Advanced point cloud processing

George Vosselman
ITC
Enschede, the Netherlands

Laser scanning platforms

Airborne systems

- mounted in airplane or helicopter
- GPS/IMU positioning
- 250 kHz
- multiple echoes / full waveform
- < 5 cm accuracy (geo-referenced)
- 10-20 pts/m^2

(FLI-MAP 400 – Fugro Aerial Mapping)

Laser scanning platforms

Terrestrial systems

- mounted on tripod
- 500 kHz (pulse)
- 1.2 MHz (phase)
- < 1 cm accuracy (relative)
- > 1 pt/mm^2 at 10 m

(Riegl VZ-400)

ITC

Laser scanning platforms

Mobile systems

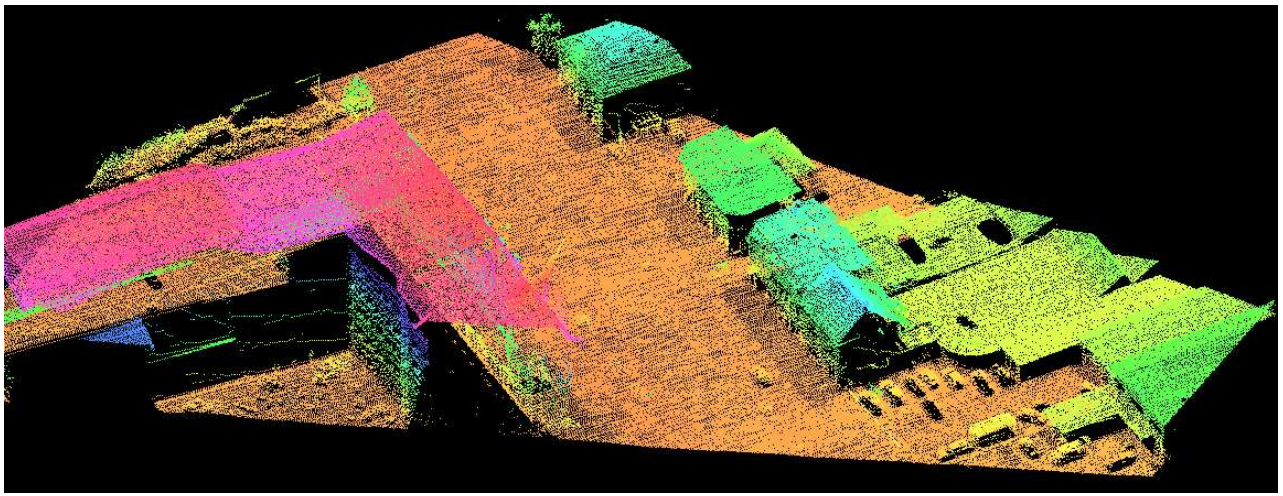
- mounted on vehicle
- GPS/IMU positioning
- 200 kHz
- < 5 cm accuracy (geo-referenced)
- < 1 cm accuracy (relative)
- > 1 pt/cm^2 at 10 m

(Optech Lynx - TopScan)

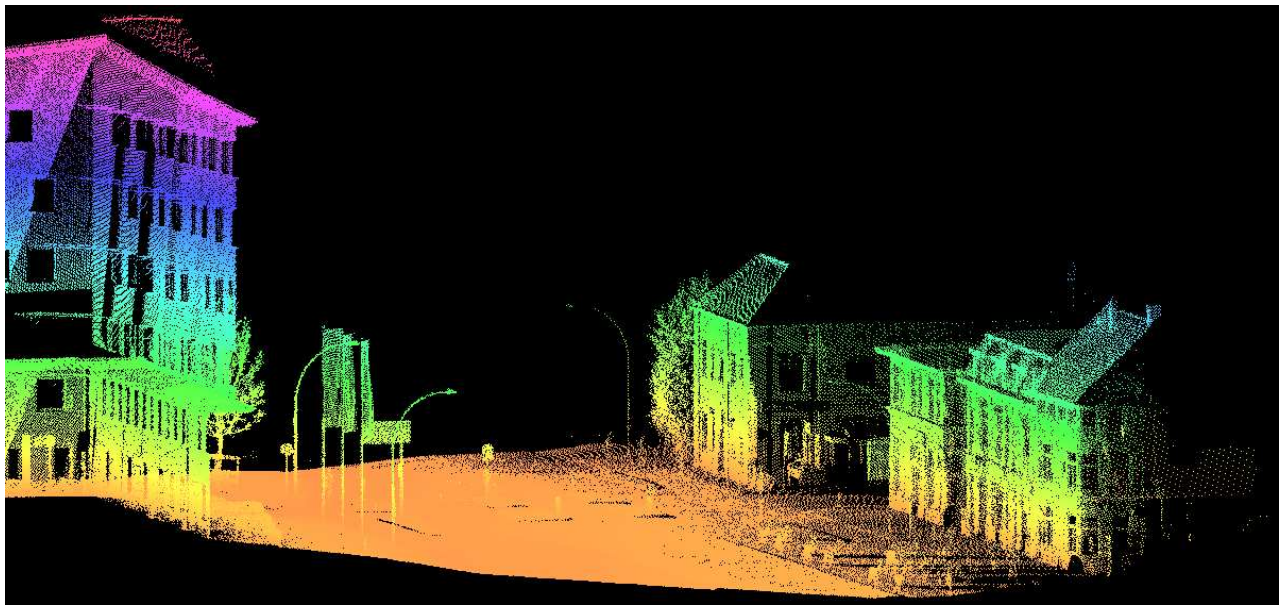
ITC

Point cloud examples

- Airborne



- Mobile



Processing of point clouds

- Segmentation and classification
- Airborne laser scanning
  - 3D building models
  - Curbstones
- Mobile laser scanning
  - Road markings
  - Poles of traffic signs and lights
  - Building façade extraction
- Terrestrial laser scanning
  - Building façade modelling
  - Building façade texturing

ITC

Segmentation of point clouds

Goal

- Grouping points that potentially belong to the same object surface

Objects

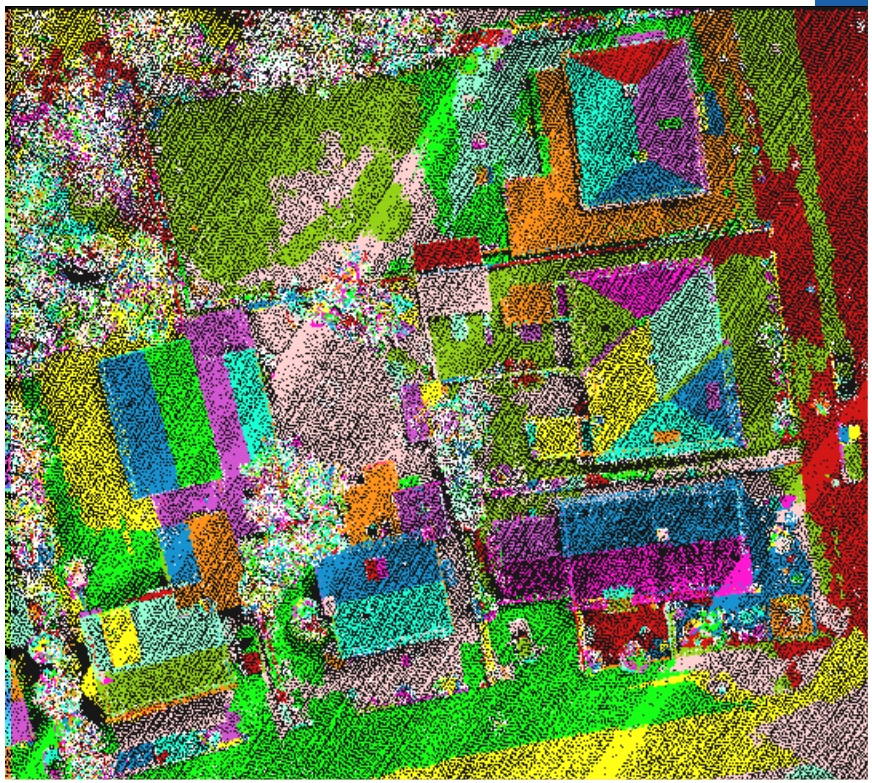
- Man-made objects – parametric shapes
- Terrain surface – smooth

