Vehicle detection in aerial LiDAR point clouds

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Terra) Imaging

Structure

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- Results
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1. Introduction

- TerraImaging / now part of Aerodata Surveys
- Remote Sensing Company
- Berlin, Utrecht, Paris
- Focus on LiDAR:
  - Airborne Surveys
  - Calibration of flightlines
  - Classification of point clouds
  - Further use as DTM / DSM

1. Introduction

- Increasing point density:
  - Possible uses beyond DTM and DSM
- Research Question:
  - Automatic algorithm for detection of vehicles
- Why?
  - ➢Non-permanent objects
  - ➢Transportation and infrastructure surveys

2. Materials

- Materials:
  - LiDAR point cloud covering Rotterdam with 60pt/m², thinned (30pt/m² and 10pt/m²)
  - 250m x 250m
  - TerraSolid, ArcMap10, CloudCompare (OpenSource) and MatLab2010
  - Manual marked vehicles

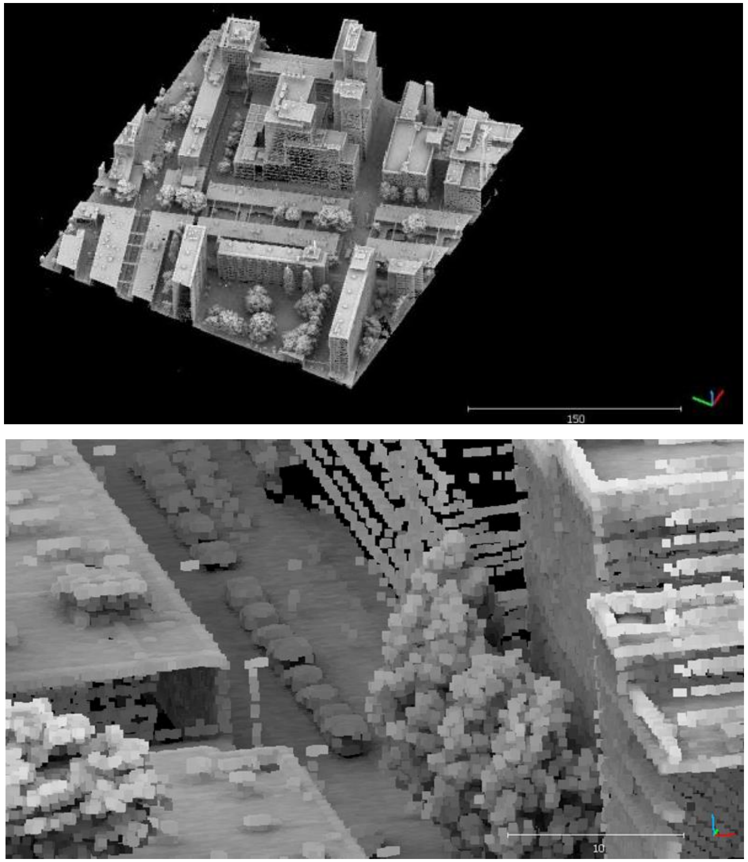

Figure 1 + 2: Visualization of point cloud covering investitgation area

2. Methology

- Reference approach
  - Developed by researchers from TerraImaging
- Research Approach
  - Development and implementation of a new algorithm for automatic vehicle detection using reference and literature
  - Tested on three different point cloud densities
  - Quality assessment (number and area)

2. Methology

- Global classification of point cloud:
  - Ground points
  - Building point
  - Interesting class for vehicles
  - Class of vegetation
- Triangulation and gridding of:
  - possible vehicle points

