Powerline Mapping

International School on Lidar Technology

2008

IIT Kanpur, India

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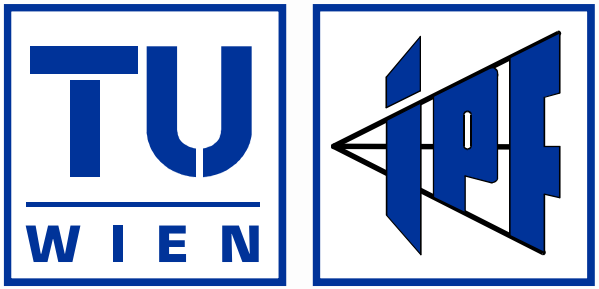
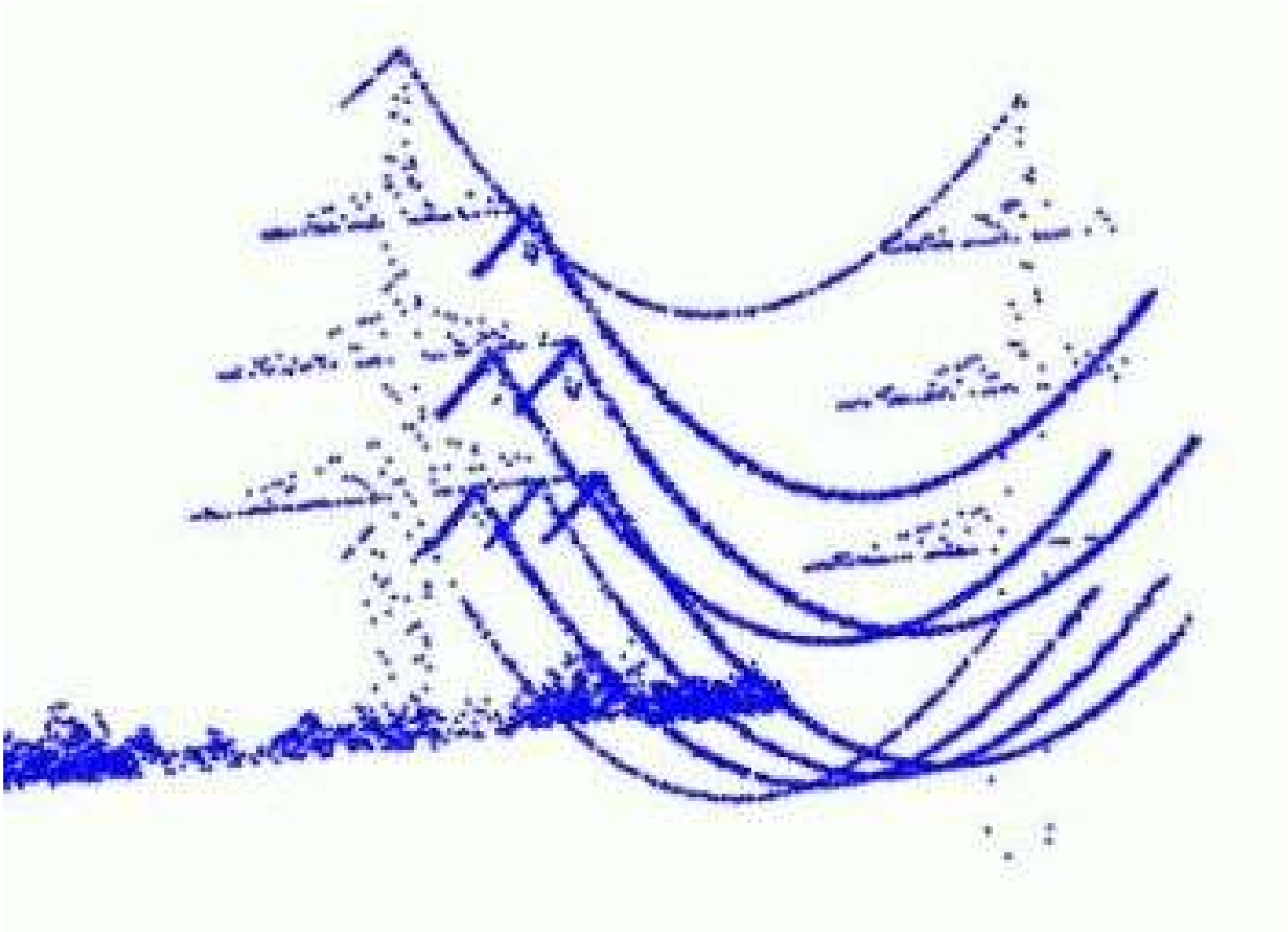


Presented material partly researched and implemented
at the Christian Doppler Laboratory, I.P.F. – TU Wien

Christian Doppler Laboratory
Spatial Data from Laser Scanning
and Remote Sensing

International School on
Lidar Technology 2008
IIT Kanpur, India

The Challenge



Overview

1. Flying + Manual approach + Result
2. Automation

Typical Platform: helicopter
… holds generally for corridor mapping

BEWAG

GEO service

Inertial navigation system (IMU)