Segmentation of point clouds

Method

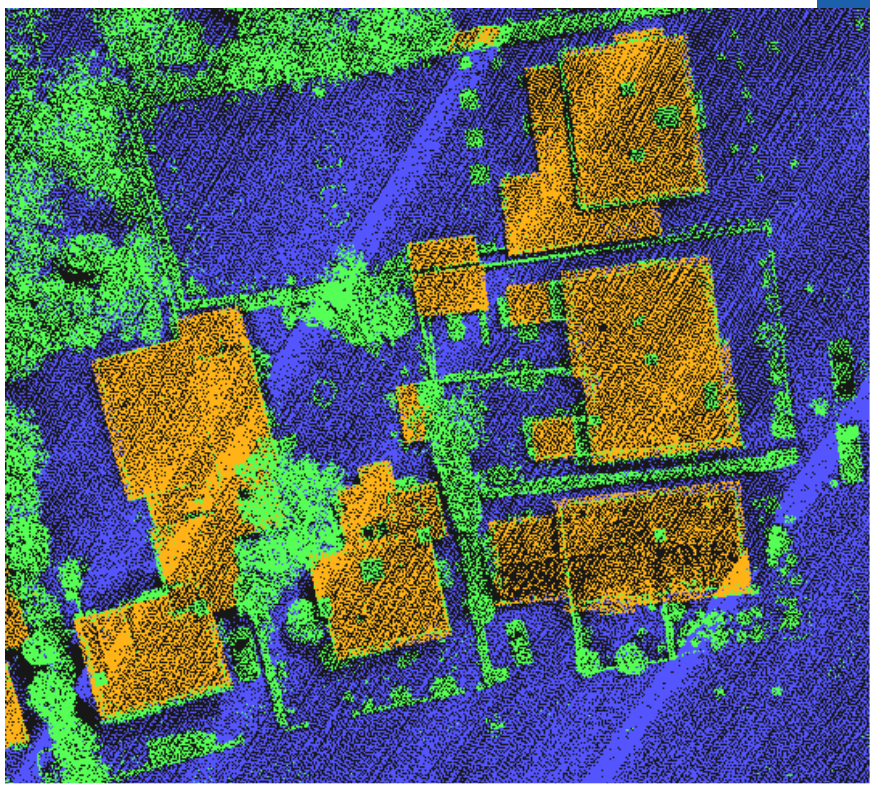
- Select local sets of co-planar points (RANSAC, 3D Hough transform)

- Surface growing: expand seed surface with adjacent points that are close to surface



Classification of point clouds

- Point based vs. segment based classification
- Useful attributes to discriminate between buildings and vegetation
  - Height above the ground
  - Segment size
  - Percentage of last return pulses
- Further improvement by using spectral data and more advanced reasoning

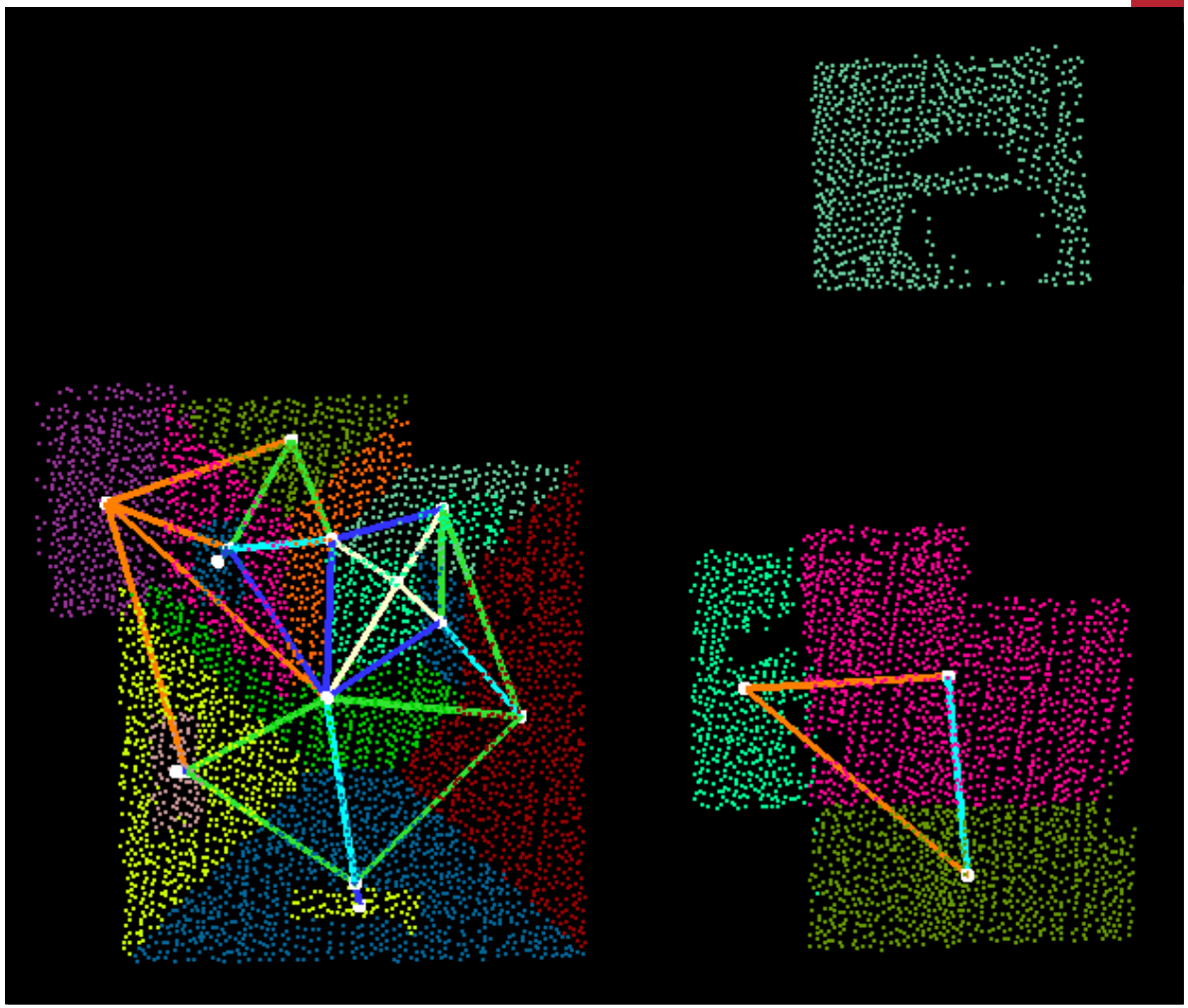


ITC

3D building modelling

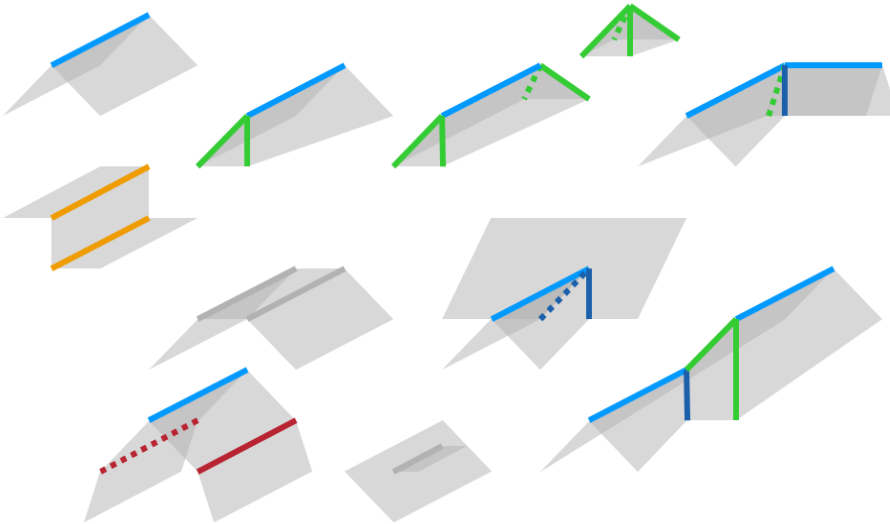
Graph matching for building reconstruction