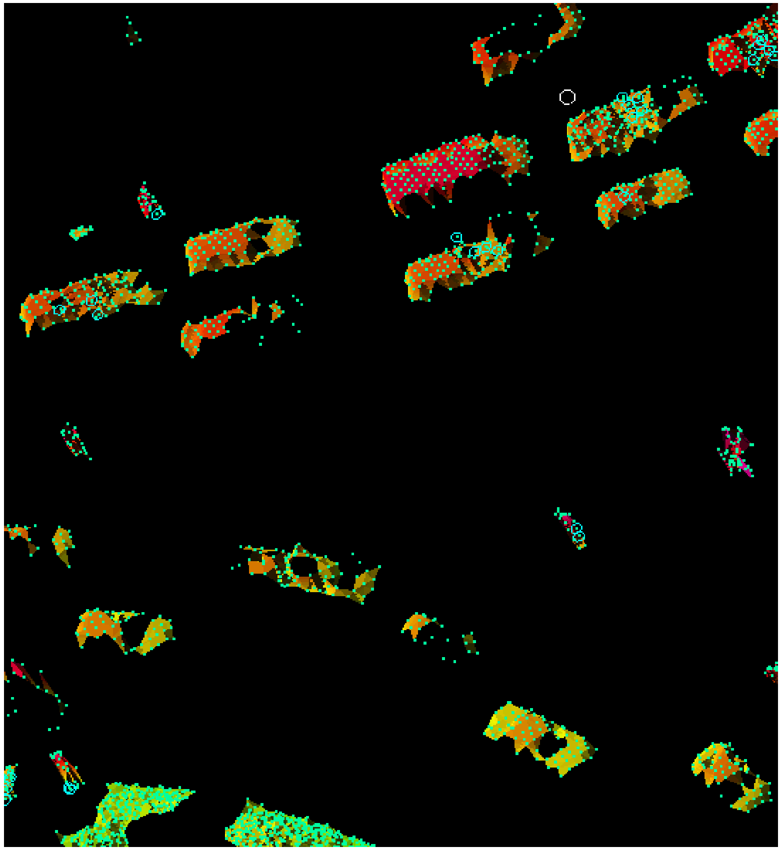

Figure 3: Triangulated vehicles in point cloud

2. Methology

- Image processing of connected components on binary image
  - Numeric Eccentricity
    - $e = \frac{\sqrt{(a^2 - b^2)}}{a}$ (ellipsoid)
  - Area (pixels)
  - Minor / major axis length -> vehicle extend
  - Substraction of areas with vegetation
  - Reconstruction of vehicle shape (convex hull)

3. Results

250m

Figure 4: Unclassified investigation area (250m*250m (60pt/m²)

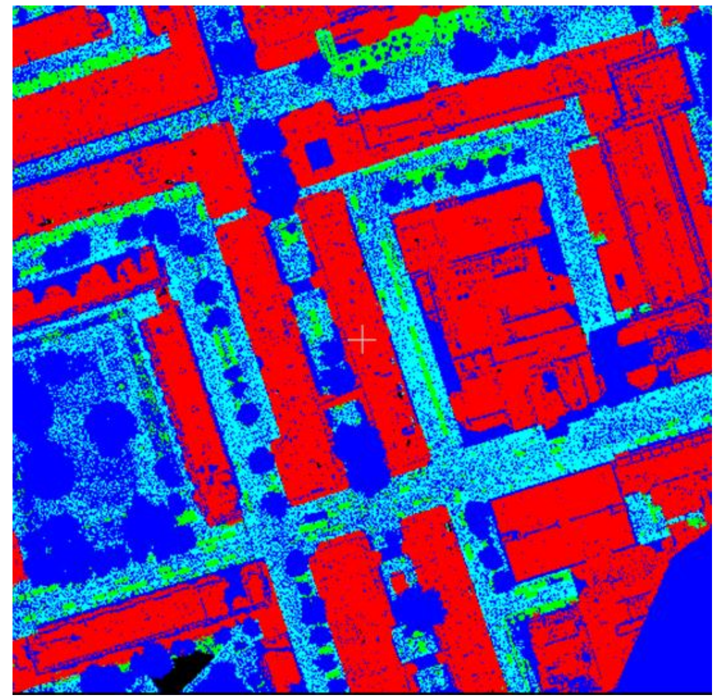

Figure 5: Classified point cloud (60pt/m²)
Red: building,
Green: low vegetation,
Blue: high vegetation + rest,
Turquoise: ground)

