Intelligent feature selection method for accurate laser-based mapping and localisation in self-driving cars

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Outline

Intelligent feature selection for accurate laser-based mapping and localisation

Introduction

Laser-based mapping

Localization

Experimental results

Conclusion and Future works

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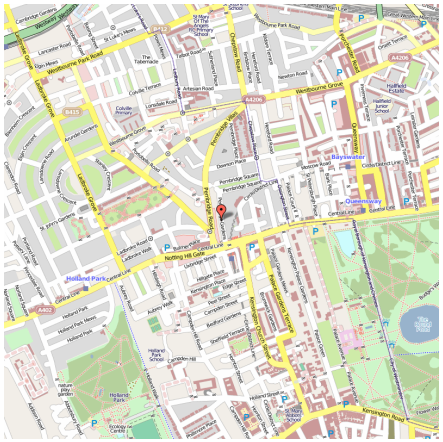
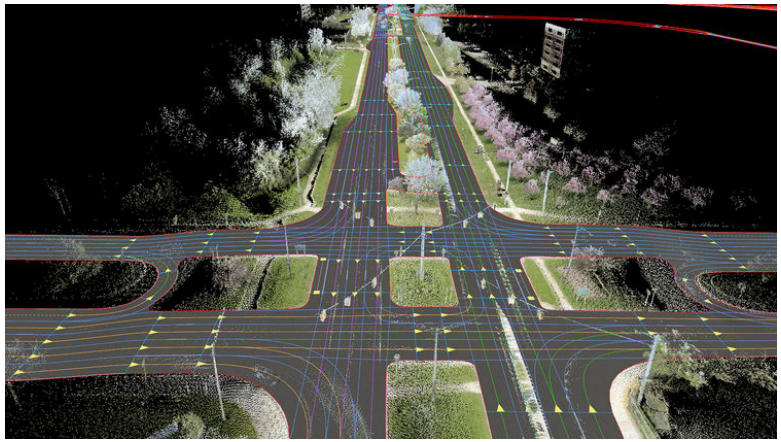
2D, 3D map and HD live Map
Introduction

- Robust and accurate 3D mapping is actually an attractive field for researchers and companies.
- Actually, 2D maps are used for self-driving tasks.
- HD Live Map technology finds integration problems.





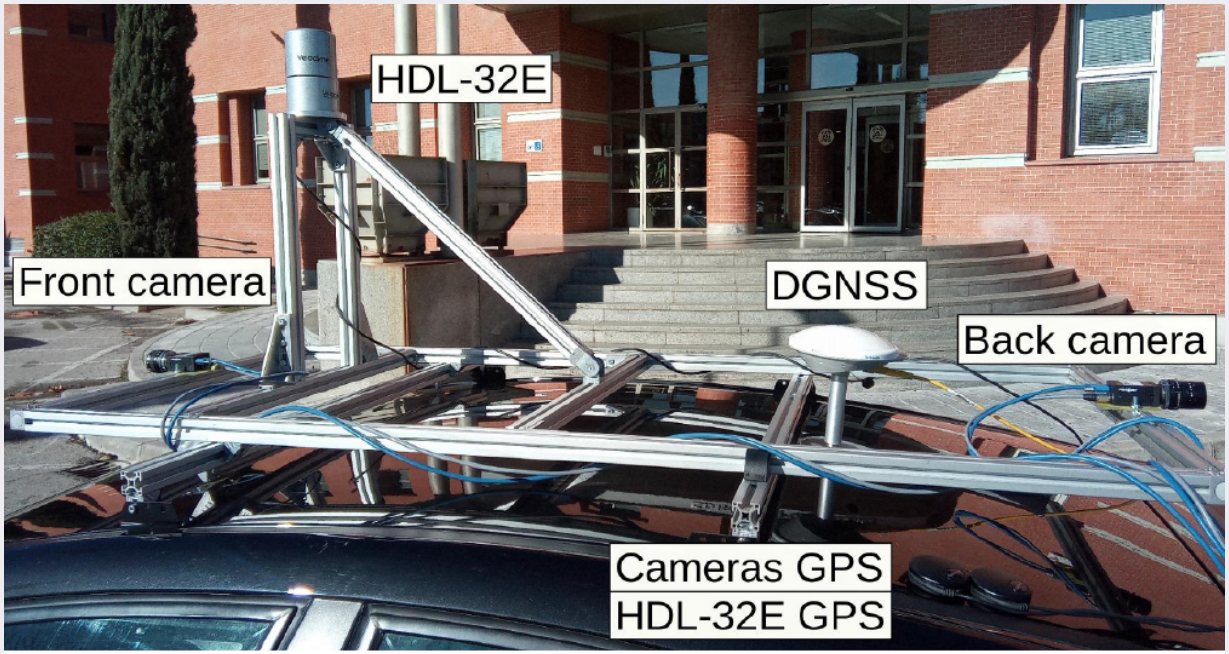
- 3D maps integrate easily HD Live Map technology for autonomous systems.
- 3D maps are based on point clouds obtained from LiDAR sensors.