- Point cloud segmentation
- Selection of roof segments
- Analysis of intersection lines and height jump edges
- Roof topology graph

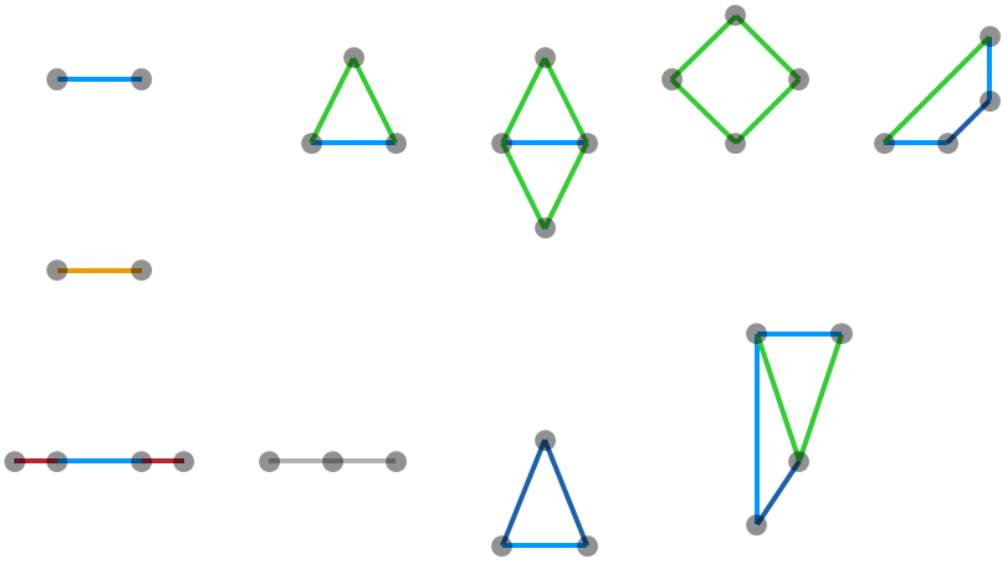


3D building modelling

- Target shapes

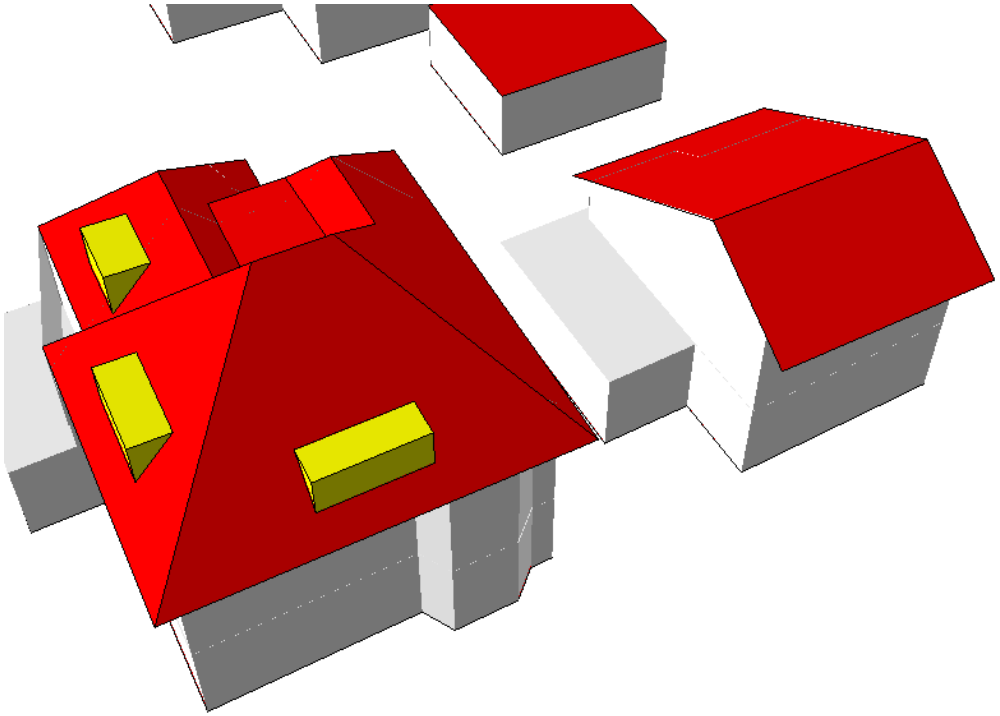


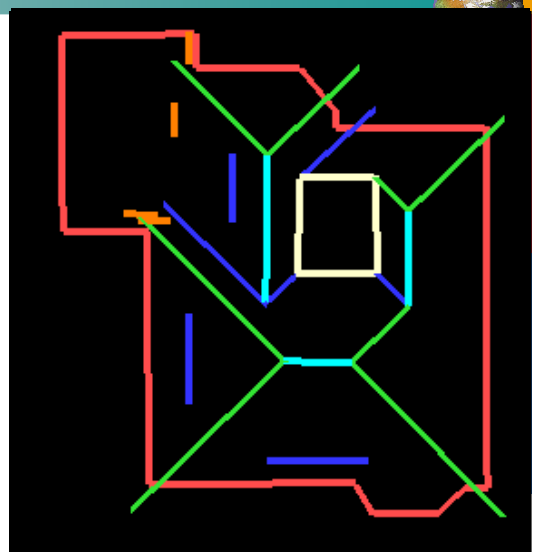
- Target graphs

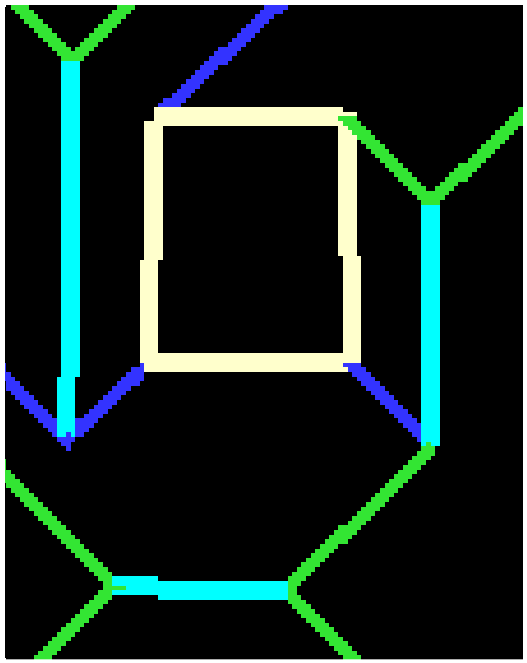


3D building modelling

- After matching
  - join intersection lines
  - determine outer bounds of roof faces
  - extend intersection lines

