

# Modelling roads and trees in urban areas

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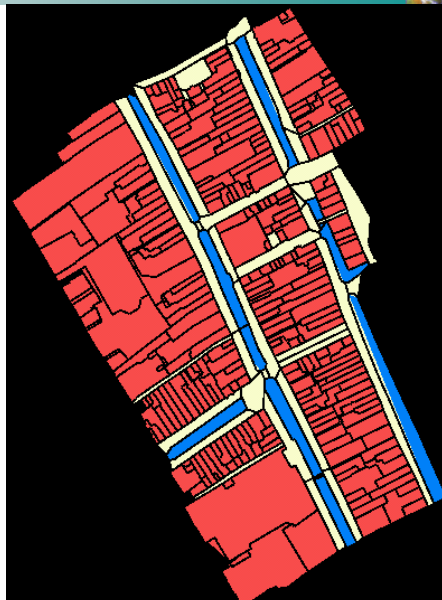


INTERNATIONAL INSTITUTE FOR GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

## Road reconstruction at 1:1000 scale

Cadastral map with

- Roads
- Buildings
- Canals

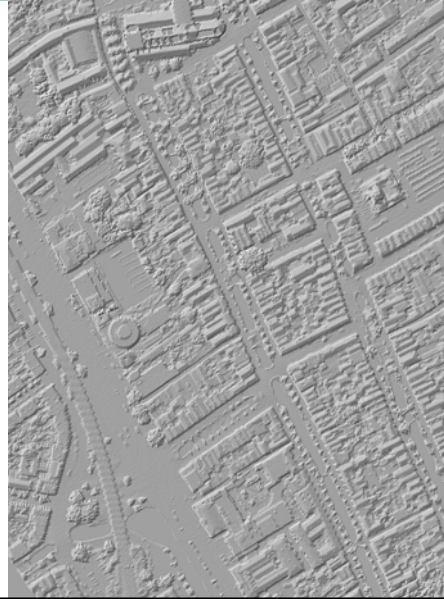


## Laser scanning data

### TopoSys data

#### Characteristics:

- Last pulse data
- 2 m point spacing in scan line
- 10 cm point spacing in flight direction

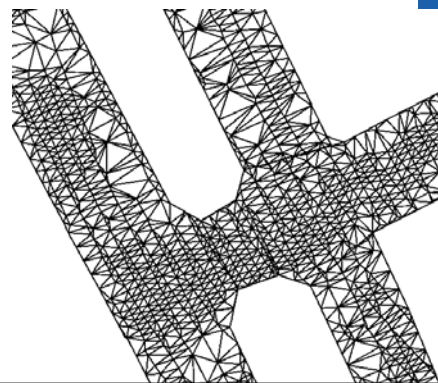


## Reconstruction of the road surface

### Points of the road surface

- Filtering of laser points
- Densification of map lines to one point every 2 m
- Constrained triangulation of map and laser points
- Variable point density

Assigning heights to road surface points



## Nearest neighbour

For laser points:

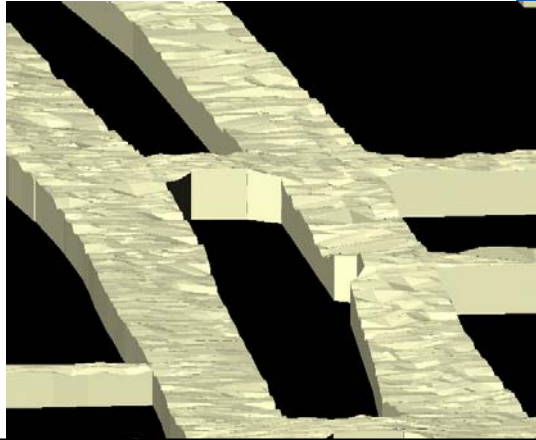
- Keep original height

For map points:

- Take height of nearest laser point

Result:

- Very noisy surface



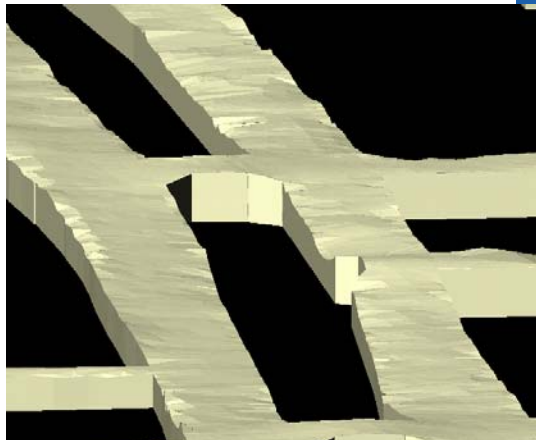
## Fitting 2<sup>nd</sup> order polynomials