On-board computer system

Data recorder

Digi camera

Laser scanner

Flying in action

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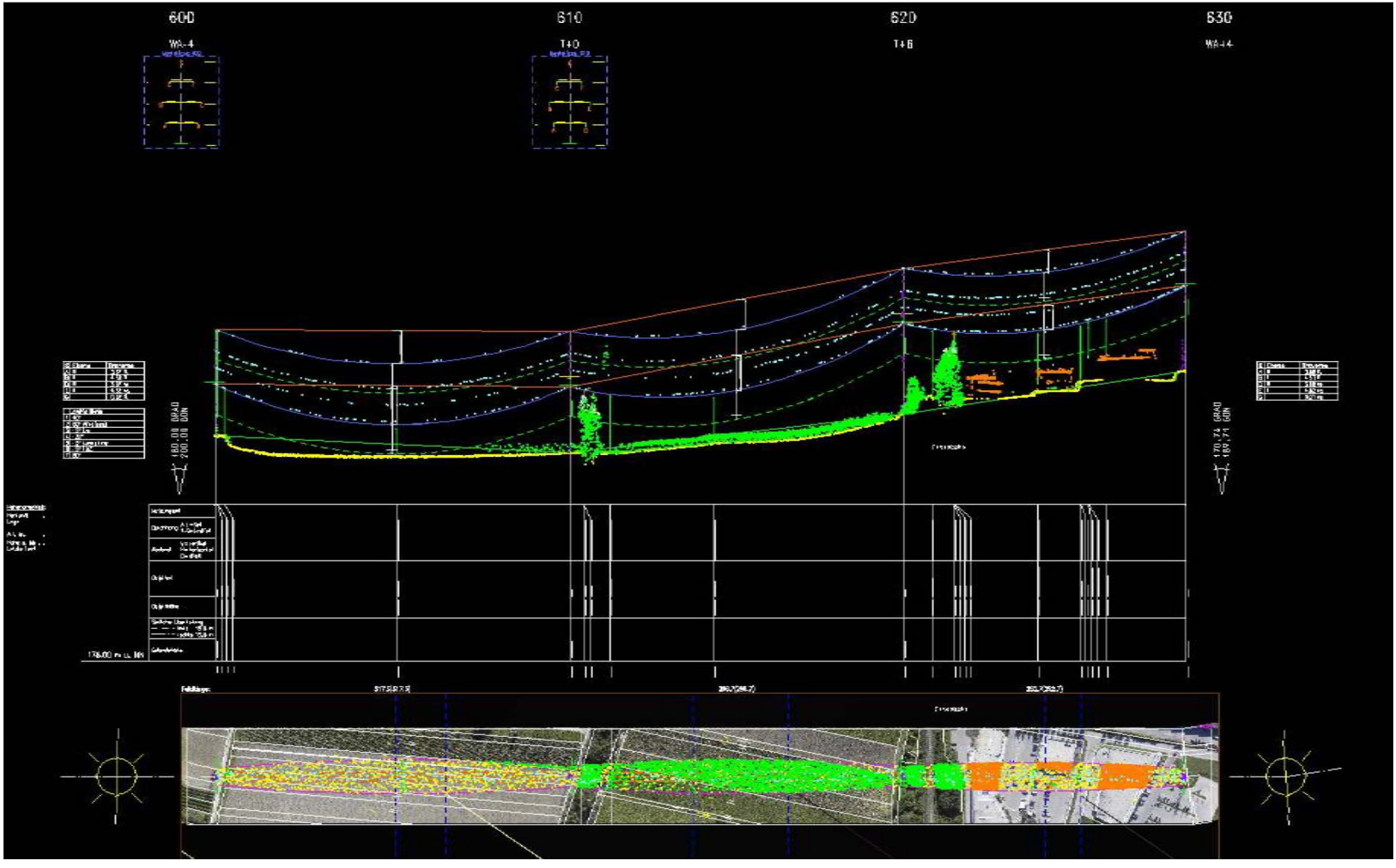
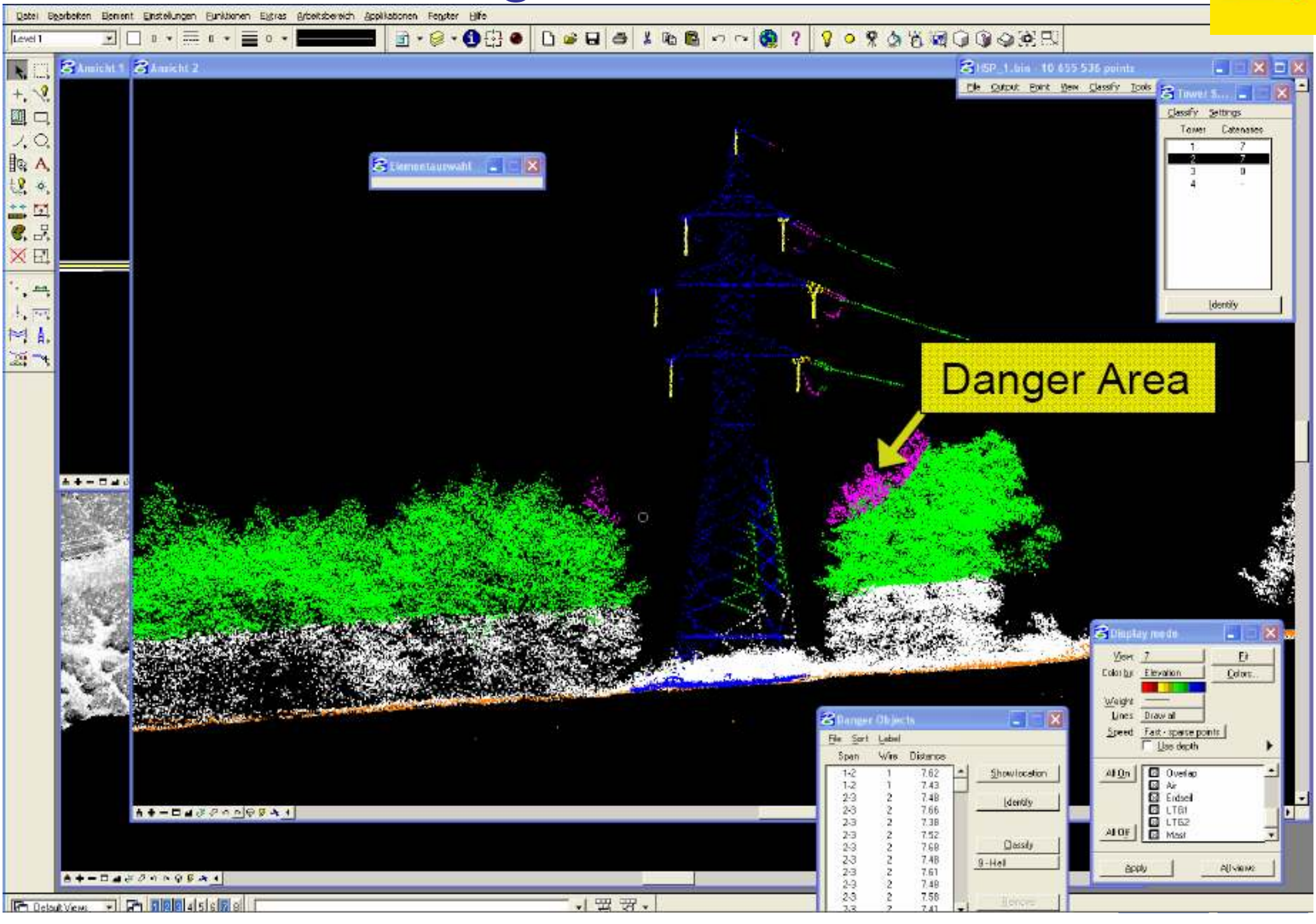
Lida
IIT

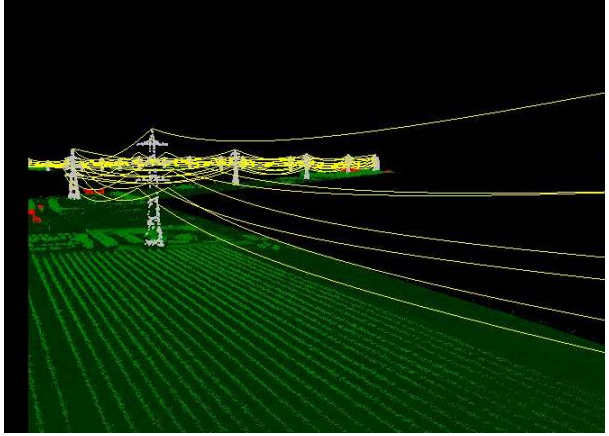
Example Evaluation of Laser Scanning Data

