carved stone from the Temple of Heliopolis, Egypt

University of Stuttgart

Carved stone
from the Temple of Heliopolis, Egypt



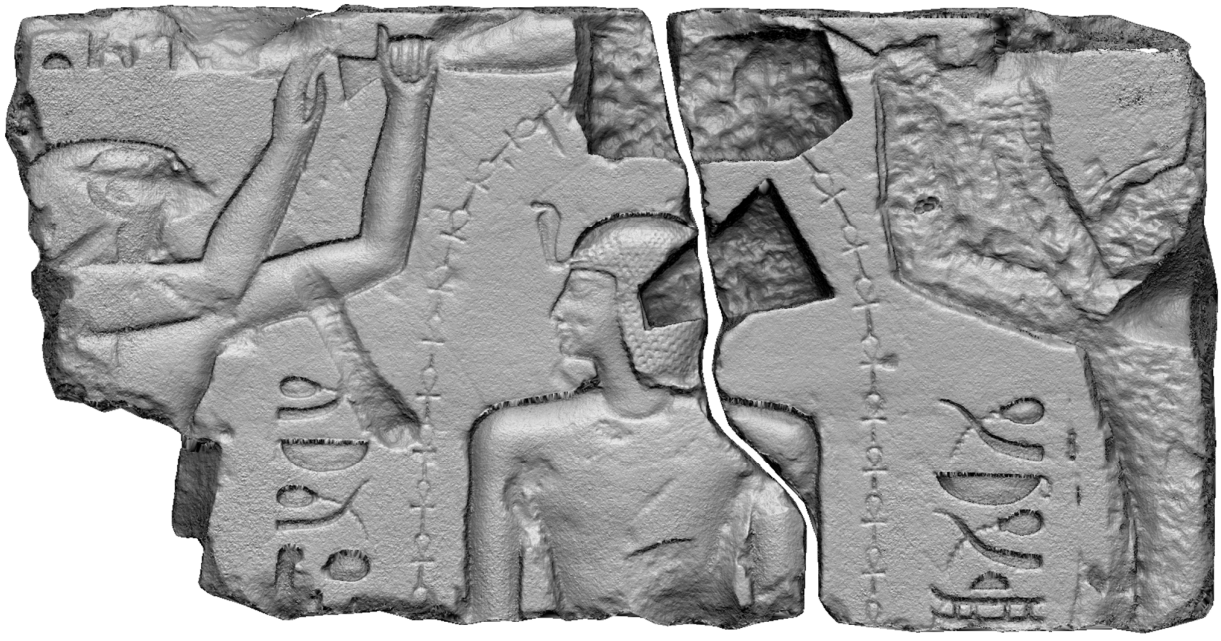
University of Stuttgart

Carved stone
from the Temple of Heliopolis, Egypt

University of Stuttgart

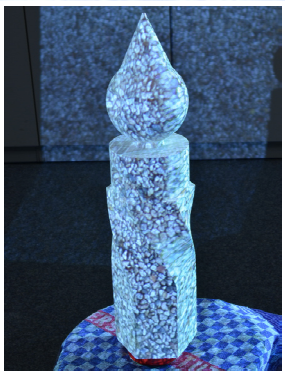
Carved stone from the Temple of Heliopolis, Egypt

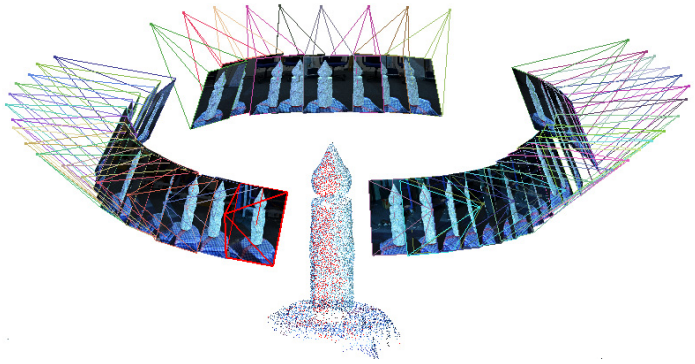
Carved stone from the Temple of Heliopolis, Egypt