3. Results

250m

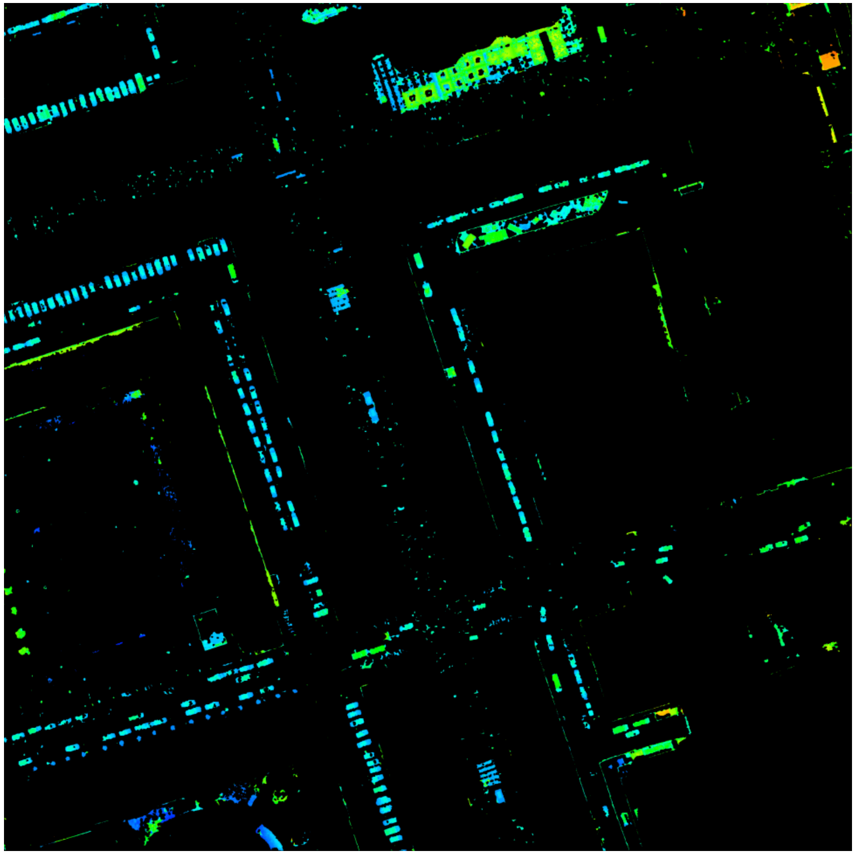

Figure 6: Gridded low vegegation class (60pt/m²)