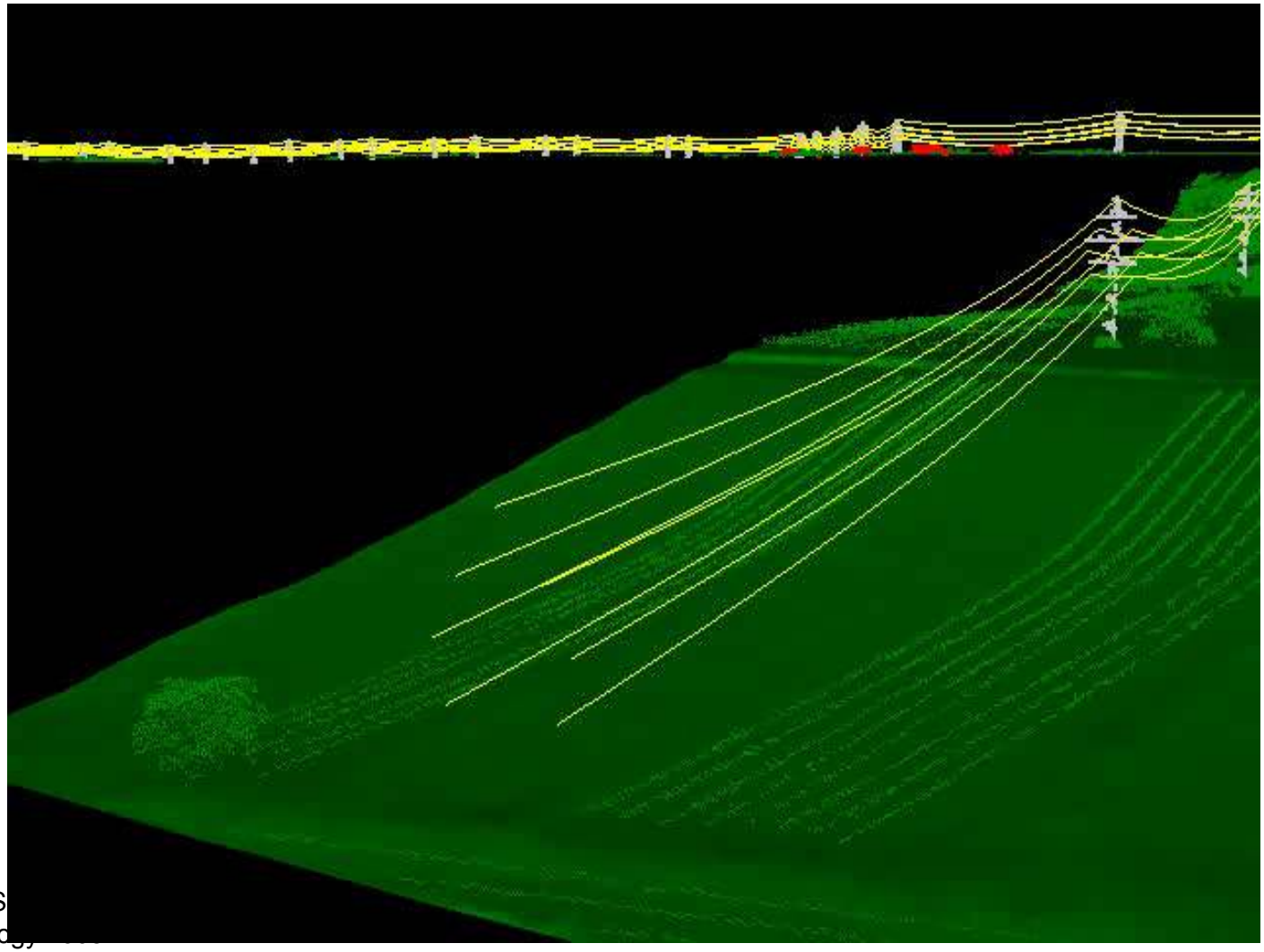


Cable Checking



Result





Automated
Derivation of Power Lines and Pylons

- Goals
  - Fully automated detection and reconstruction of power lines
  - Classification of pylons
  - Classification of nearby vegetation and buildings w.r.t. the risk they may pose to the power line infrastructure
  - **This research is performed on behalf and in in close cooperation with Pöyry!**

- Strategy
  - Global <-> Local Approach (Top Down <-> Bottom Up)
    - Fast and simple 2D-segmentation of power line corridors using image processing techniques
    - Estimation of span fields / pylon positions (span: area between two adjacent pylons)
    - 3D-segmentation of power lines within spans by means of robust model fitting (resampling)
    - Assembly of spans / estimation of missing power lines

- Vegetation segmentation/removal is a necessary prerequisite for
    - Corridor estimation
    - Power line (catenary) fitting
    - Filtering methods as presented are applied, best: segmentation based

Segmentation of Power Lines

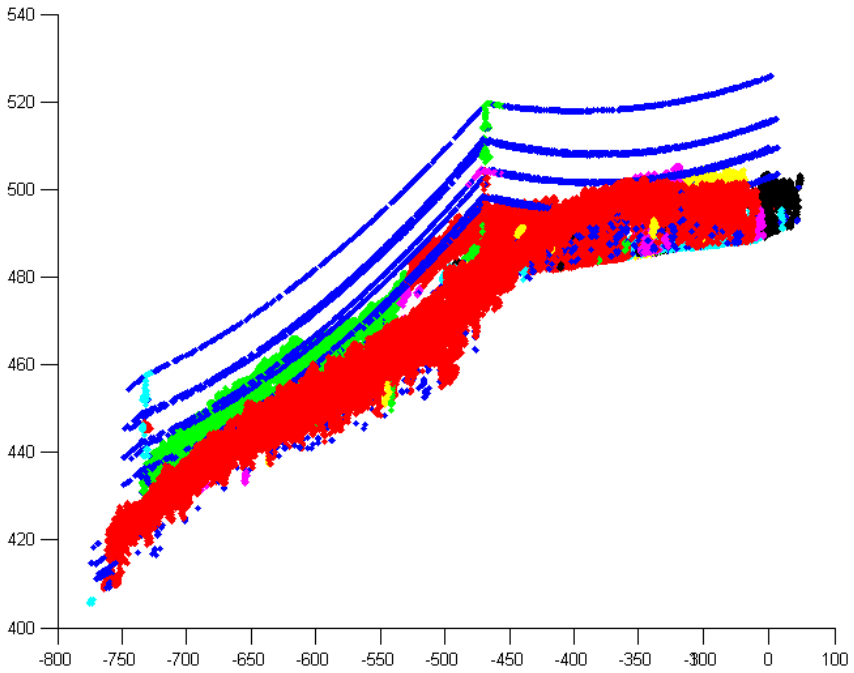
- Problems
  - No model for surrounding vegetation
  - Inherently 3-dimensional problem
  - No simple model for power lines -> non-linear optimization required for catenary fit and hypothesis evaluation

- Solution
  - Fast and simple 2D-segmentation of power line corridors using image processing techniques
  - Refined 3D-segmentation of power lines by means of robust model fitting (resampling)