For each point:

- Select all laser points within some radius
- Fit polynomial
- Assign height

Results:

- Smoother road centres
- Extrapolation errors at road sides



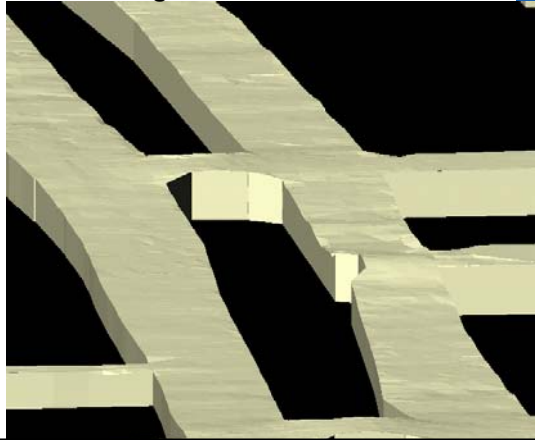
## Fitting constrained 2<sup>nd</sup> order polynomials

For each point:

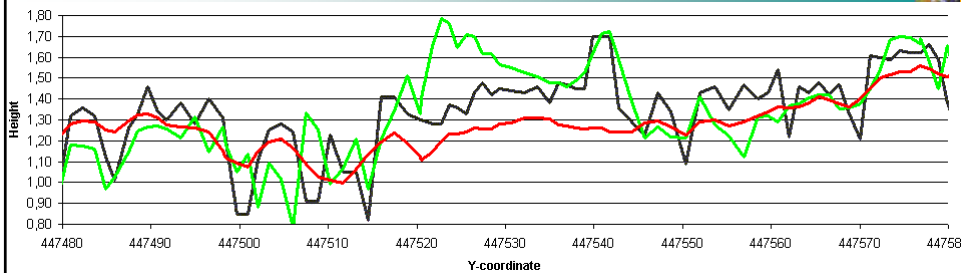
- Select all laser points within some radius
- Fit polynomial with low along road curvature
- Assign height

Results:

- Smoother road centres
- Extrapolation errors at road sides removed



## Comparison of road side profiles

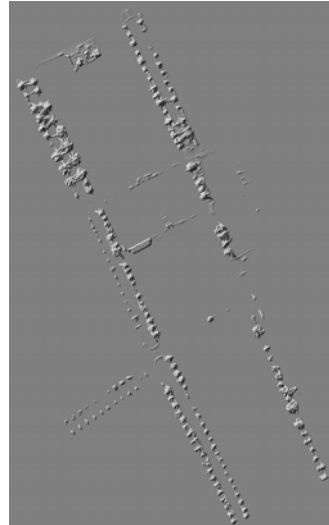
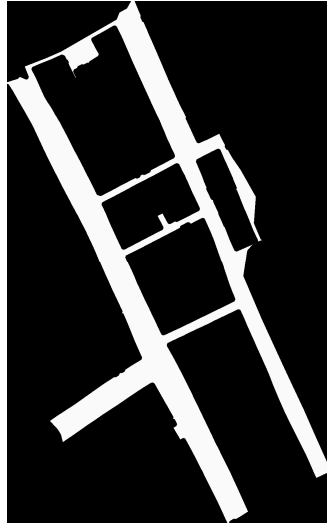


- Original points
- 2<sup>nd</sup> order polynomial fit
- Constrained 2<sup>nd</sup> order polynomial fit



## Detection of trees

Map based selection of points



## Detection of trees

Processing

- Minimum tree height
- Local maximum
- Grouping of points
- Estimation of tree location

Results

- 177 out of 182 detected
- 3 % omission error (5 trees)
- 5 % commission error (9 non-tree objects)