DRIVERTIVE hardware system
Introduction

- **DRIVERTIVE system** has been used to built the robust and accurate 3D maps.
  - RTK-GPS, CAN bus and low-cost IMU.
  - LiDAR sensor (Velodyne-32).

DRIVERTIVE hardware system

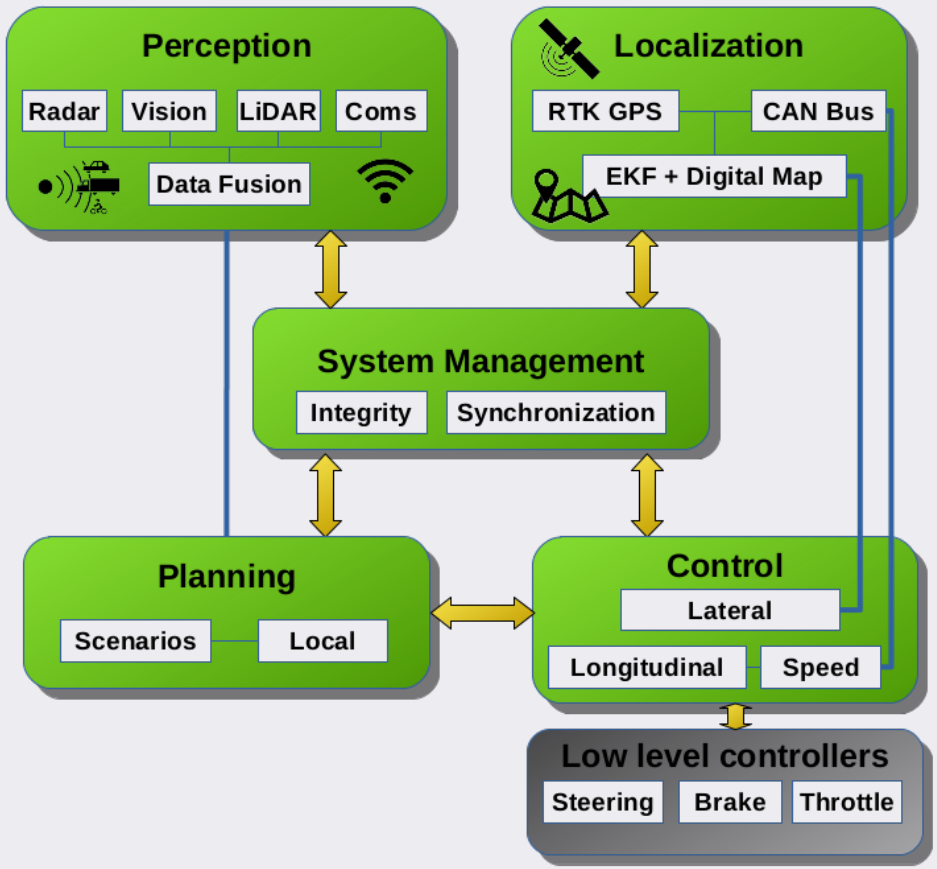
Introduction



Sensor Setup

- **DRIVERTIVE system** has been used to built the robust and accurate 3D maps.
  - RTK-GPS, CAN bus and low-cost IMU.
  - LiDAR sensor (Velodyne-32).

DRIVERTIVE system architecture
Introduction



Outline

Introduction

Laser-based mapping
- 3-DOF pose estimation (1st stage)
- 6-DOF pose estimation (2nd stage)