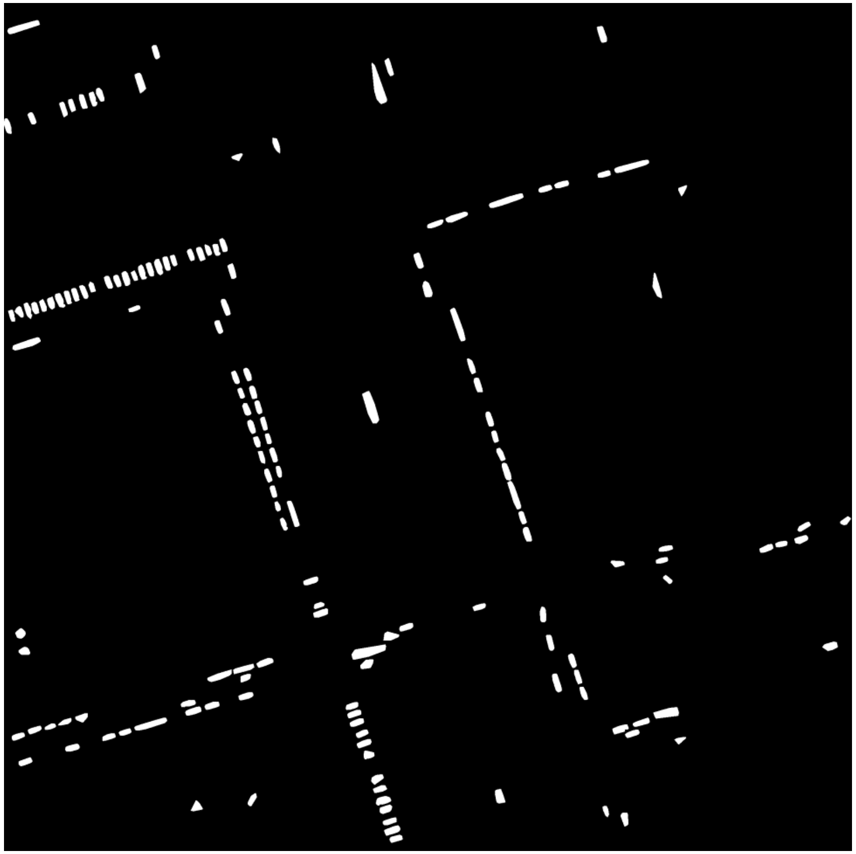

Figure 7: Result of vehicle detection

3. Results

250m

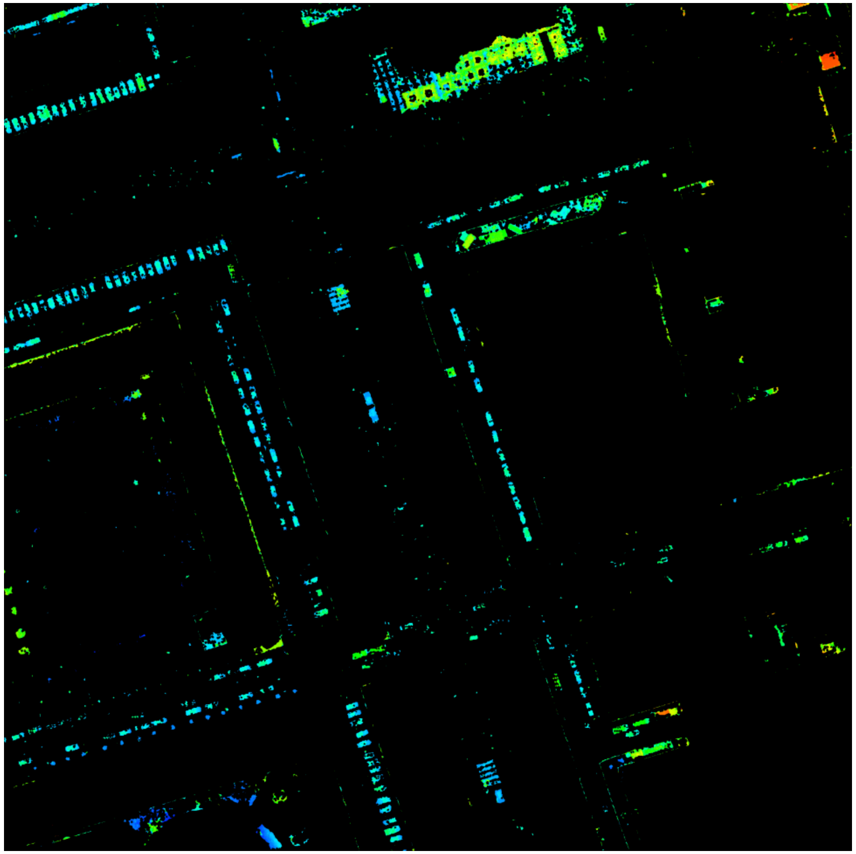

Figure 8: Gridded low vegegation class (30pt/m²)