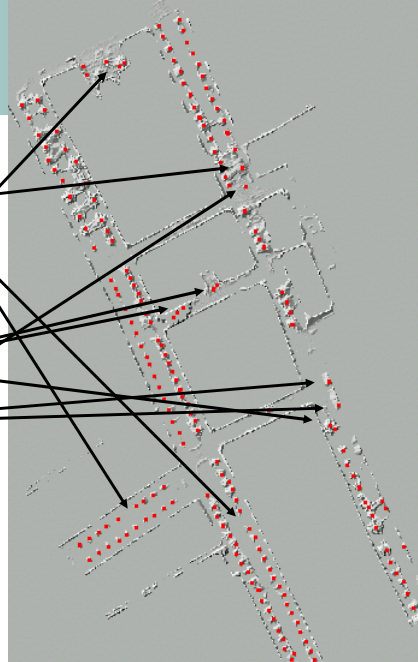
## Tree detection results

### Omission errors:

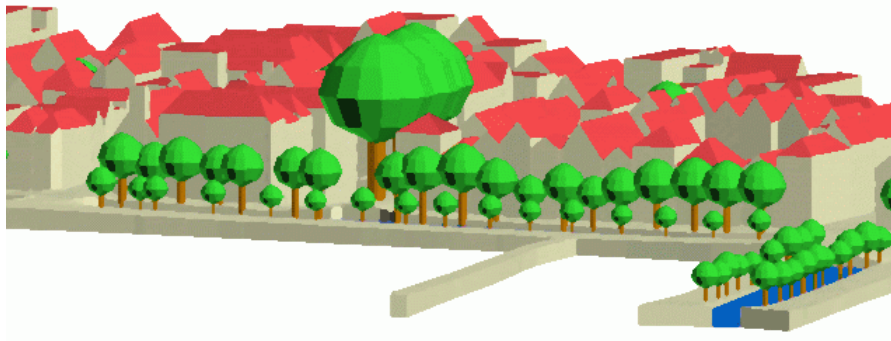
- Nearby trees seen as one tree
- No pulse reflection on tree

### Commission errors:

- Double counted trees
- Small buildings
- Sun-shades
- Street light



## Combining buildings, streets and trees



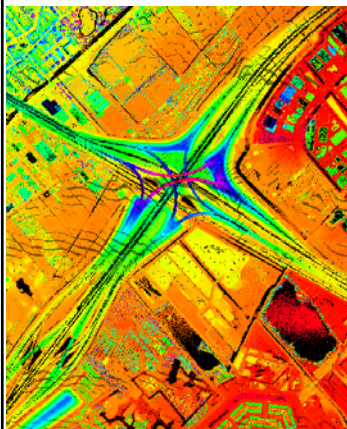
## Conclusions on large scale modelling

- Large amount of information contained in laser scanning data sets.
- Accurate classification (>95%) of terrain, buildings and vegetation if high point density (>1 pt/m<sup>2</sup>) is available.
- Extraction of 3D building models requires interactive methods.



## Road reconstruction at 1:10.000 scale

Laser scanner data



Point cloud  
1 point / 9 m<sup>2</sup>

Topographic database



Object based, 1:10.000

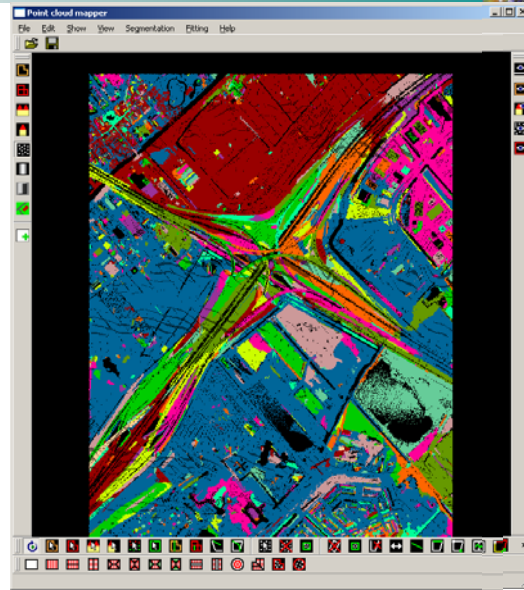
Outlines  
Classification  
2D Semantics