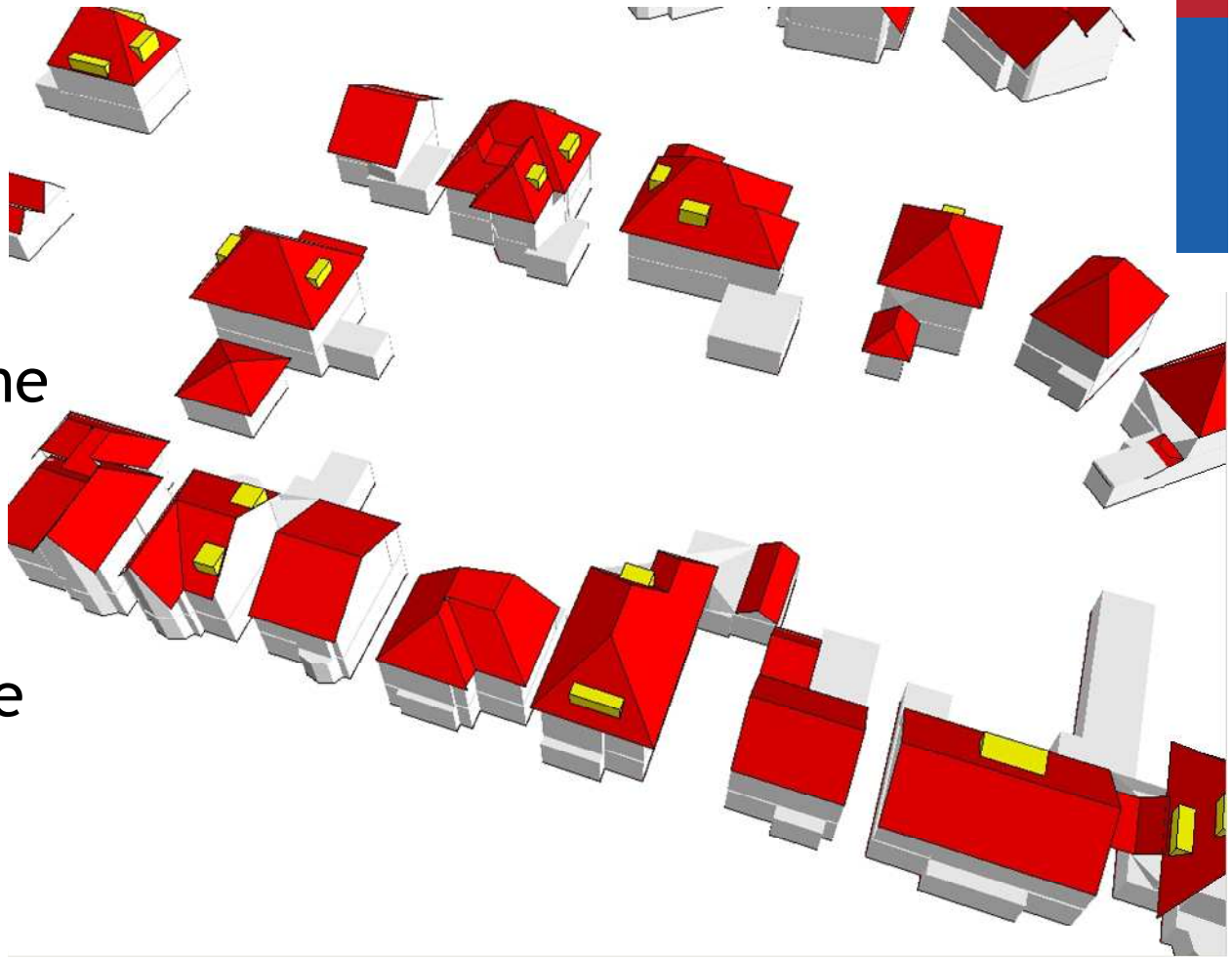






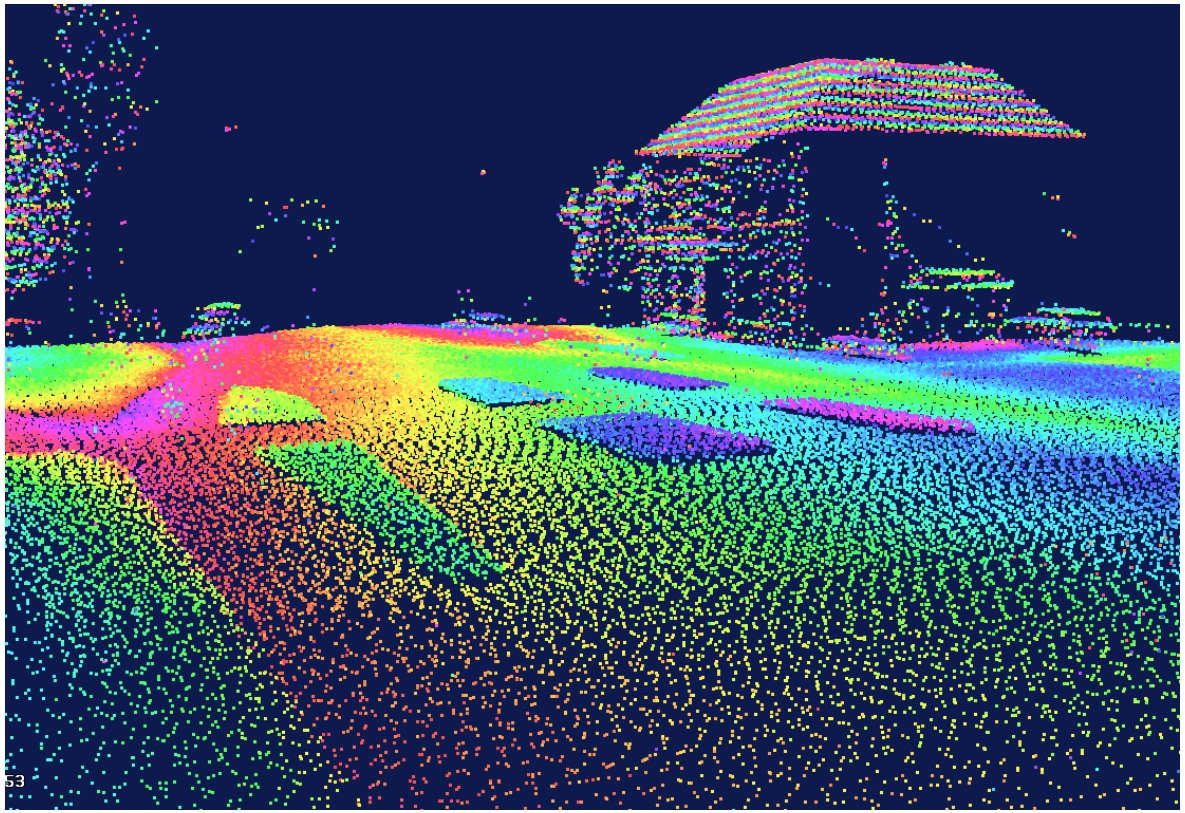
3D building modelling

- Results for suburban areas with 729 buildings
- 81% correct
- Problems
  - Segment not detected (7%)
  - Intersection line not detected (4%)
  - Target shape not in database (2%)