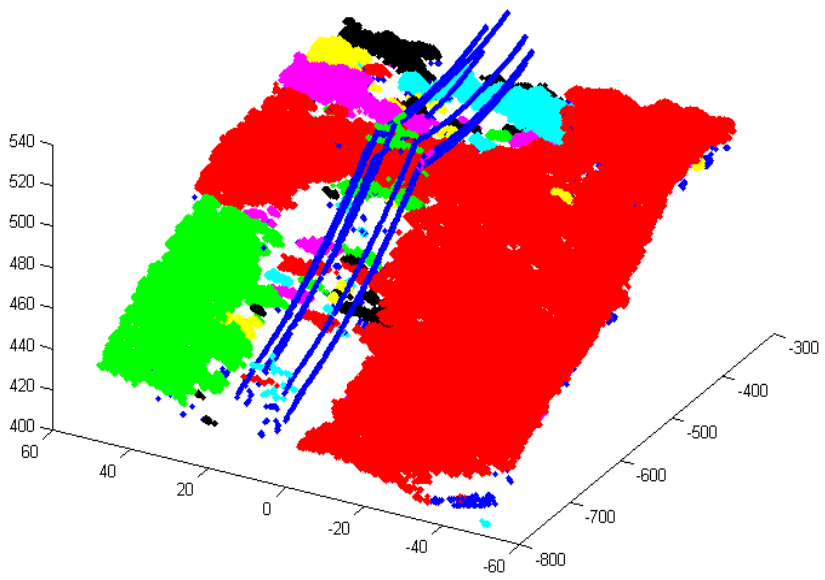
Data Set: Piestingtal Scan

- Challenges

  color coding reflects results of mean-shift segmentation
  (remember: filtering for ground detection by segmentation)



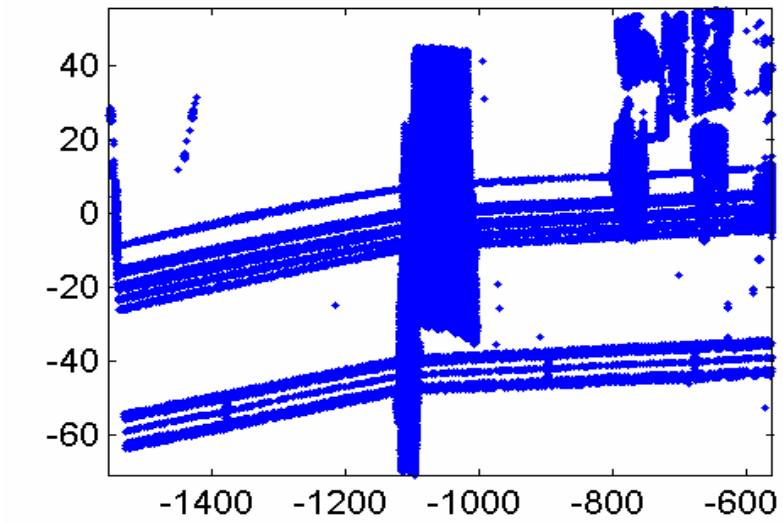
Difficult Topography



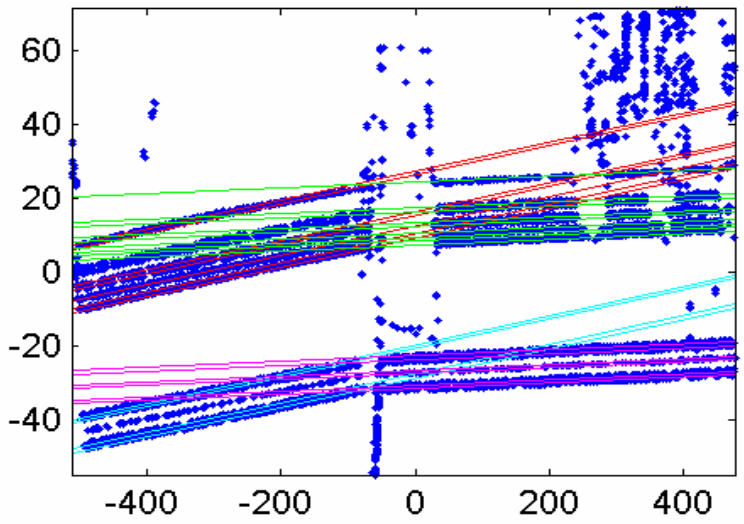
Dense Vegetation

From Points to Corridor Segments

- **Scan is subdiveded into segments of 500m length each**
- **Vegetation is removed using both mean-shift and a morphological filter**
- **Power line corridors are estimated using the Hough transform**

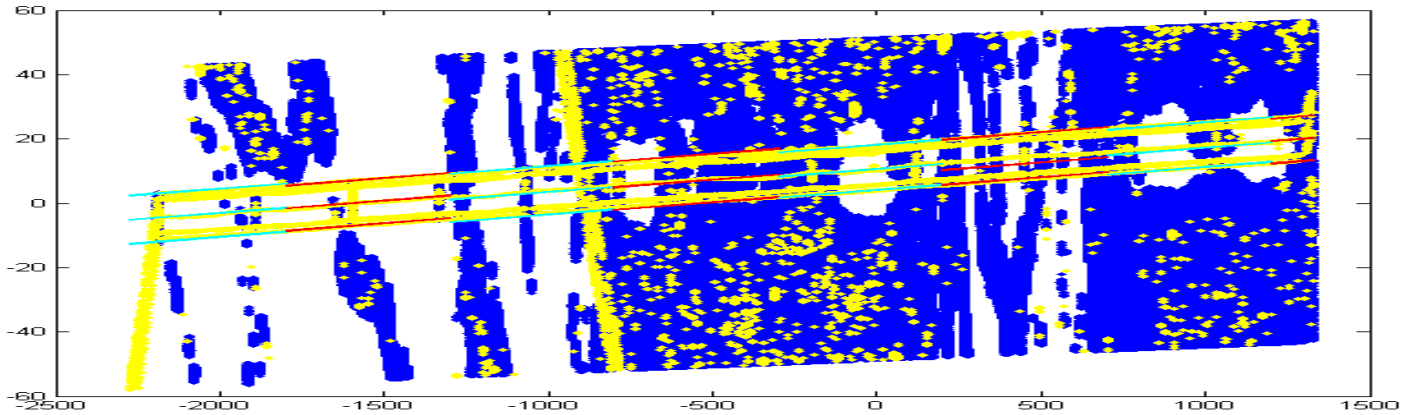


Planimetric view of aligned data.
Terrain points are already removed.