Localization

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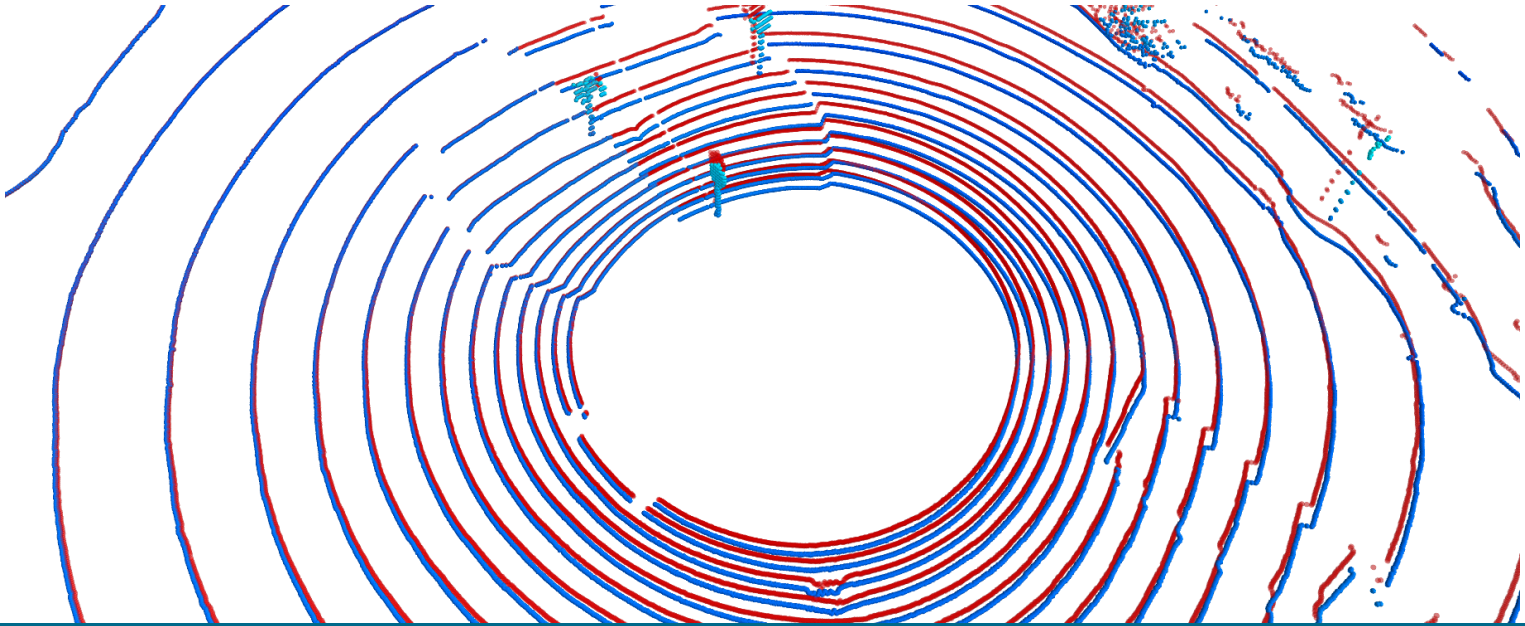
An ideal process for laser-based mapping

- Propose a 6-DOF pose for each point included on the point cloud.

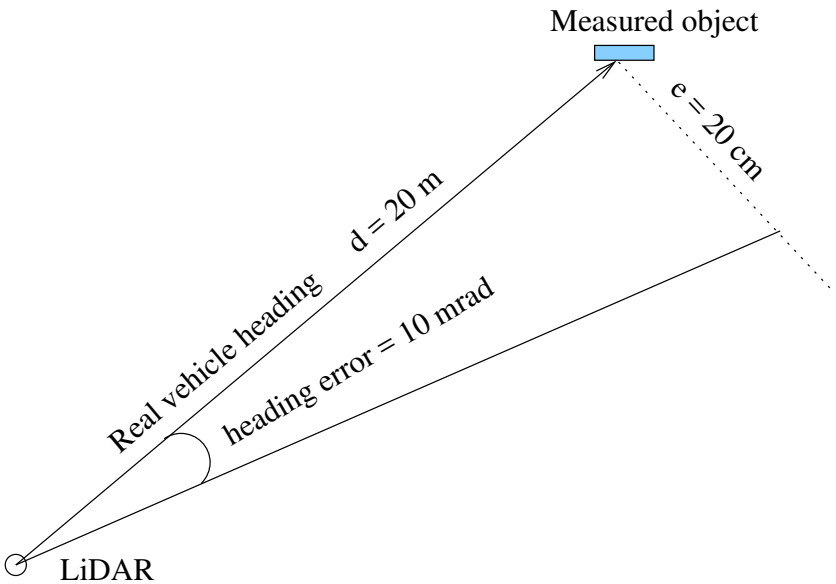
- The first stage only evaluates a 3-DOF pose for point cloud.
  - Linear parameters: $[x, y]$.
  - Angular parameter: $[\alpha_{yaw}]$.
- To go to a ideal situation **sweep correction process** is applied.