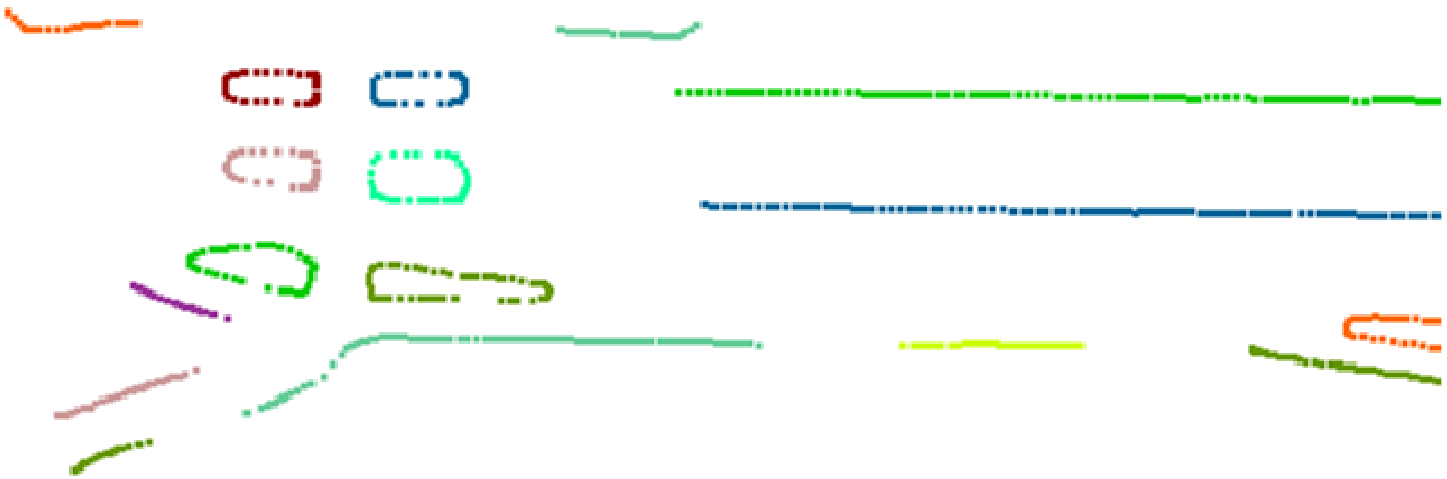
Mapping curbstones

- Height differences of just a few cm are visible



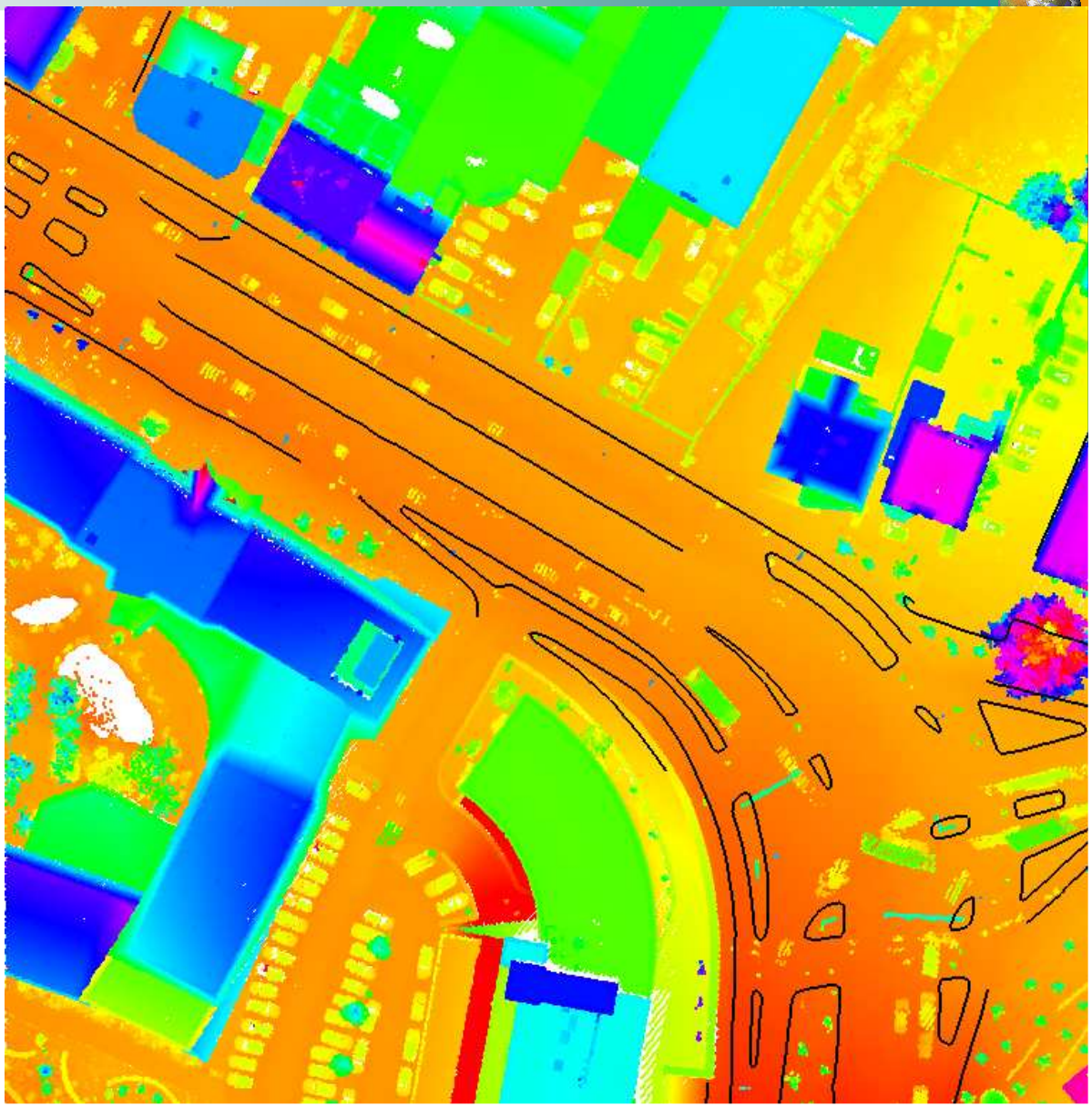
Mapping curbstones

- Extraction of locations with small height differences
- Reconstruction of road side topology
- Closing gaps and smoothing road side polygons



Mapping curbstones

- 20 points/m^2
- Completeness 86%
- Correctness 84%
- Accuracy 0.1-0.2 m
- Problems
  - Occlusions
  - Absent height jumps