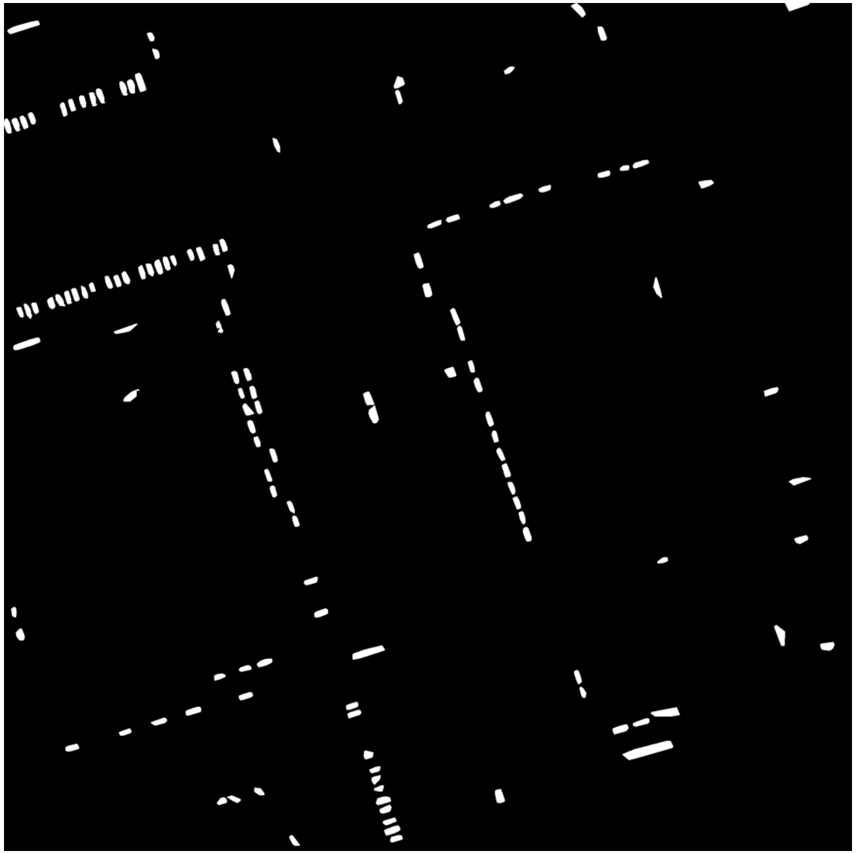

Figure 9: Result of vehicle detection

3. Results

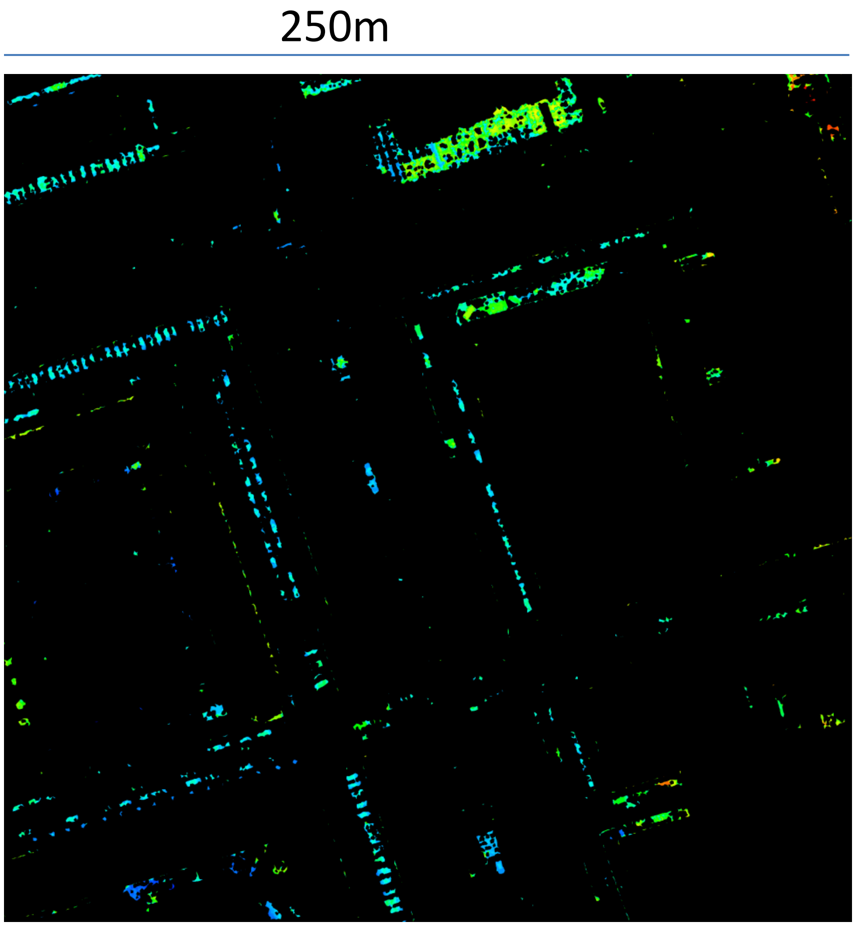

Figure 10: Gridded low vegegation class (10pt/m²)