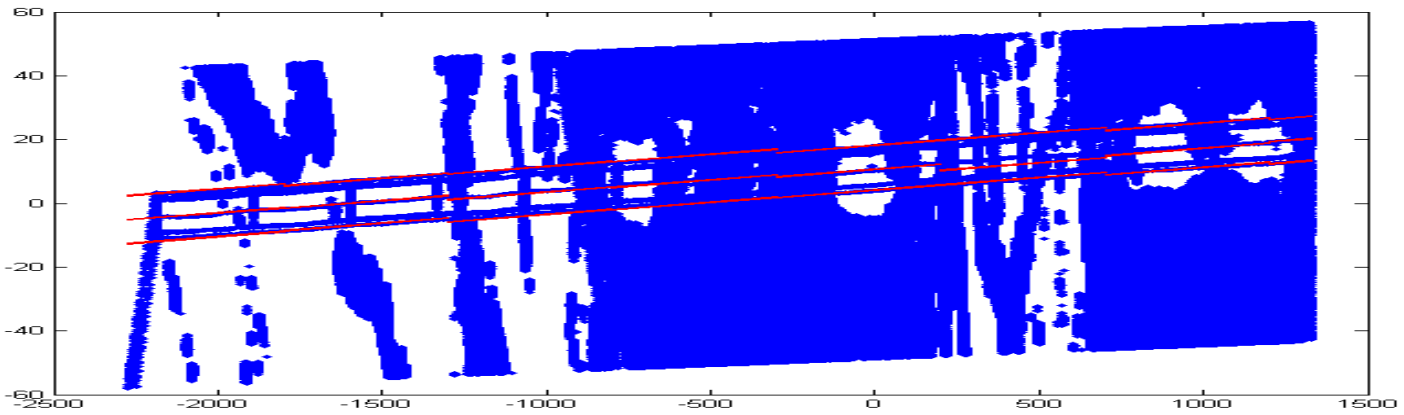


Data set after filtering +
lines found by Hough transform (HT)