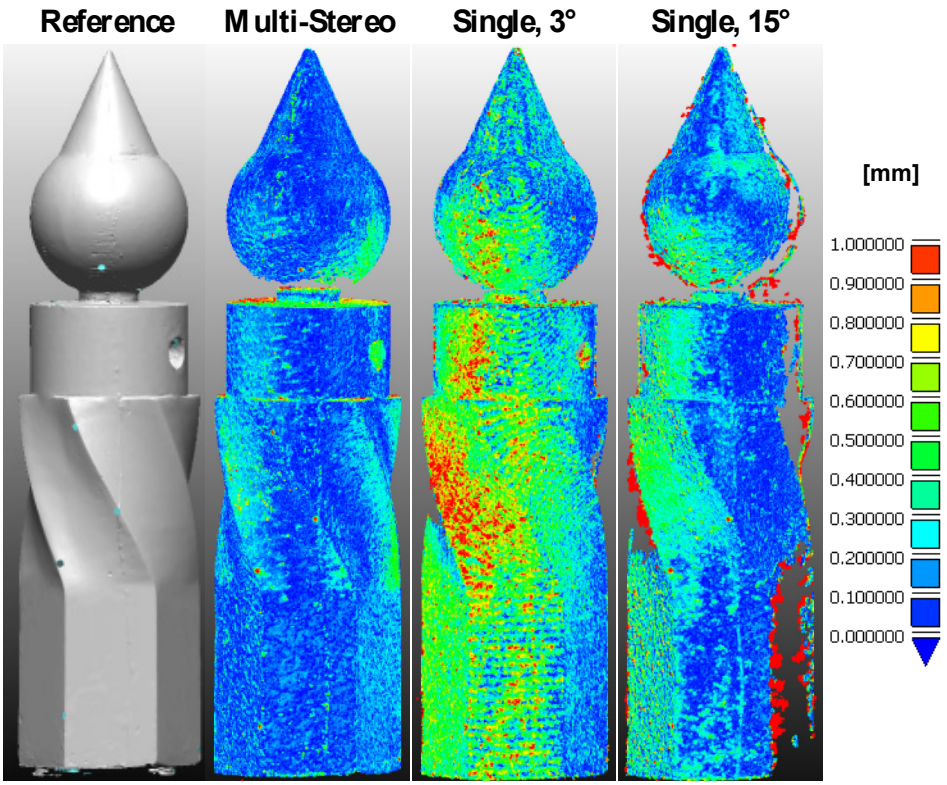
Multi-Stereo acquisition
Test object *Testy*

- „Testy“
  - 35cm test object
  - Developed by HU Berlin
- Acquisition
  - 46 images
  - Small steps
  - Each image covering whole object
- Orientation
  - VisualSfM
- Dense Surface Reconstruction
  - SURE