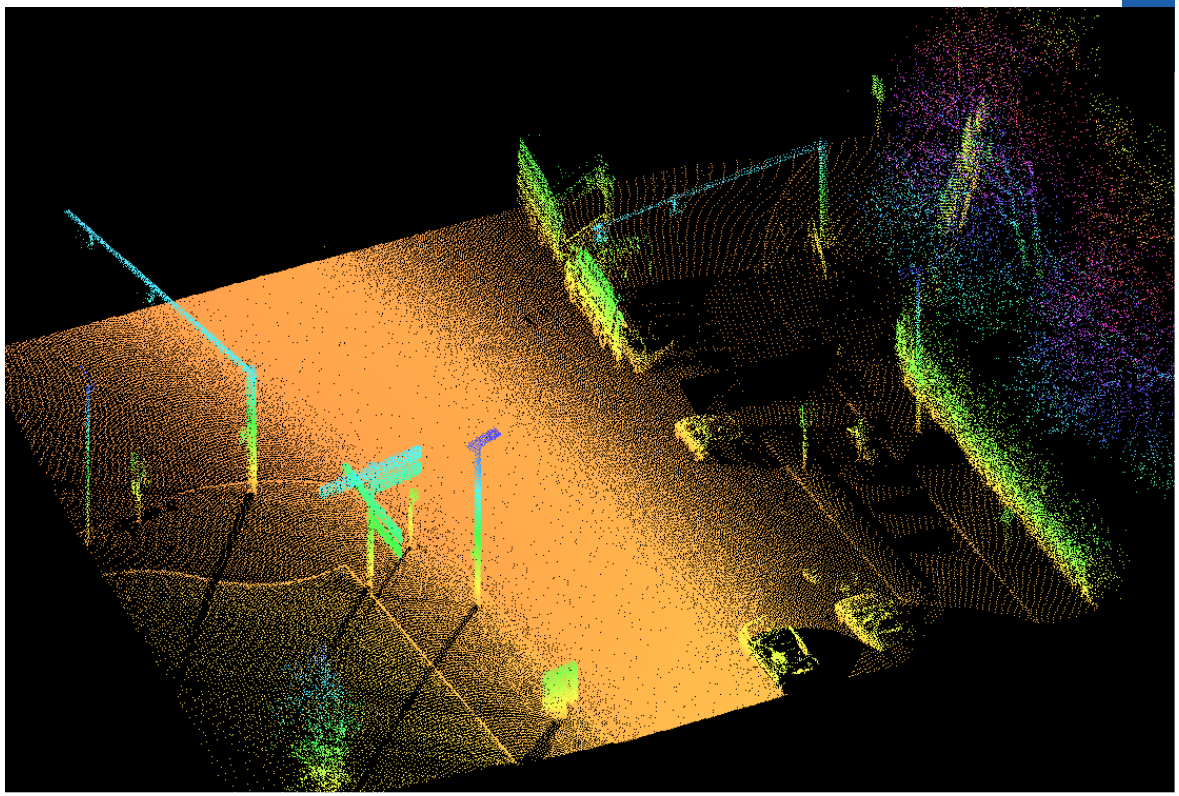
Mapping road inventory

Applications

- Road maintenance management
- Road safety analysis
- Car navigation

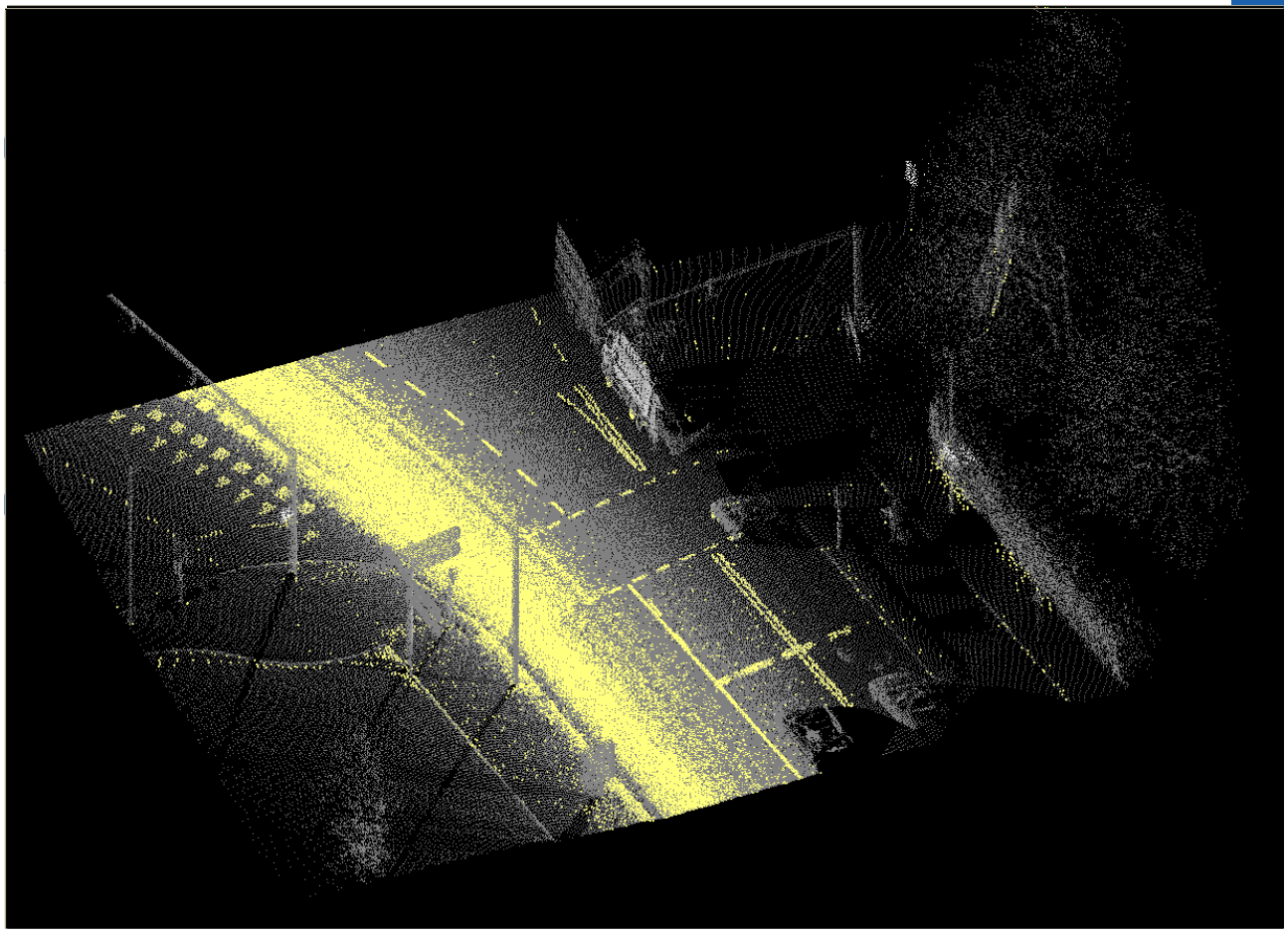
Examples

- Road markings
- Poles of traffic signs and lights



Extraction of road markings

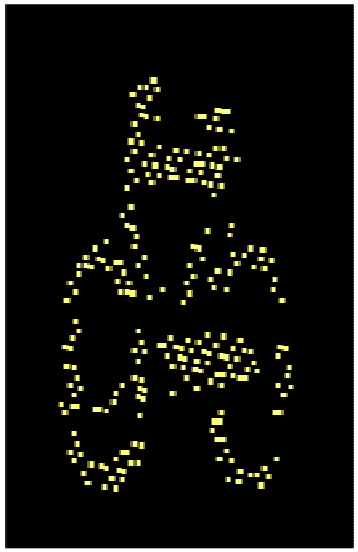
- Reflectance strength of returned signal depends on
  - Distance
  - Incidence angle
  - Material properties