Concatentation of Segments into Corridors

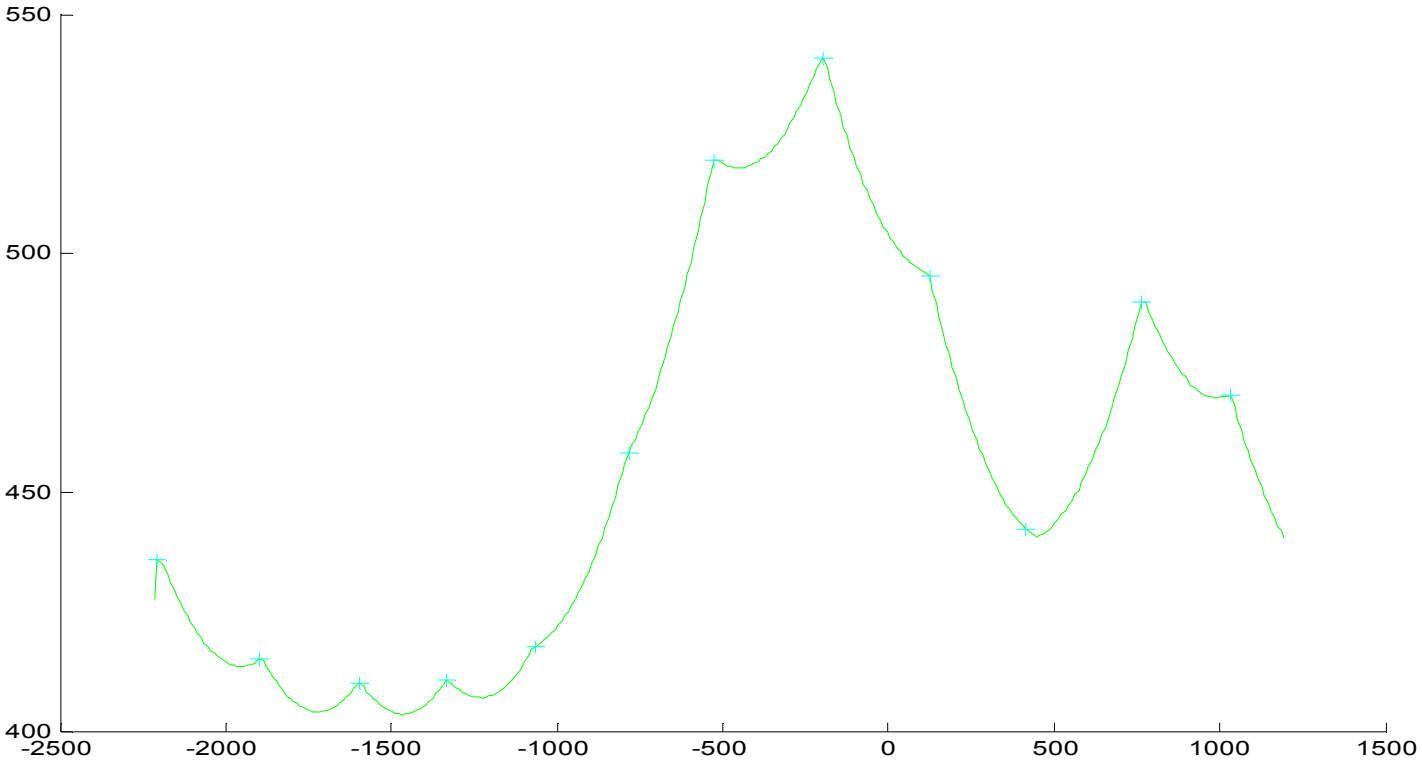


2D view: adjacent corridor segments; yellow points are input to the HT



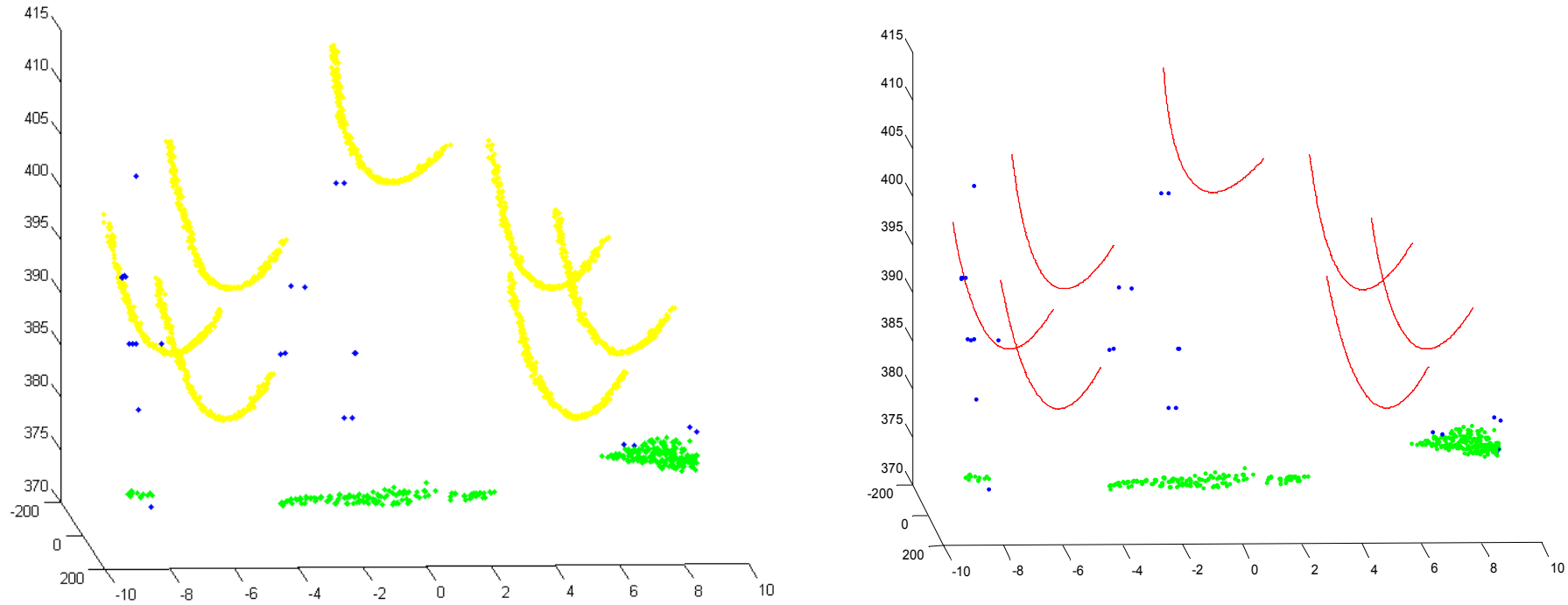
Concatenated segments

Top Down: Estimation of Pylon Positions and Spans



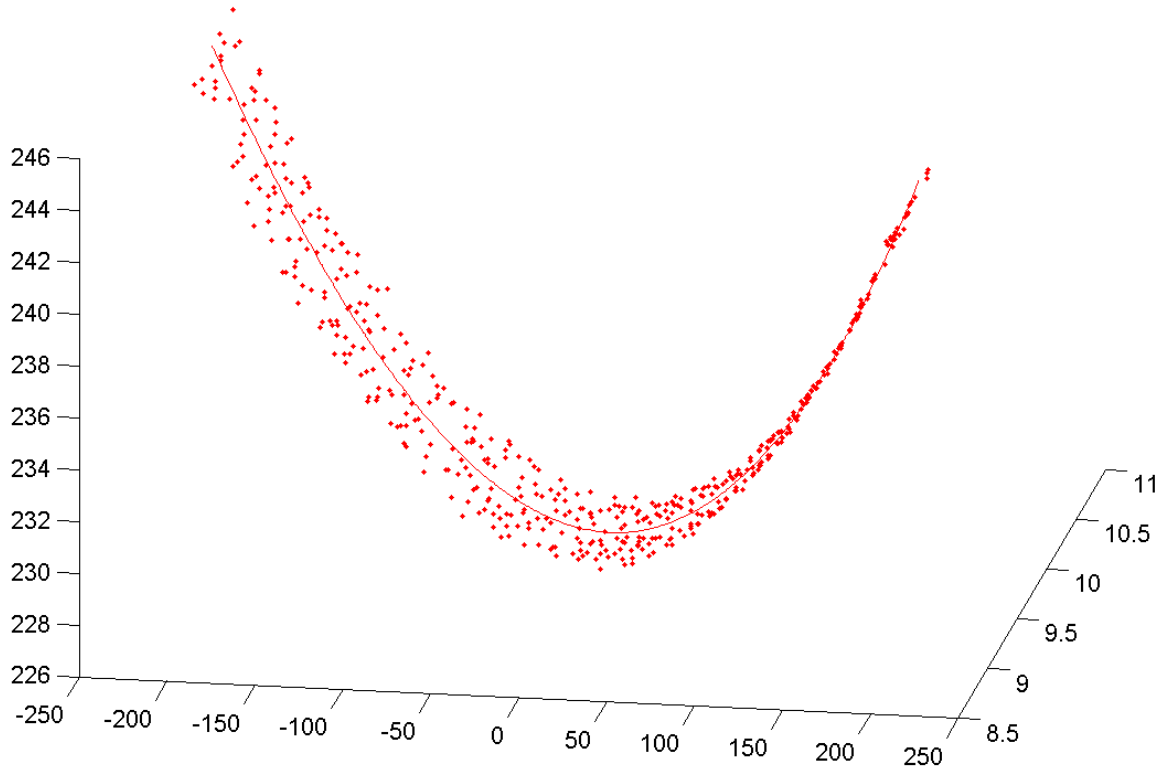
Empirical height profile of the corridor. Estimated pylon positions are denoted by +. The area between two pylons is referred to as span (span field).

Segmented Span



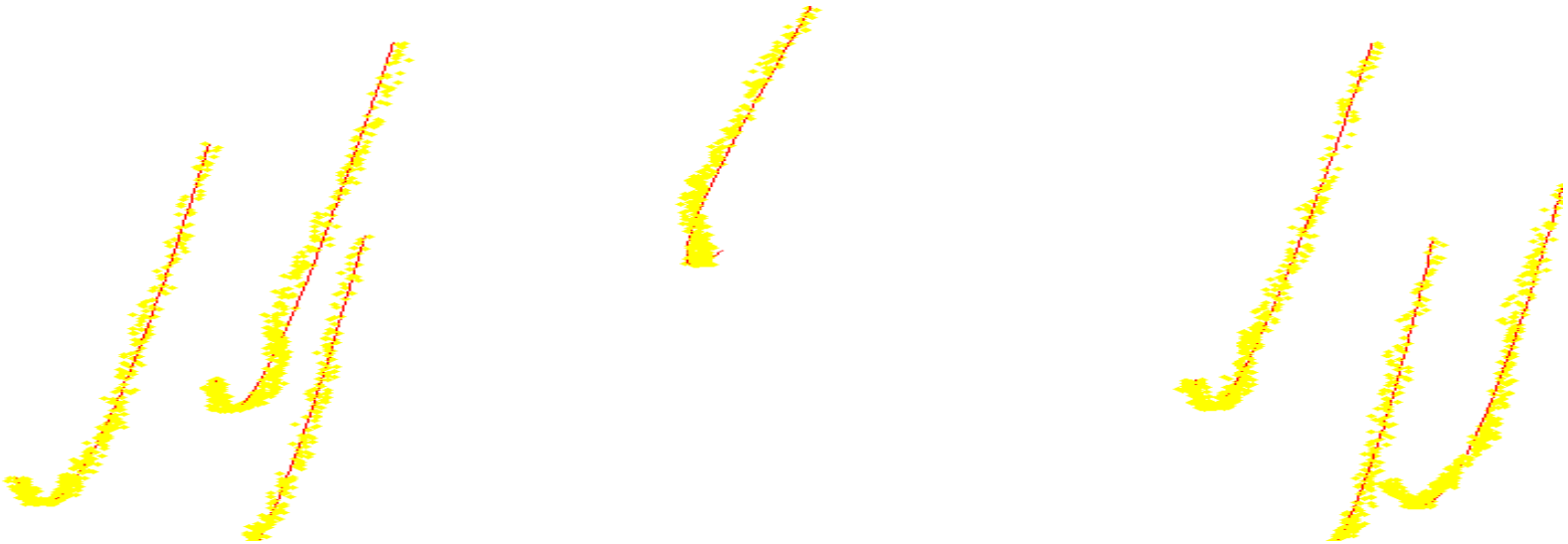
Support + vegetation + residual points (outliers, res.vegetation)
Fitted catenaries are shown as solid lines.
Fit is performed robustly using RANSAC.