Height to  
objects

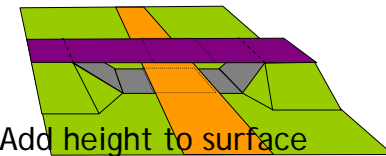
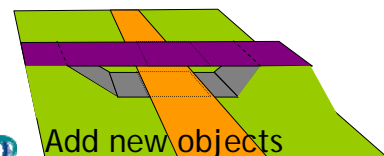
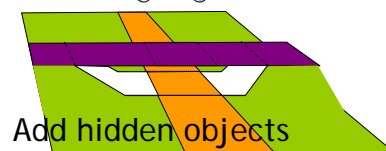
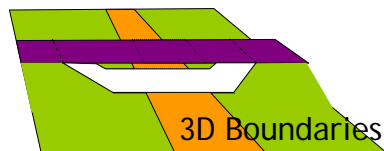
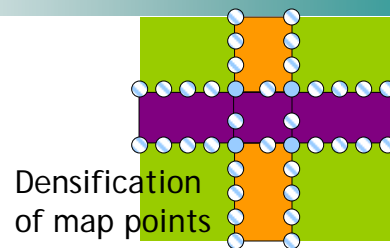
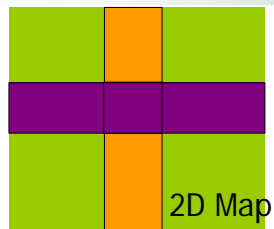
## Preprocessing laser data

Extract smooth surfaces

- Seed surface detection by fitting planes
- Growing smooth surfaces
- Remove small segments



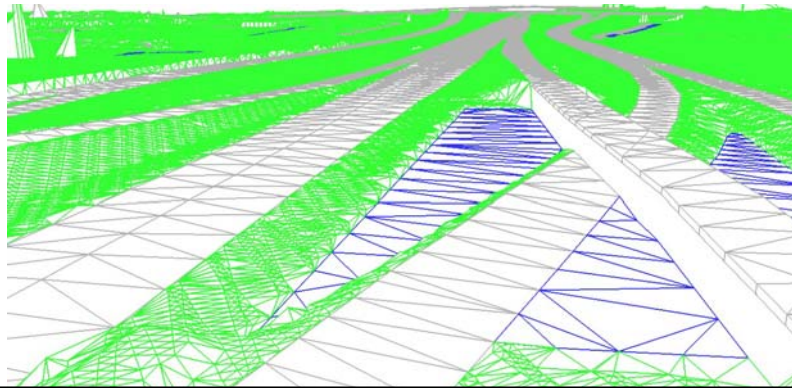
## 3D landscape reconstruction





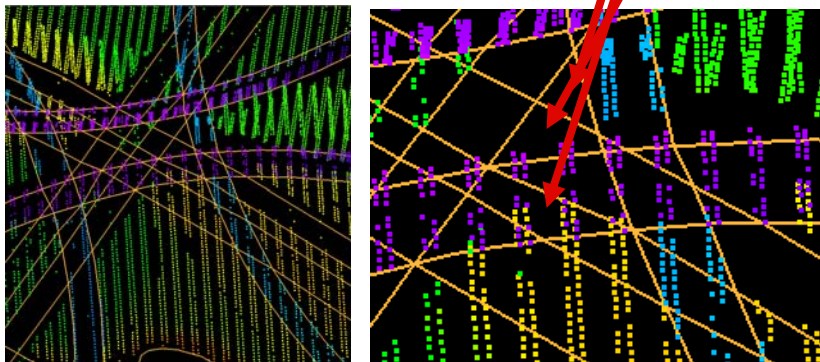
## Utilisation of knowledge

- Water surfaces are horizontal
- Road surfaces are smooth
- Road heights are more accurate than grassland heights



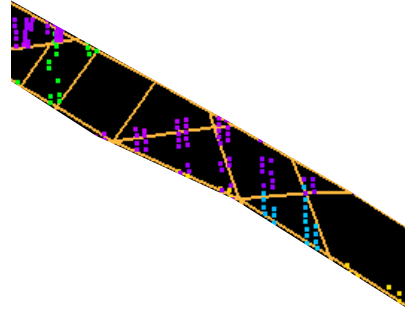
## Complex cases

- No laser data in map segment
- Incorrect heights in map segment
- Multiple heights in map segment