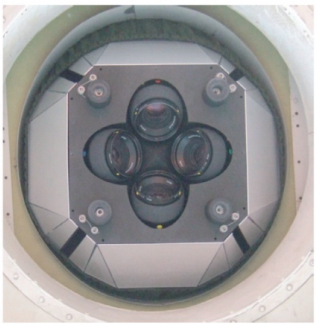


Multi-Stereo acquisition
Test object *Testy*



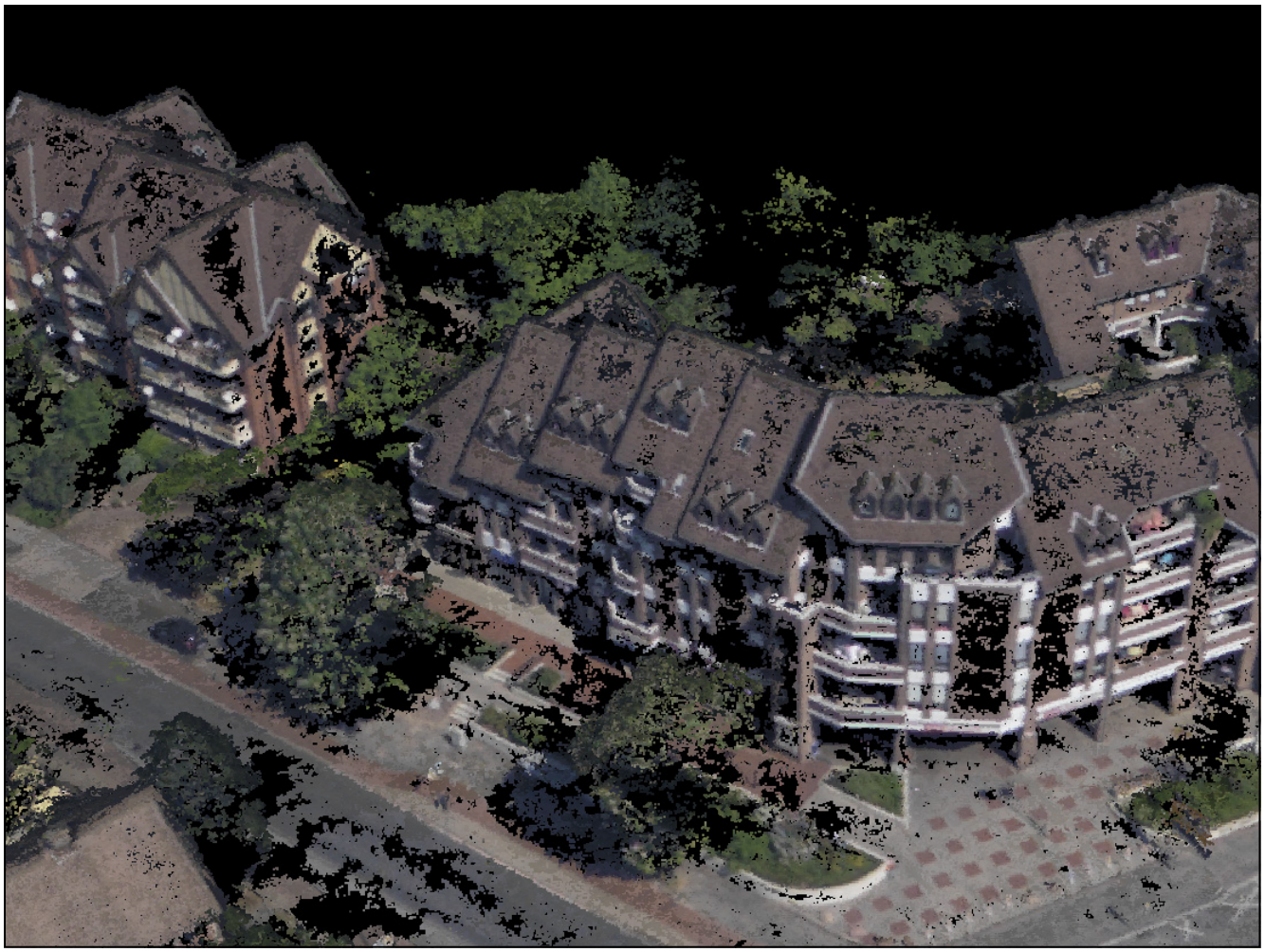
Dataset: Lünen, Germany
Oblique imagery

- IGI Quattro DigiCam Oblique
  - angle: 45°
  - forward, backward, left, right
- Acquisition: 1st of May, 2011
  - AEROWEST GmbH
- 757 images x 4
  - extract: 170 oblique images
- 760 agl. ➔ 6.7cm – 13.6cm GSD
- AT: Match-AT (Trimble)
- BA: BINGO (GIP)



University of Stuttgart

mathias.rothermel@ifp.uni-stuttgart.de / konrad.wenzel@ifp.uni-stuttgart.de



Further paper:

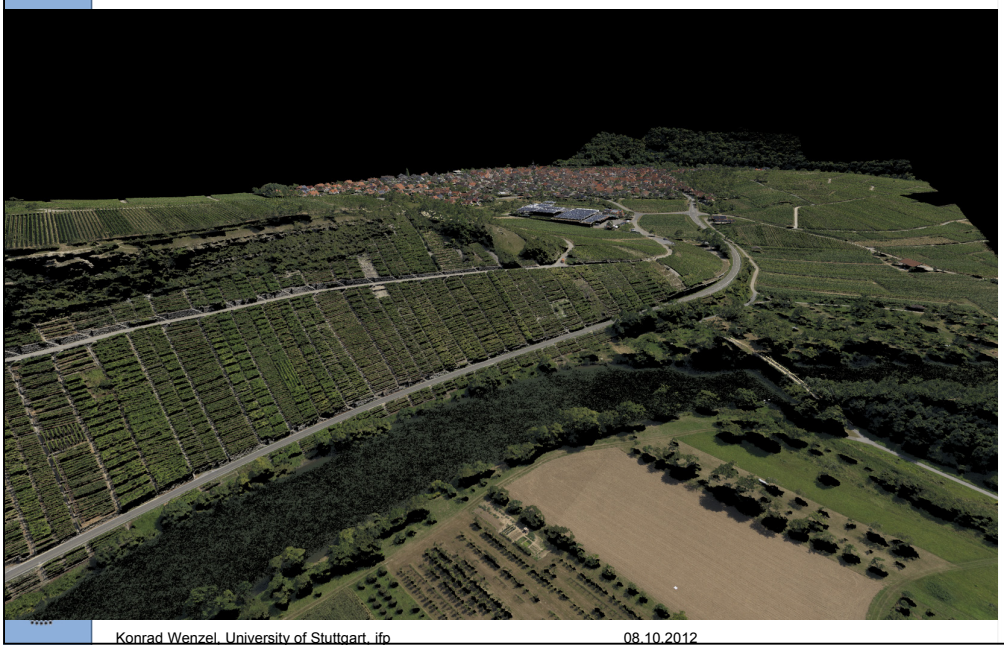
Dieter Fritsch & Mathias Rothermel:

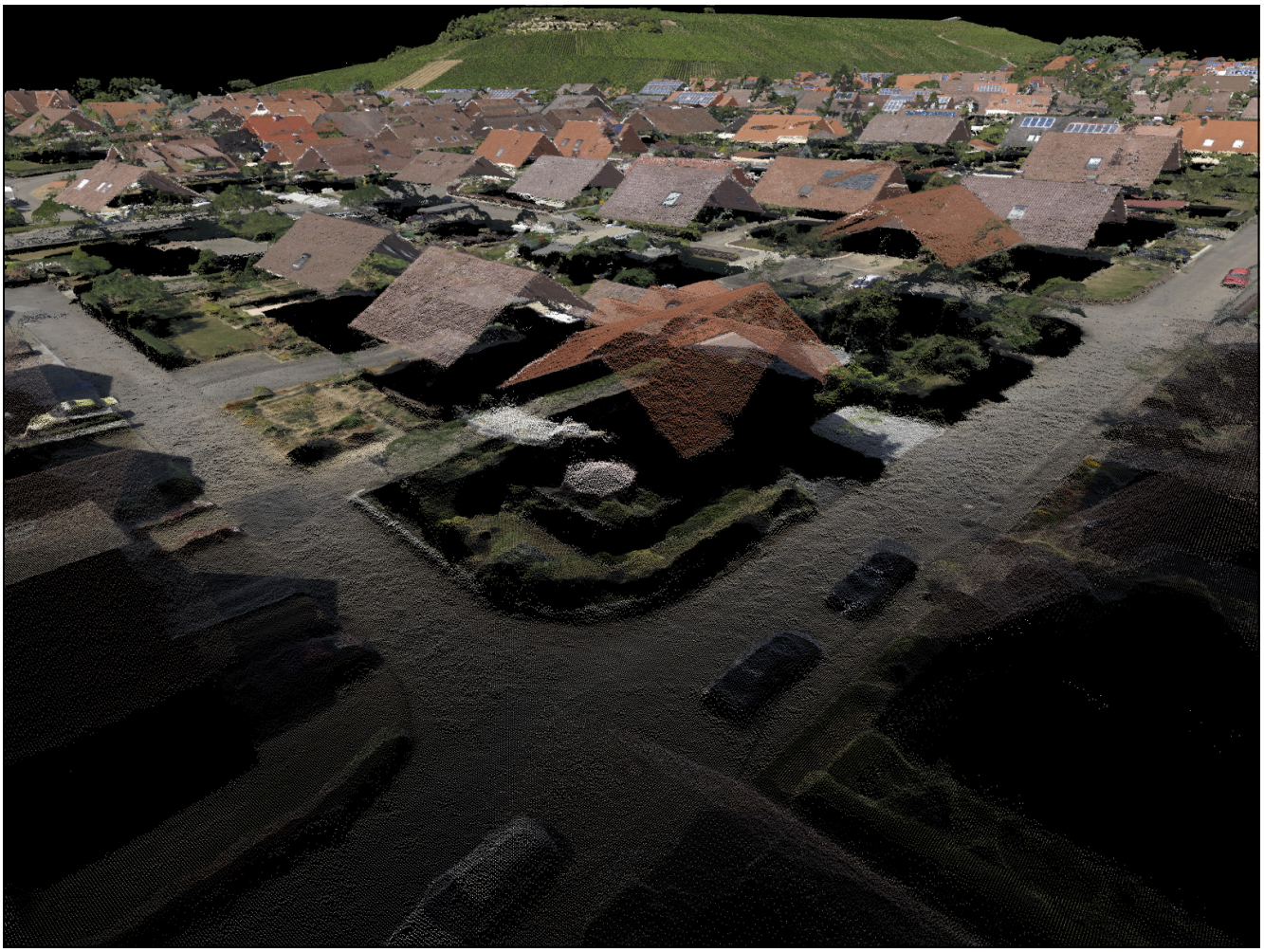
Oblique Image Data Processing – Potential, Experiences and Recommendations