Fitted 3D Catenary + Support



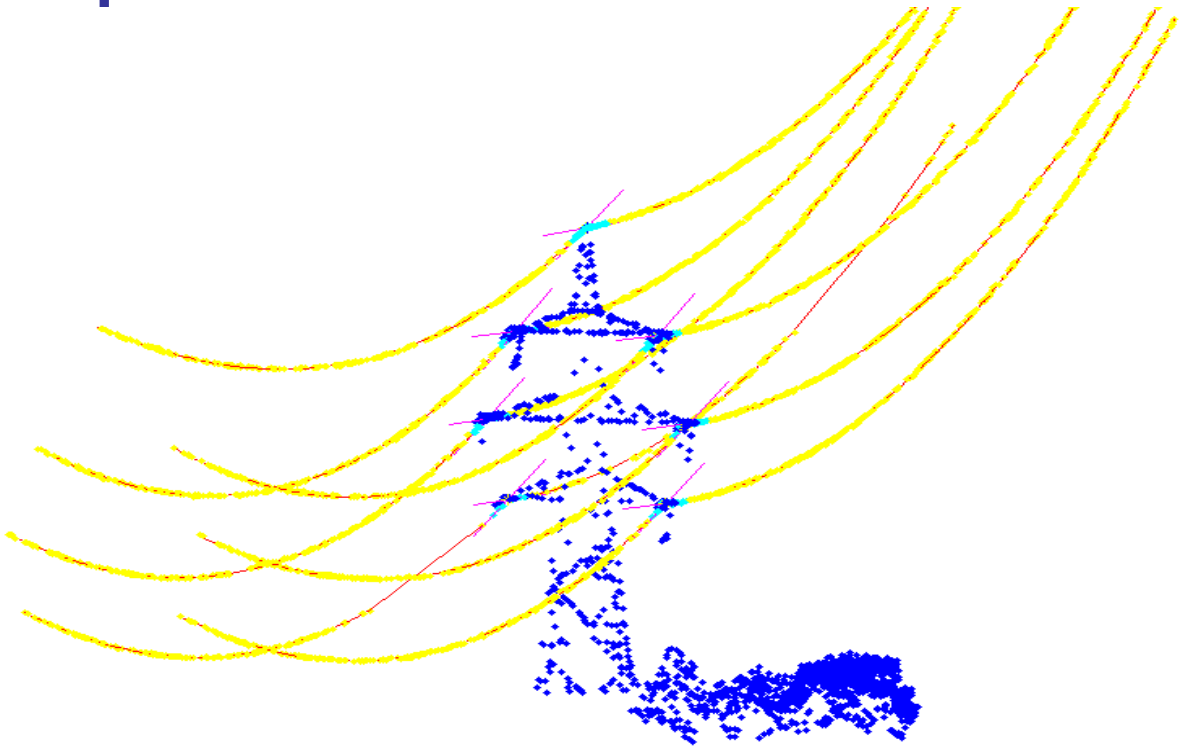
Quality of the Fit

- Typically, about 66% of the support points have residuals < 8 cm.
- However, in certain situations, residuals up to 30 cm have been observed.



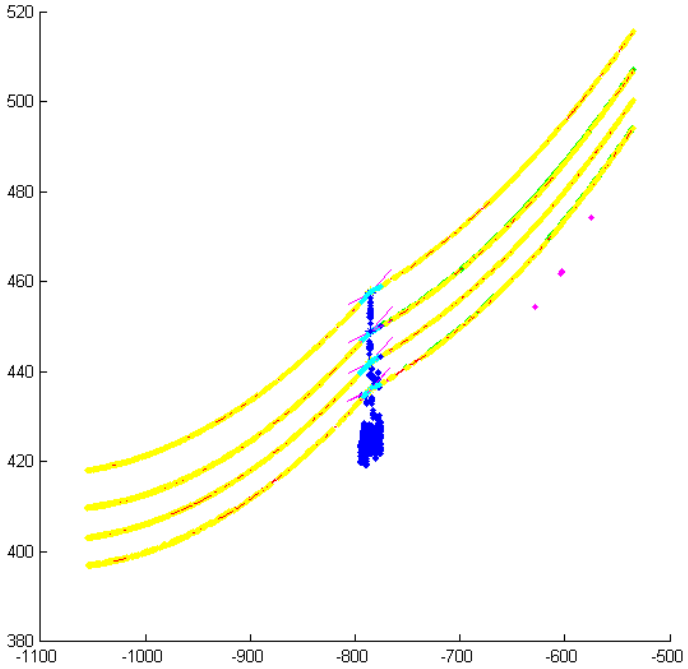
Support und fitted catenaries (superimposed). The oscillations could be due to wind and / or insufficient quality of the INS/GPS solution.

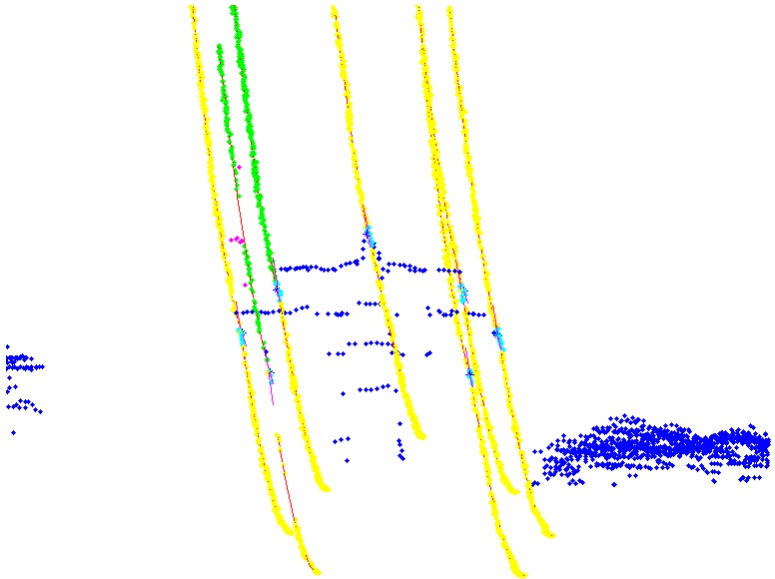
Bottom Up Again: Concatenation of Line Spans



Adjacent spans are concatenated by matching corresponding catenaries from both spans. The match criterion is the distance of the catenary tangents.