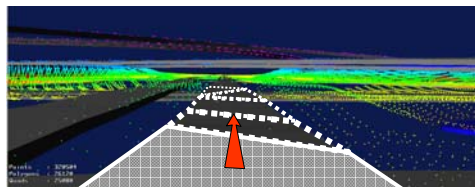
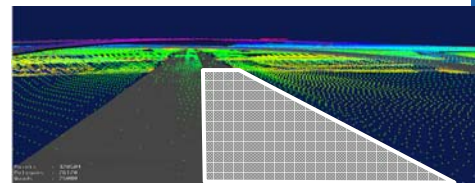
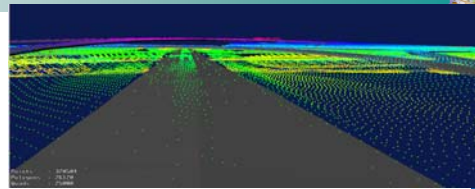
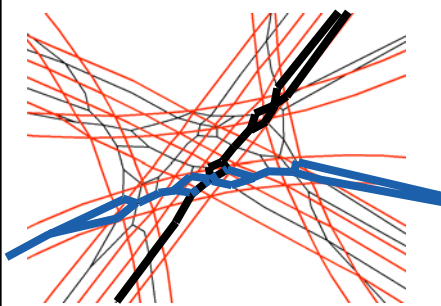


## Complex cases (II)

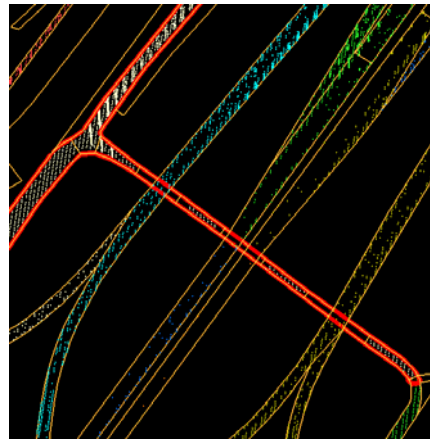
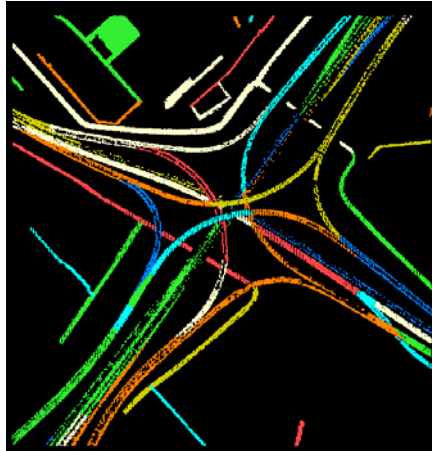
- 1 road
- 12 polygons
- 1000 m<sup>2</sup>
- 5 correct laser points
- >150 false laser points



## Combined map and laser growing

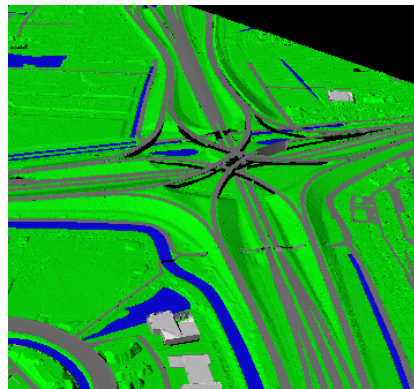


## Laser points coloured by grown polygon



## Results

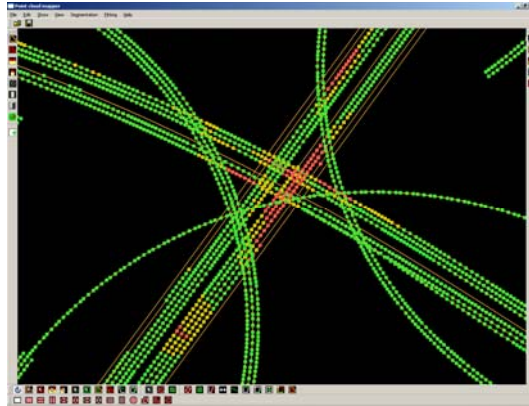
- Reconstructed road junction



## Quality check

Comparison to large scale 3D road database

- <0.2 m green
- 0.2 - 0.5 m yellow
- >0.5 m red



## Conclusions

- Airborne laser data contain large amount of information
- Extraction of surfaces is fairly reliable in case of high point densities
- Many features can be extracted (semi-) automatically
- Integrated processing of point clouds with imagery to be developed further