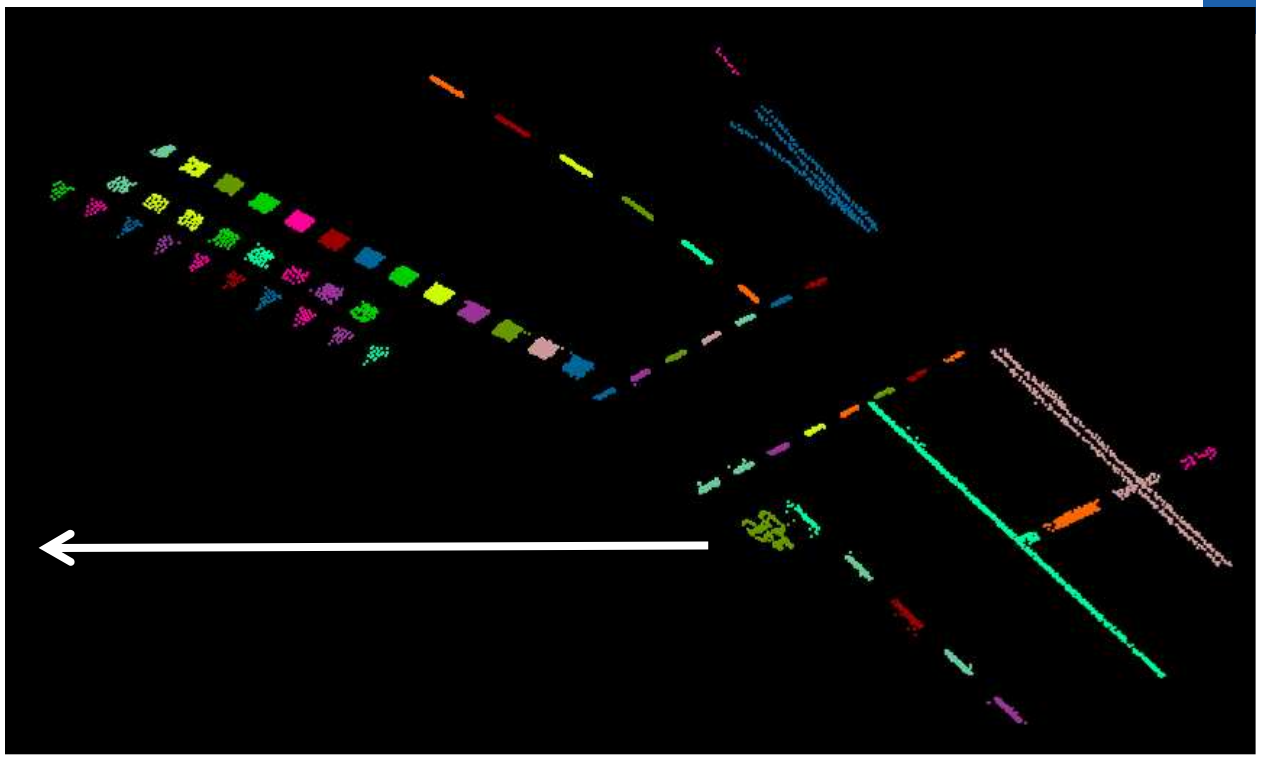


ITC

Extraction of road markings

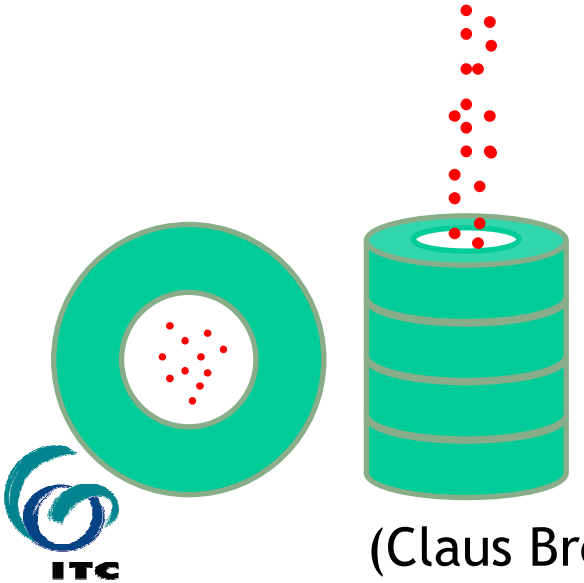
- Normalisation of reflectance strength
- Connected components in point cloud
- Pattern recognition and model fitting
- Combination with imagery

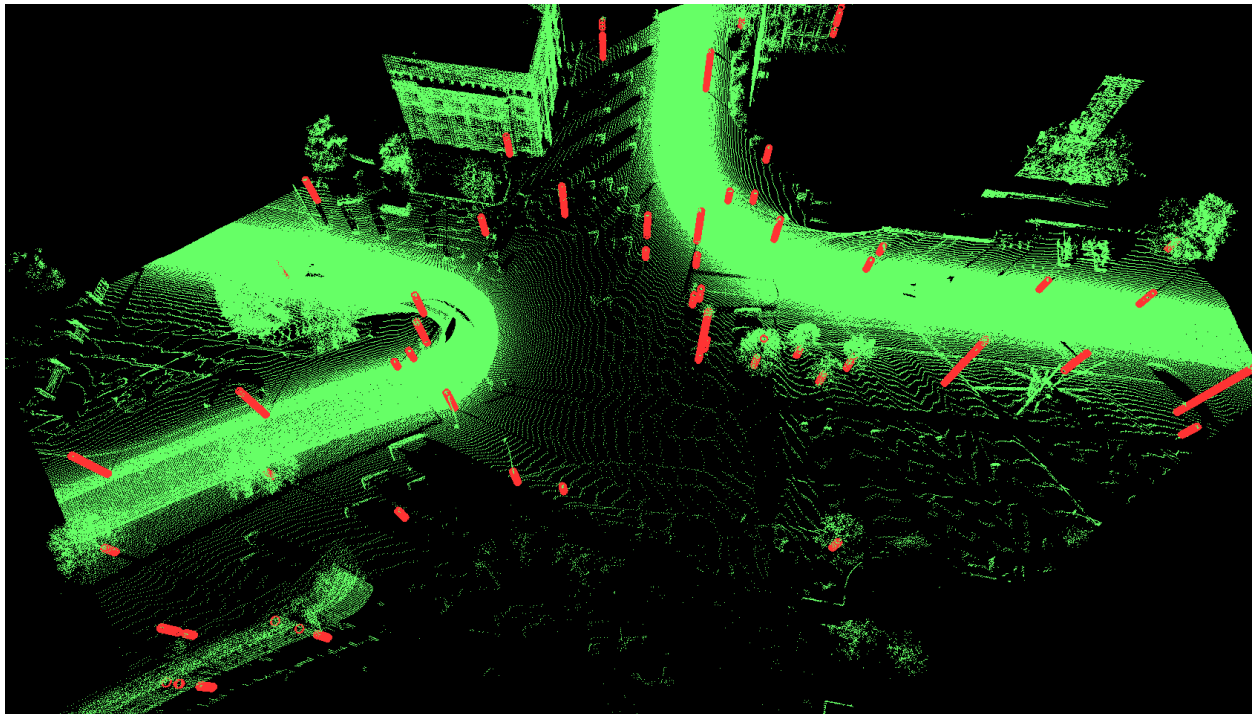




Extraction of poles

- Typical point distribution of poles
  - Dense along pole axis
  - No points around the pole

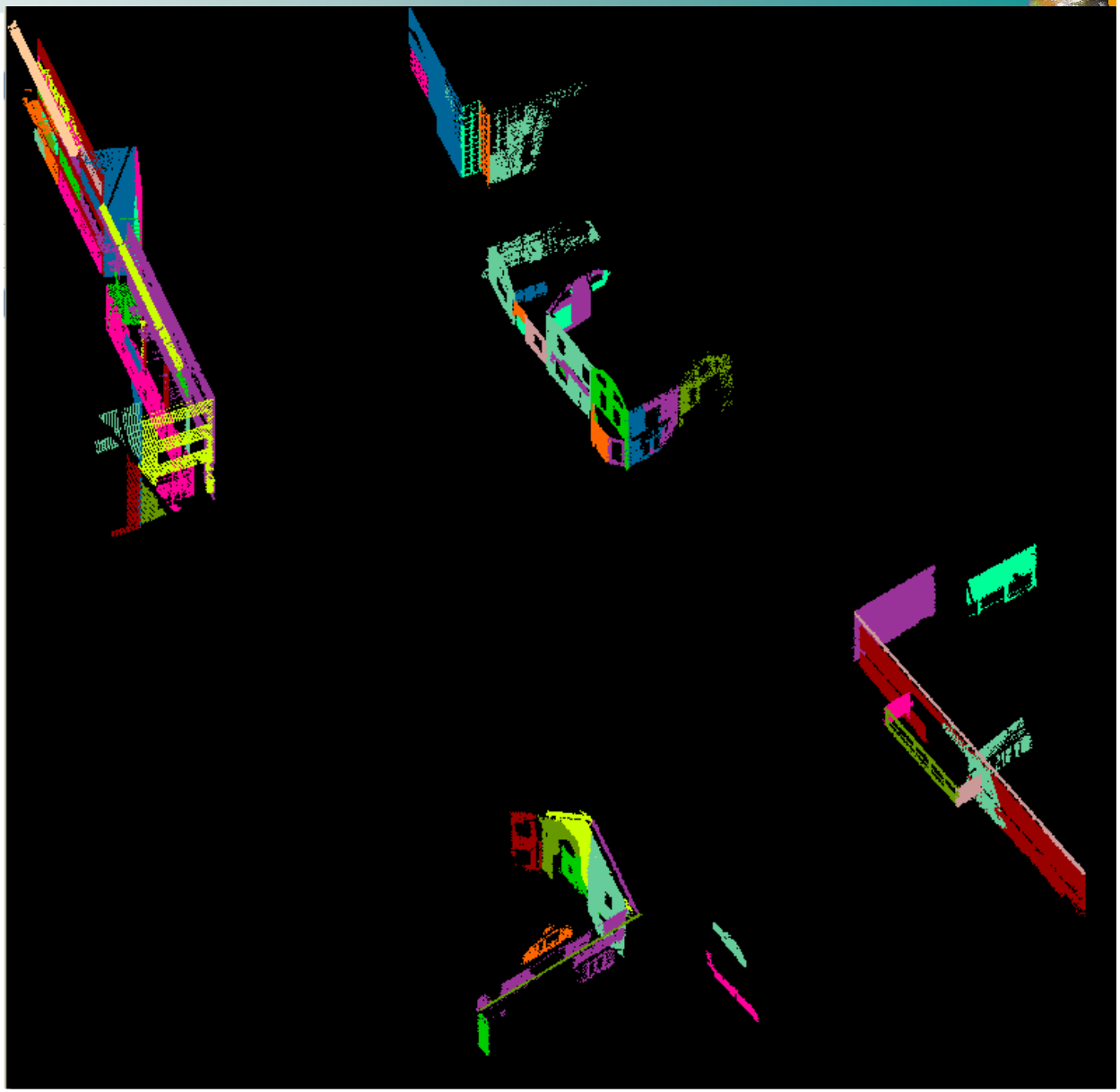




(Claus Brenner – Leibnitz Universität Hannover)