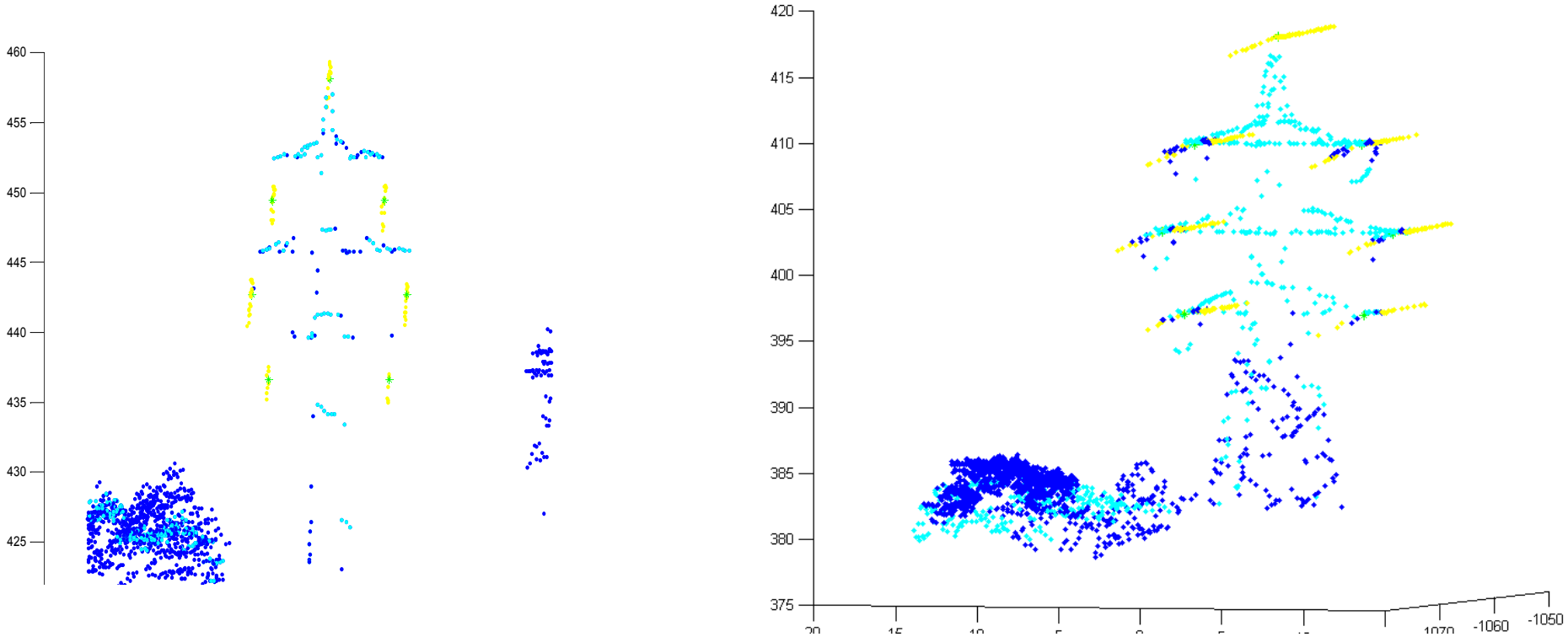
Reconstruction of Missing Catenaries





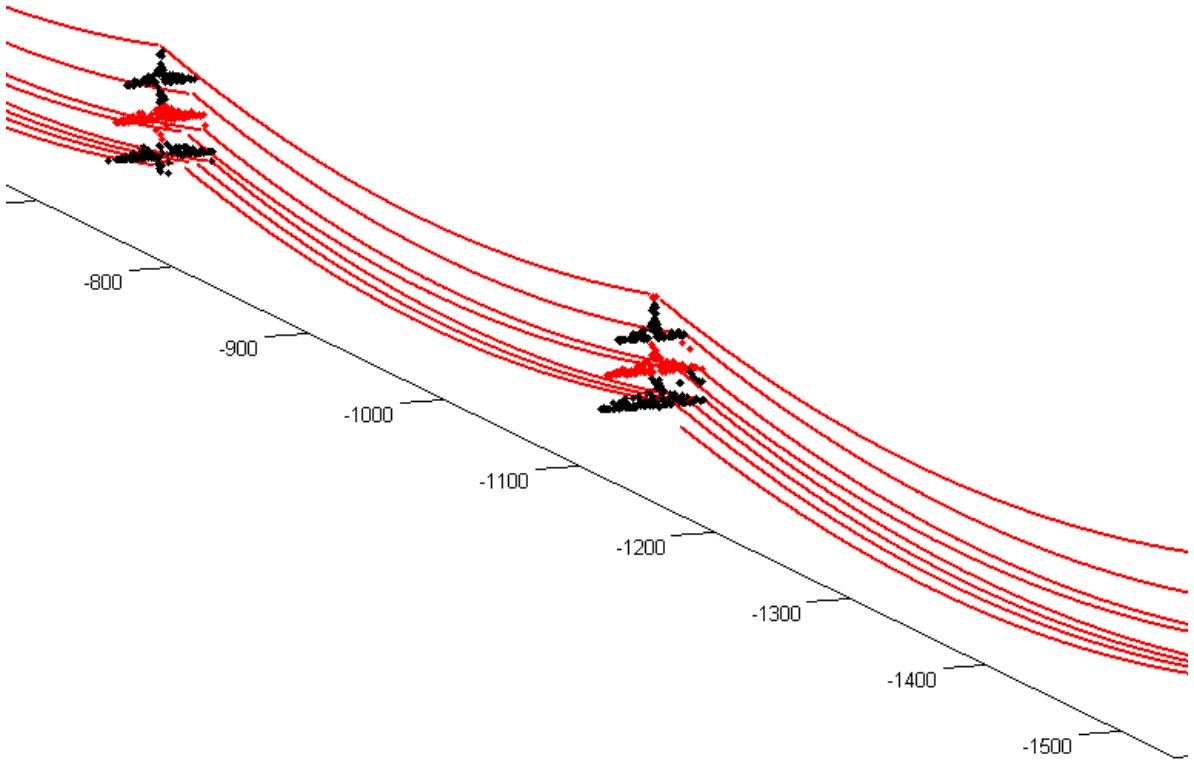
Missing matches can be used to initiate tentative catenary fits (automatically), starting from the position of the unmatched catenary. Green: catenaries reconstructed from tentative fits. This works very well in practice.

Derivation / Classification of Pylons



Position and signature of the pylons can also be determined by matching adjacent catenaries (green points: intersections). “Direct” classification or even geometric reconstruction using laser returns classified as pylon points (cyan) is not feasible in general due to the low number of laser returns from the pylon.

Partial Reconstruction of a Corridor



By analyzing the endpoints of catenaries converging in the same pylon area, we can identify different height levels (indicated by alternating red and black) and - after some additional processing - segment the pylons from the remaining points (mostly vegetation).

Summary

- Fully automated derivation of power lines has been implemented
  - Performance on Piestingtal-Project
    - 3 km, ~1M non-terrain points, 14 spans
    - Computation time: 20 minutes (Windows XP workstation)
- Reconstruction of pylons remain a challenging task
  - Pylons can, in general, not be reconstructed directly, but catenary intersections can give us valuable clues as to their class