3D Object Detection of 9-million LiDAR Point Cloud Using Semi-Supervised Machine Learning

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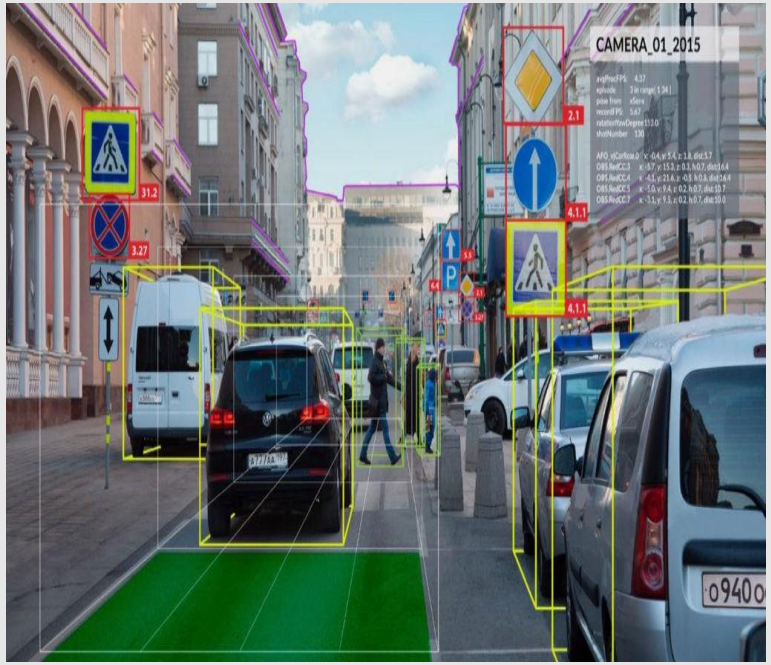
Problem Definition

Objective: Reconstruct the 3D objects in a local neighborhood with minimum dimension

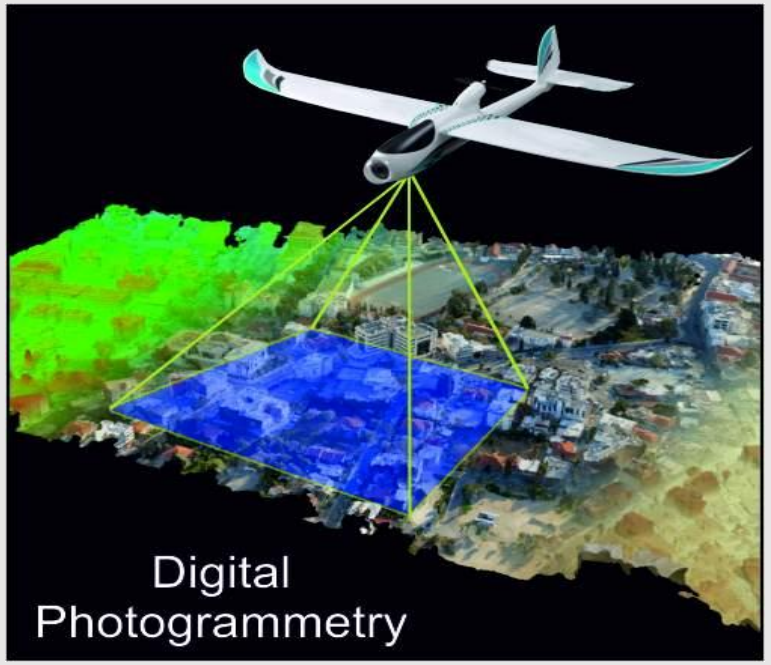
Motivation: Minimize the Misclassification

Applications:

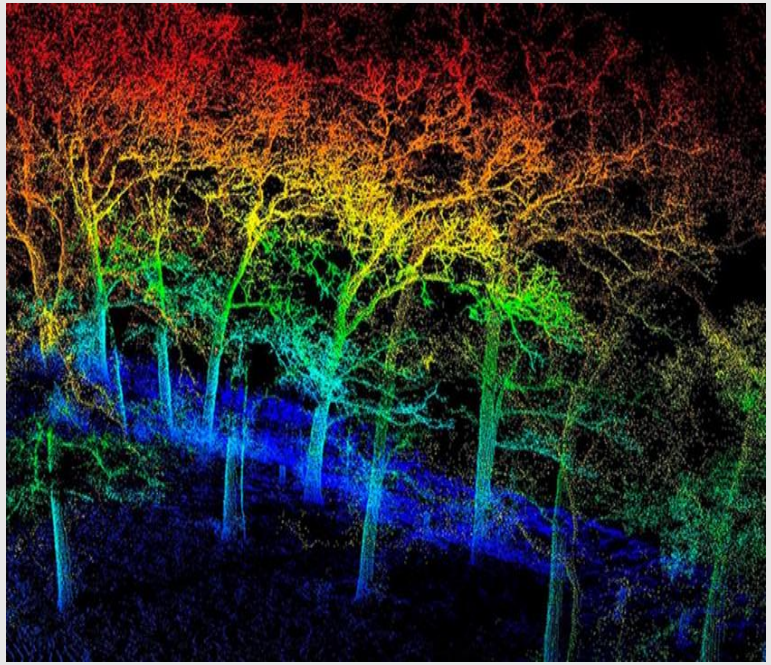
- Autonomous Driving
  (LYCMU, CVPR ‘19), (CKZBMFU, NIPS ‘15), (FDU, NIPS ‘12)



- Digital Photogrammetry
  (HH, ISPRS ‘18)

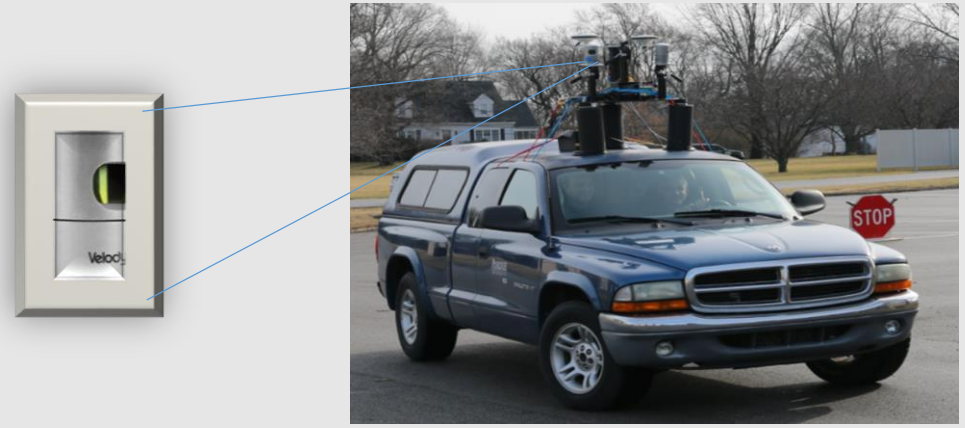


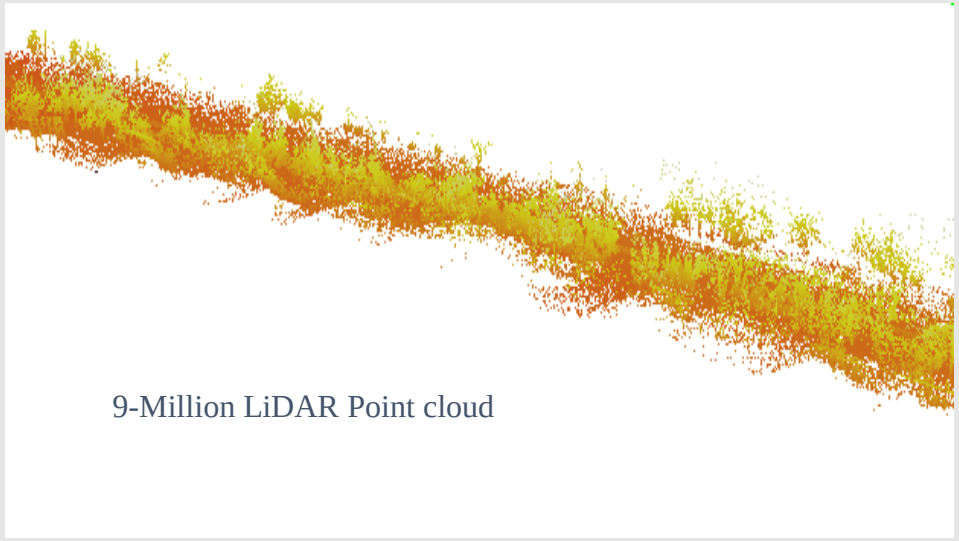
- Forestry & Vegetation
  (DMS, CVPR ‘12)