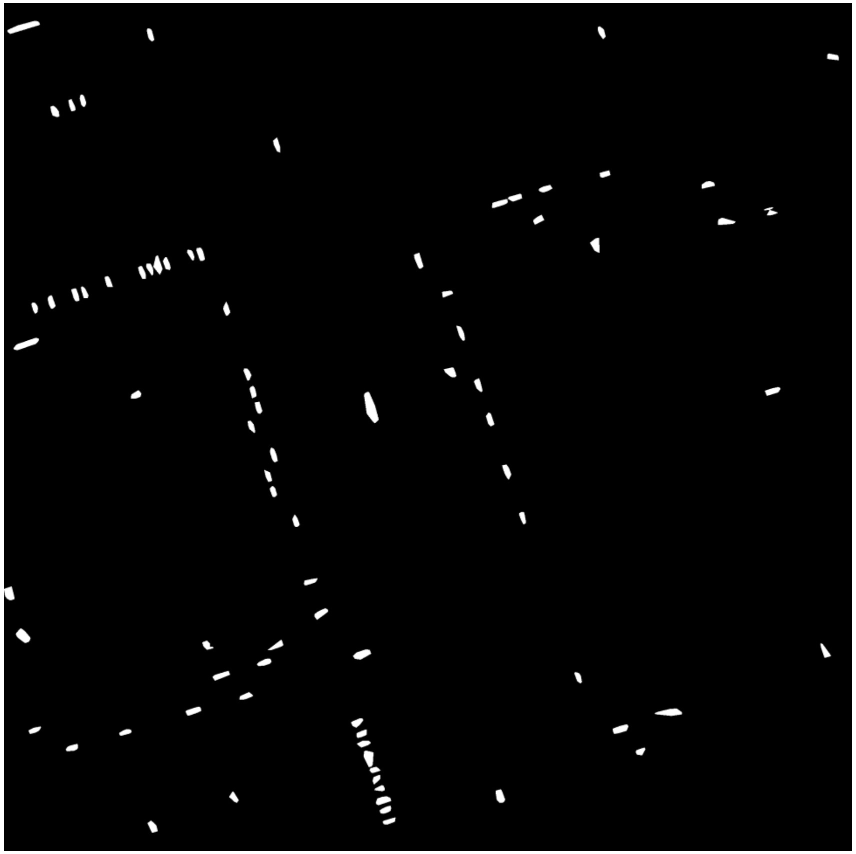

Figure 11: Result of vehicle detection

3. Results

- Quality assessment
  - Vehicle number
  - Covered vehicle area (%)
  - Share of marked area outside vehicle shapes (%)
- Four algorithms (with increasing complexity) + reference tested

3. Results

Point density	Covered vehicle shape area (research)	Covered vehicle shape area (reference)	Share of marked area outside vehicle shapes (research)	Share of marked area outside vehicle shapes (reference)	Vehicle detection (total: 167) (research)	Vehicle detection (total: 167) (reference)
60pt/m²	84% - 90%	66%	18% - 38%	26%	132 -158	132
30pt/m²	76% - 90%	64%	27% - 47%	33%	105 – 140	129
10pt/m²	58%- 72%	73%	26% - 44%	39%	63 – 123	120

Table 1: Summarized results of vehicle detection algorithms

4. Discussion

- Decreasing sucesss in vehicle detection (area / number) with decreasing point density
- Image processing complexity needed for higher point cloud density
- Strongly differing success within one point density depending on method

5. Conclusions

- Research methods are improvement
- Up to 90% of vehicle area detected
- Error rate between 18% and 27% (best of each)
- Improvements image processing:
  - Height / orientation of connected components
  - Reconstruction of vehicle shapes (orientation and axis lengths)
  - Combination with aerial imagery (Stereo Vision)

6. Literature

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Thank you for your attention!

Questions?