Tuesday, 8:30

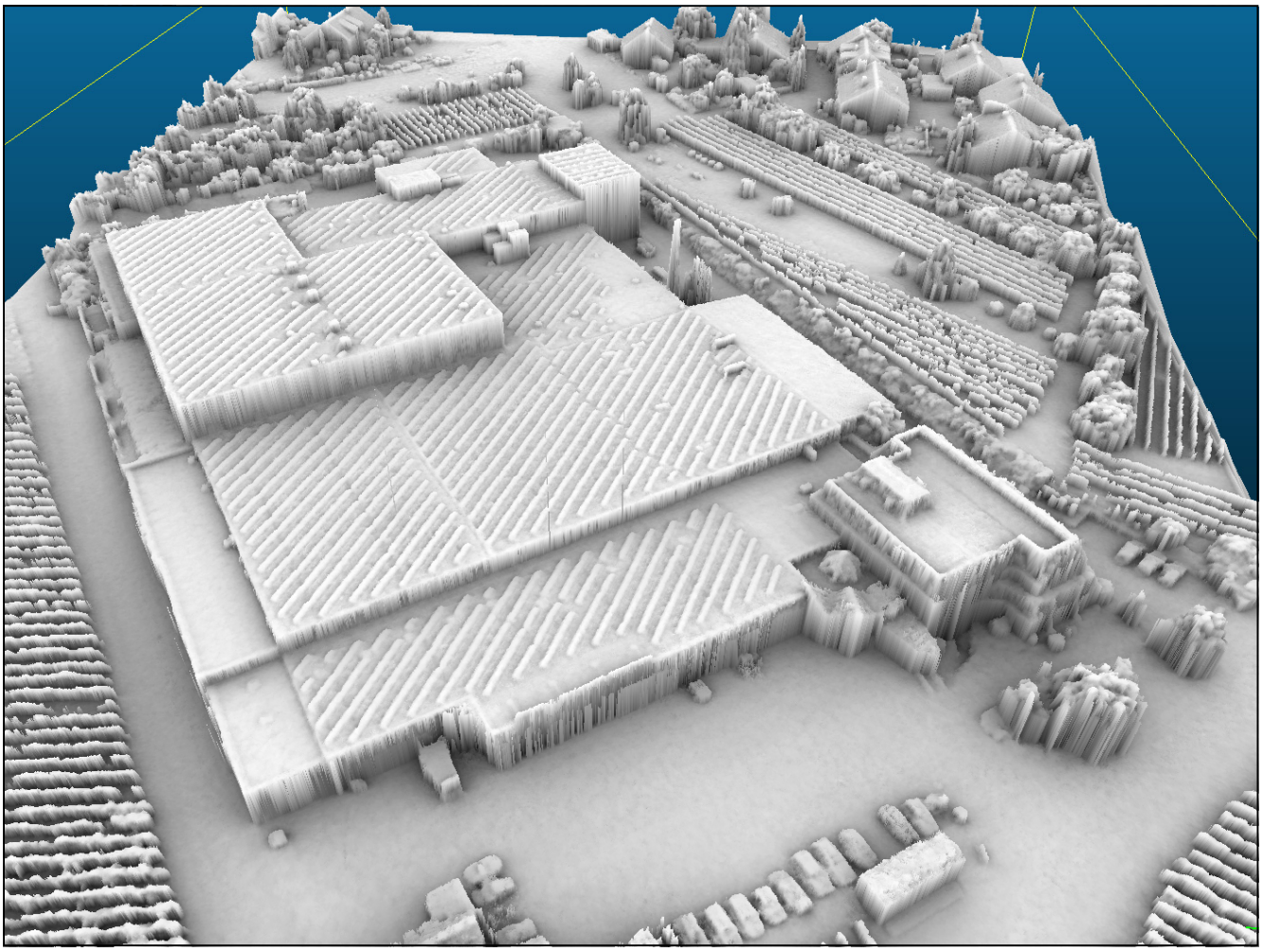
Gyrocopter & IGI DigiCAM

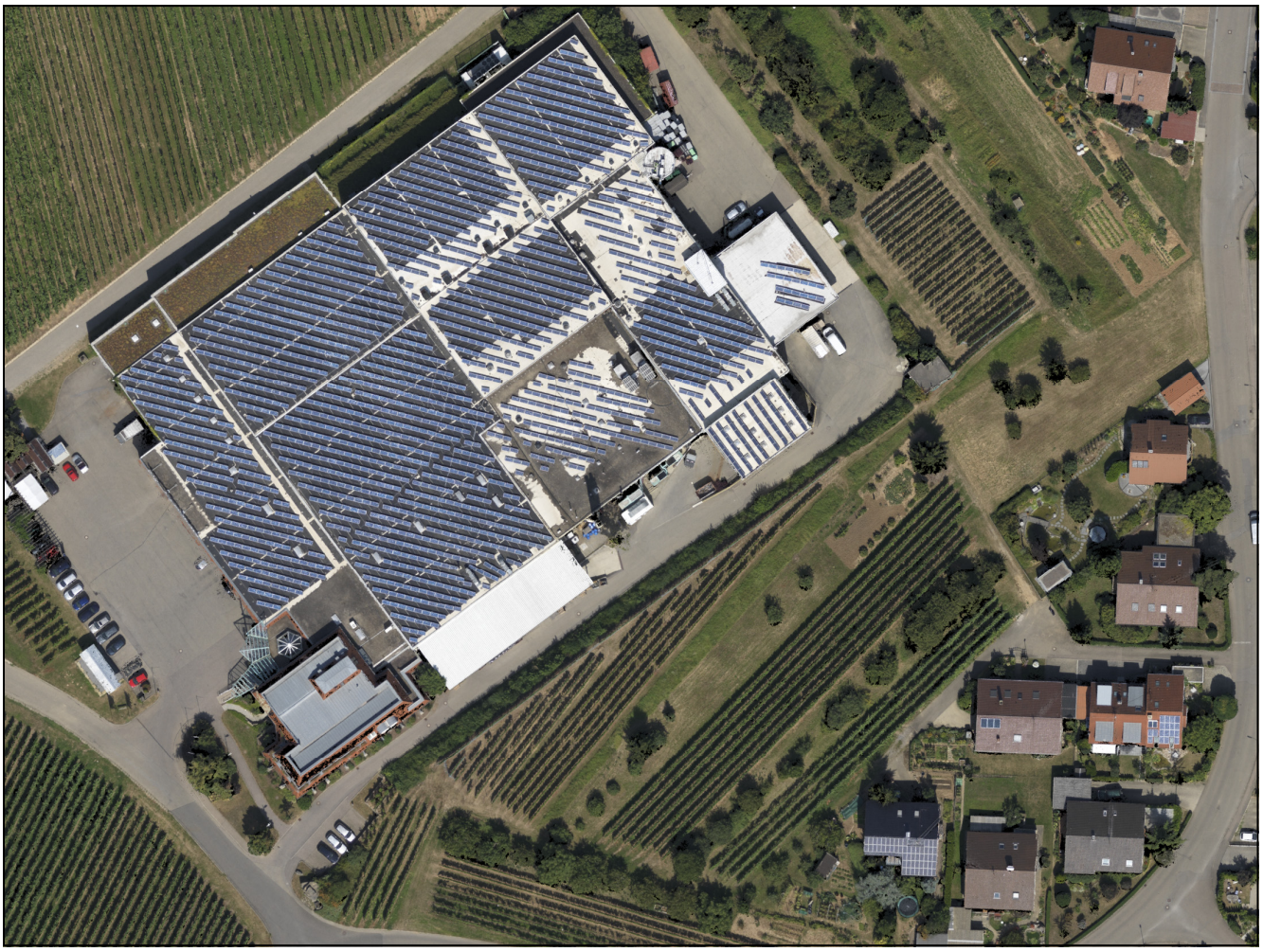
- IGI DigiCAM 50MP
- 131 images






55





SURE
Features

- **Scalability** for large datasets
  - Large amount of images & large image resolution
- **Parallelized** implementation with low memory consumption
- Available for **Windows & Linux**

- **Precision information** for each 3D point from forward intersection
- **DSM & True Orthophoto** generation module
- Additional options for various filters, model selection and more

- **Easy & scriptable interface**
  - command line, drag&drop, library
  - **Robust default parameter setting** for all kind of sensors and block configurations like aerial nadir, aerial oblique, close range etc.
- **Orientation interfaces**
  - e.g. Match-AT, Bundler, VSFM, Pix4D and more

University of Stuttgart

mathias.rothermel@ifp.uni-stuttgart.de / konrad.wenzel@ifp.uni-stuttgart.de

nFrames

- Founded in spring 2013
- Goal
  - Distribution of surface reconstruction software SURE
  - In particular adressing applications with high requirements regarding dataset scalability and precision information
  - Continous research and development
- Concept: Provision of surface reconstruction software SURE
  - As standalone version
  - As plugin library
    - For the tight integration into other software providing specific workflows
    - Uncomplicated integration

SURE

- 3 different interfaces available
  - **SURE** standalone version
    - Easy & scriptable interface
    - Full workflow performed automatically
  - **libSURE** library
    - High level C++ library interface
    - Full workflow performed automatically
    - Status feedback during processing for tight integration
  - **libTSGM** library
    - Low level C++ library interface
    - Functions for image rectification, matching and 3D point triangulation

Future features

- Processing on Graphics Cards (GPU)
- 3D Integration & Meshing on large scale
- Distributed processing
- Graphical User Interface
- Continous improvement of existing algorithms