Data Collection & Preparation

- The dataset are acquired by HDL-32E
  - ± 2 cm accuracy
  - 32 Channels
  - 80m-100m Range
  - 700,000 Points per Second
  - 360° Horizontal FOV
  - +10° to -30° Vertical FOV
- The dataset has been labeled
- Metric: Misclassification Rate





9-Million LiDAR Point cloud

Northwestern Ave West Lafayette
(Length: 300 m)

Method

Point Cloud

Ground/Non-ground

Kd-Tree

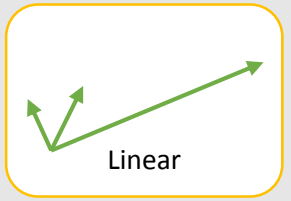
K Nearest Neighbor

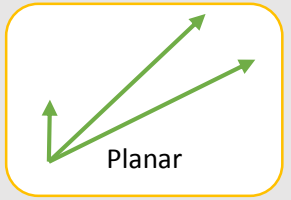
Principle Component Analysis (PCA)

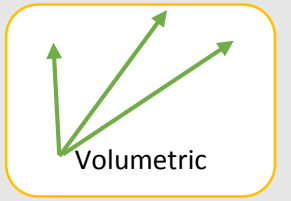
$$Cov_{3x3} = \frac{1}{n+1}\sum_{i=1}^{n+1}(P_i - \overline{P})\,(P_{i-} \overline{P})^T$$

$$\overline{P} = \frac{1}{n+1}\sum_{i=1}^{n+1} P_i$$

$$Cov_{3x3} = [\vec{e}_1 \;\; \vec{e}_2 \;\; \vec{e}_3] \begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{bmatrix} \begin{bmatrix} \vec{e}_1 \\ \vec{e}_2 \\ \vec{e}_3 \end{bmatrix}$$