Extraction of building façades

- Segmentation into planes
- Selection based on
  - Size
  - Slope



ITC

Extraction of building façades

- Map
  - 45 buildings
  - 1240 m potentially visible walls

- Extracted
  - 840 m vertical segments
  - 470 m map walls
  - 370 m fences and garden walls

ITC

Modelling of building façades

- Segmentation into planes
- Modelling knowledge on building elements
  - Wall
  - Roof
  - Door
  - Protrusion
  - Ground
- Properties
  - Size
  - Spatial relationships
  - Slope

ITC

Modelling of building façades

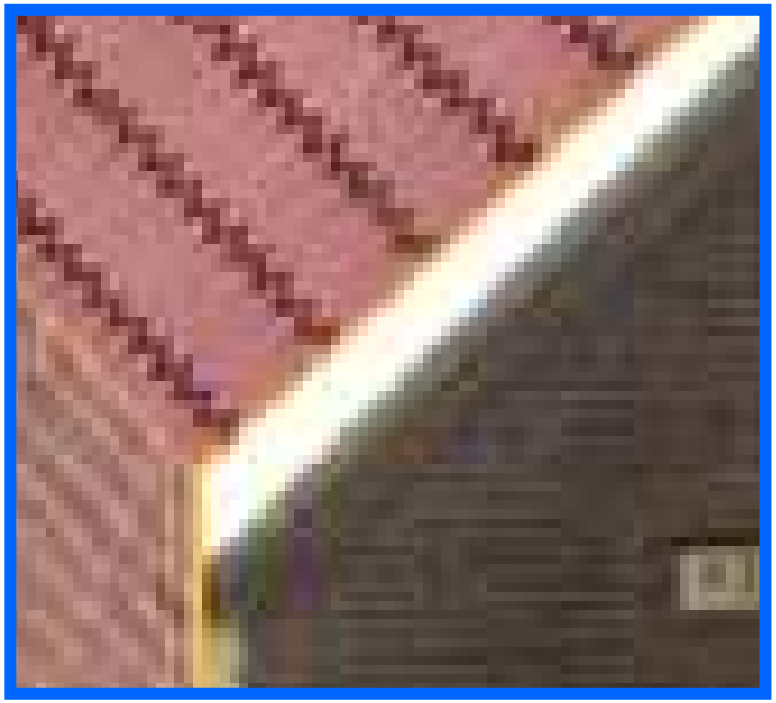
- Windows recognised as holes in wall
- Interactive handling of protrusions
  - Selection of segments
  - Improvement of generated outline
- Projection of side walls on main wall or roof surface

Texturing of building façades

- Texturing is time consuming
- Misfit between image and model due to
  - Incorrect orientation parameters
  - Model errors
  - Occluding objects (trees, cars)

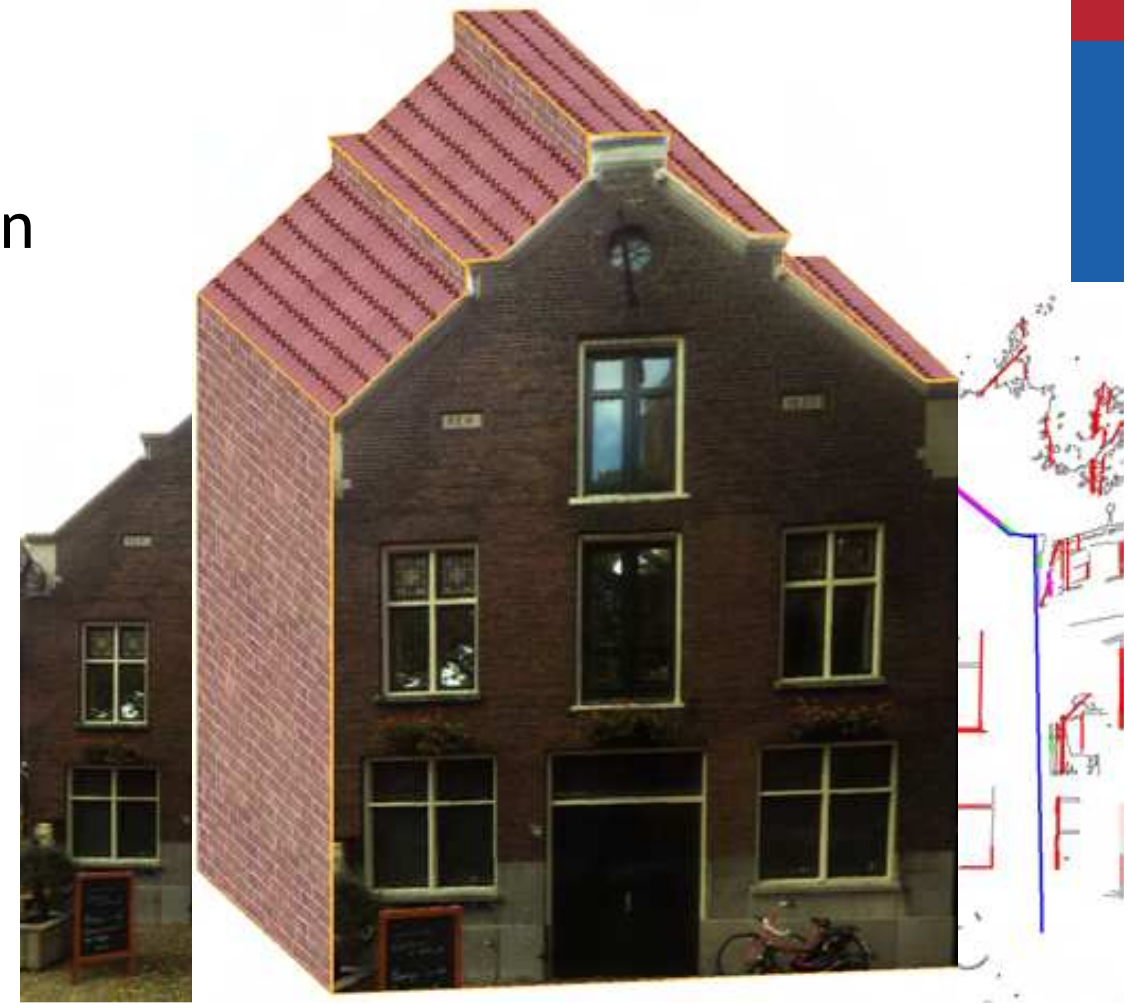
Texturing of building façades

- Incorrect texture projection



Texturing of building façades

- Matching straight image lines with model edges
- Result
  - Updated orientation parameters or
  - Modified building model



Conclusions

- Point clouds of today's scanners allow reliable extraction of object surfaces
- Like in image understanding, knowledge modelling is the key to information extraction
- Point clouds become a valuable data source for mapping projects
- Tools are to be developed further and integrated into photogrammetric workstations

ITC