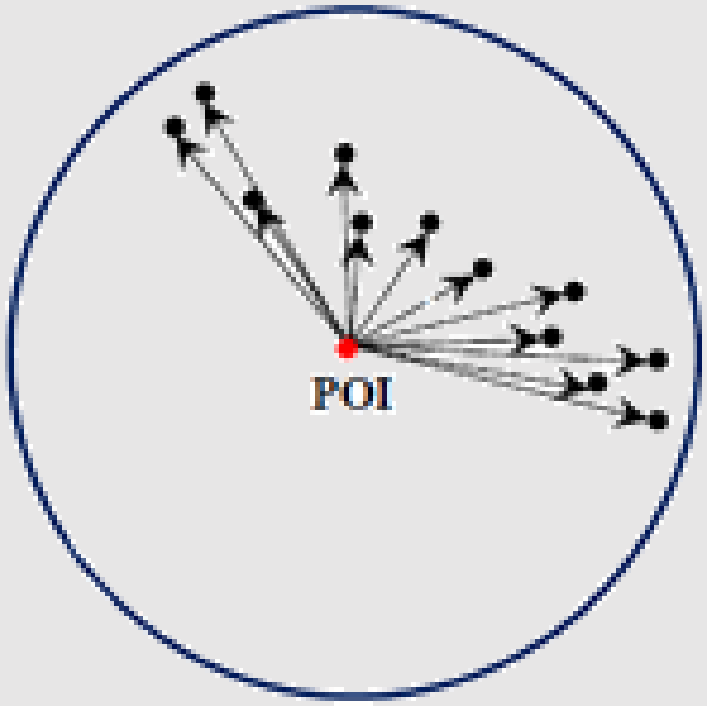


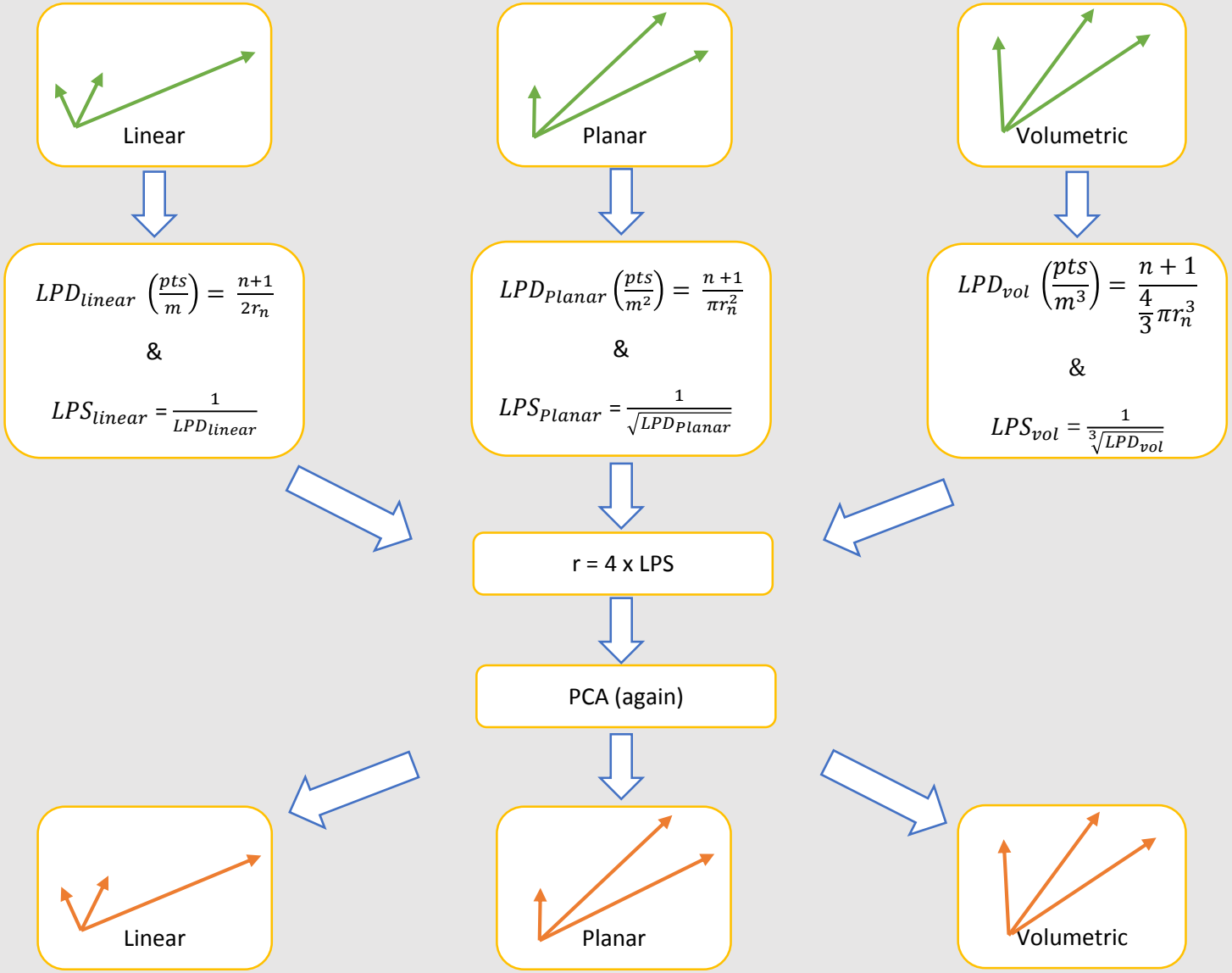




Dynamic PCA

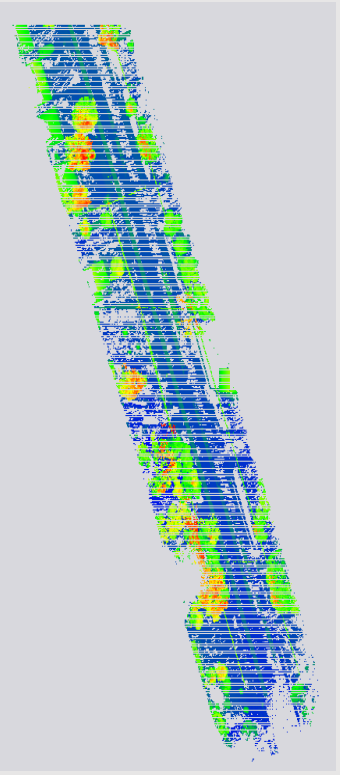
- Local Point Density (LPD)
- Local Point Spacing (LPS)
- Update the radius of Search



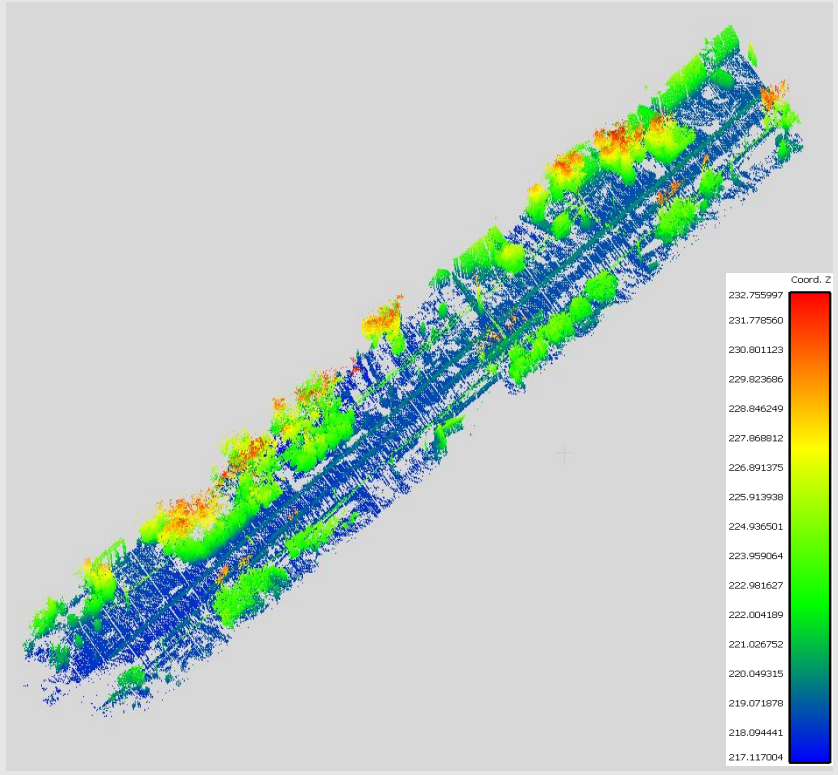


Result

Top View

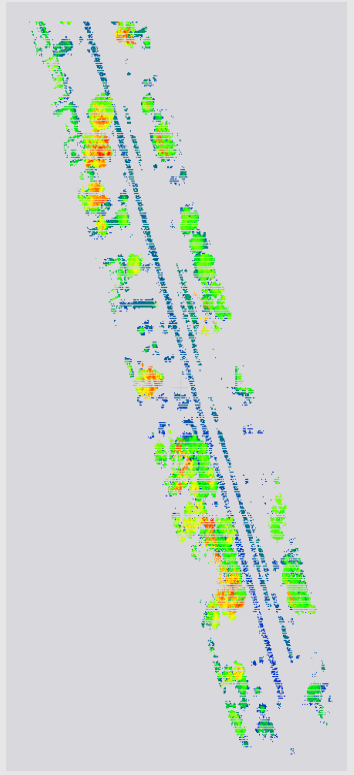


Side View

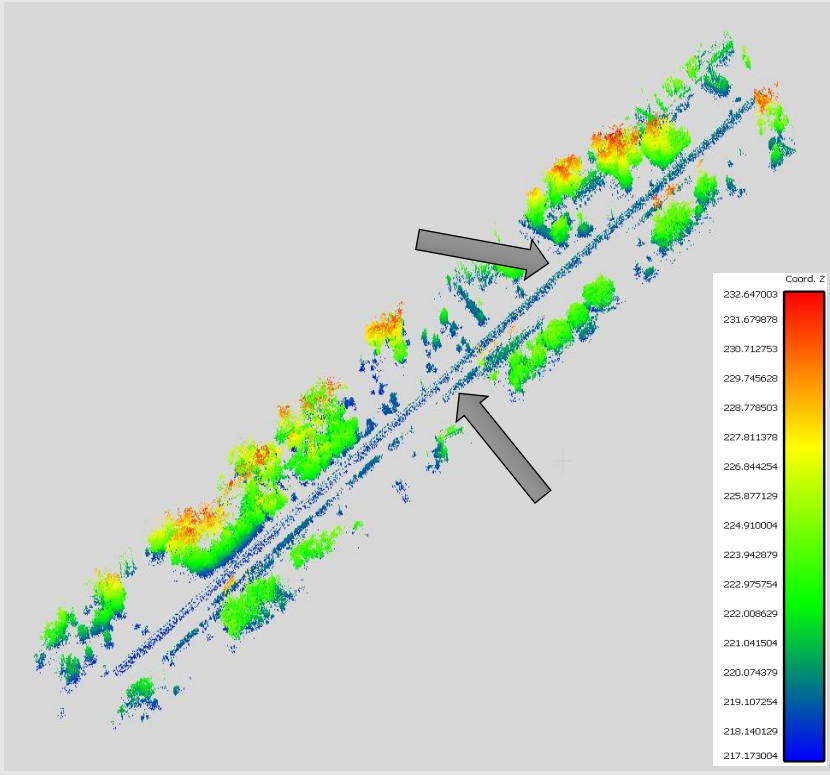


Original Data

Top View



Side View

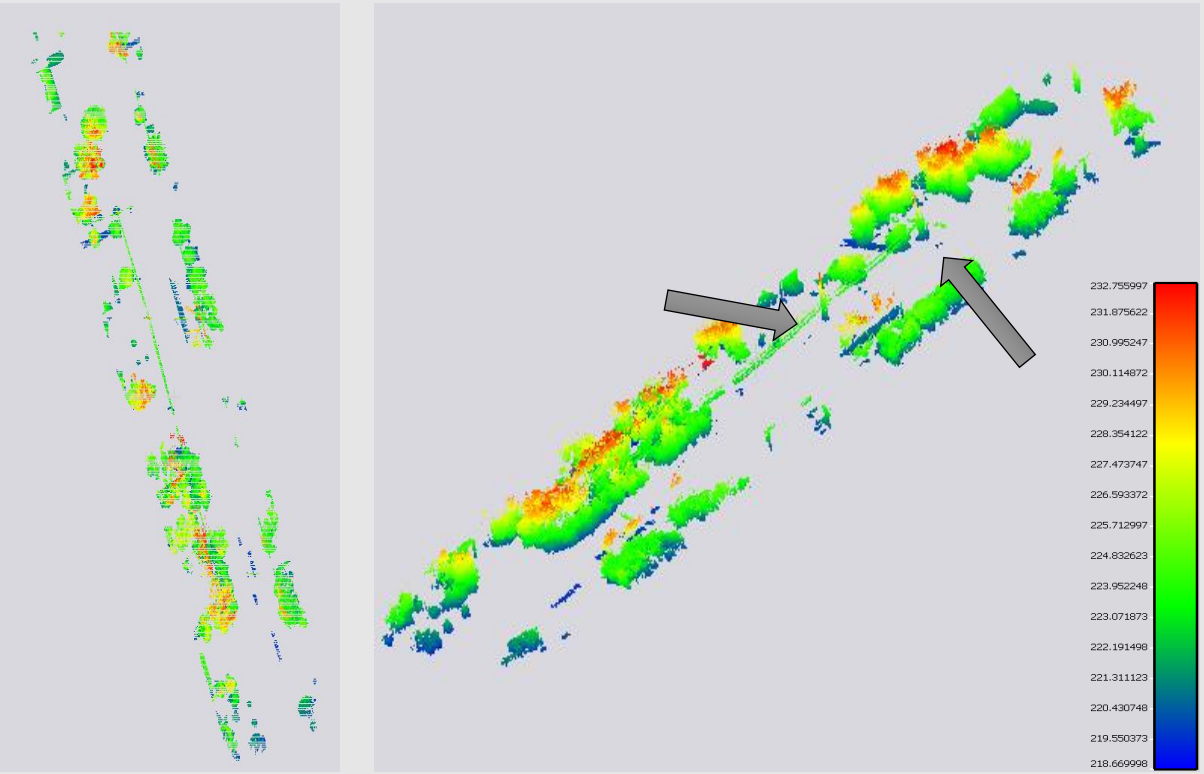


Fix PCA 70-NN

Result

Top View

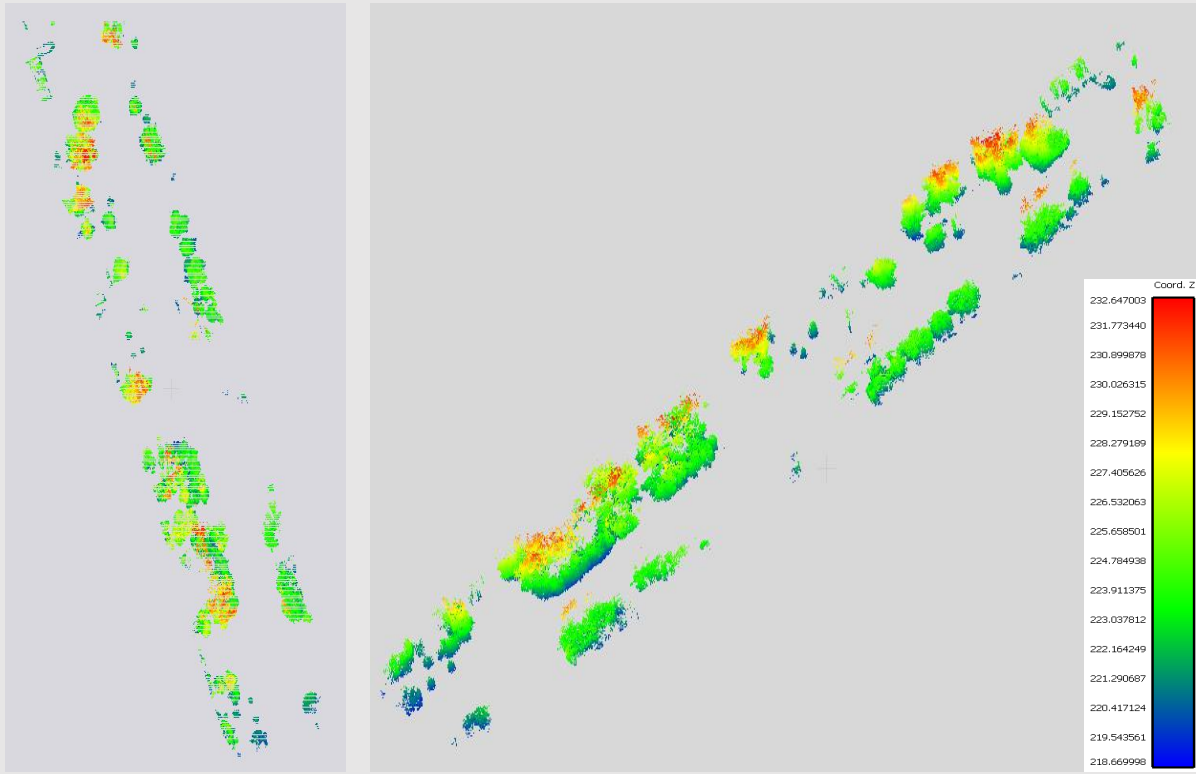
Side View



LAS Tool

Top View

Side View



Dynamic PCA

Misclassification

Misclassification Rate: $\frac{1}{n}\sum_{i=1}^{n} I(y_i \neq \hat{y}_i)$