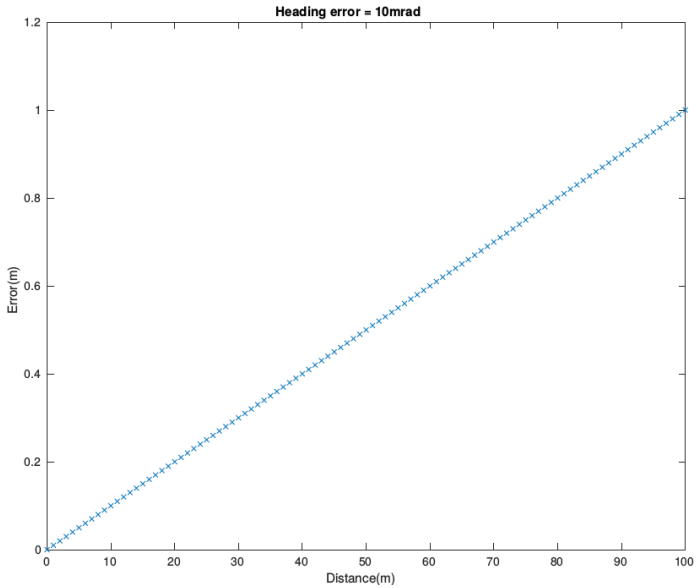


Error factors on 3-DOF pose

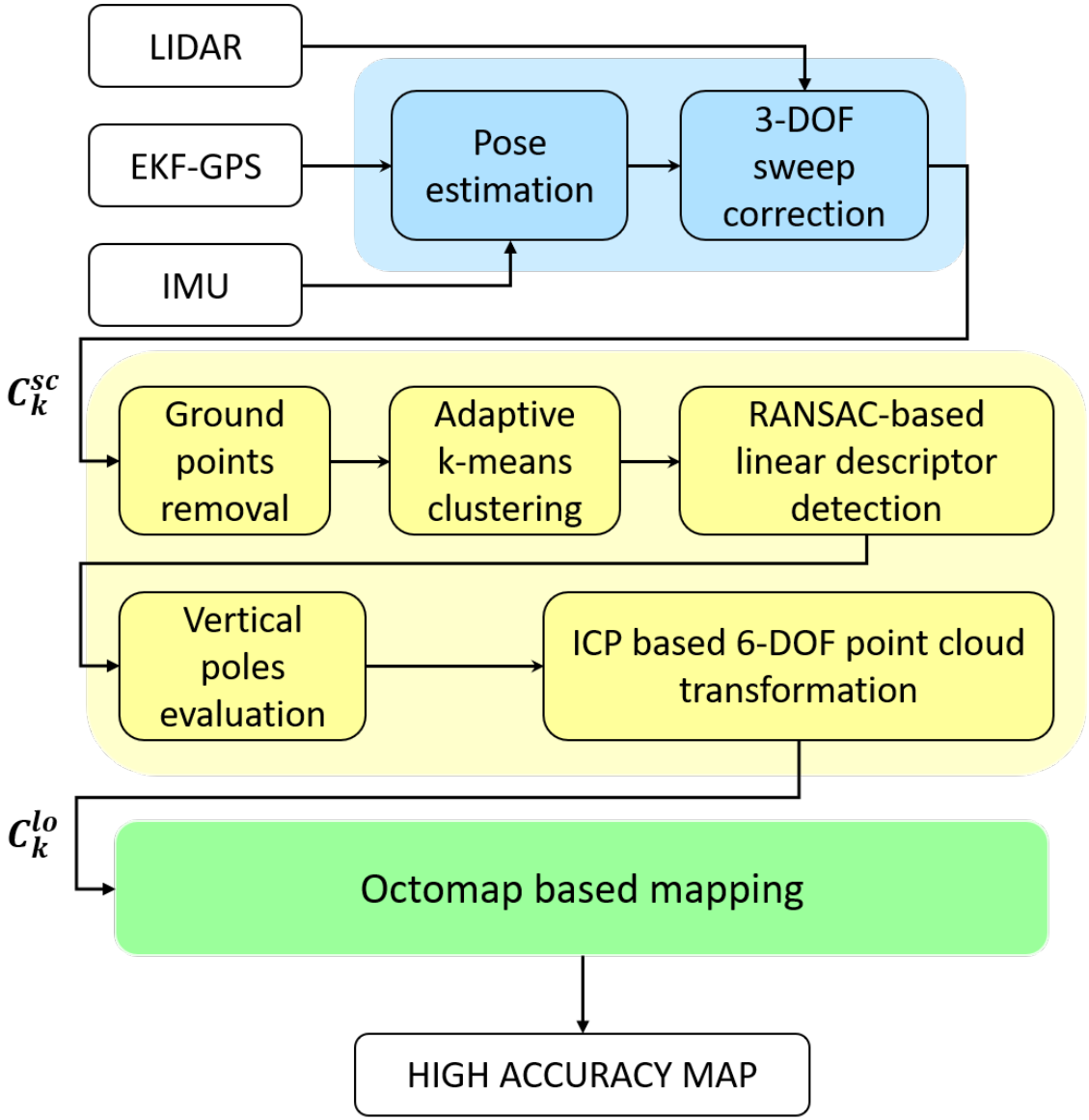
3-DOF estimation pose

- Related with EKF-based localization:
  - Undesired RTK-GPS blackout $\Rightarrow$ EKF estimation.
  - Heading measurement error.
  - Camber road and speed bumps.
  - Small roundabout and road curves.
- How does the angular error contribute to mapping process?



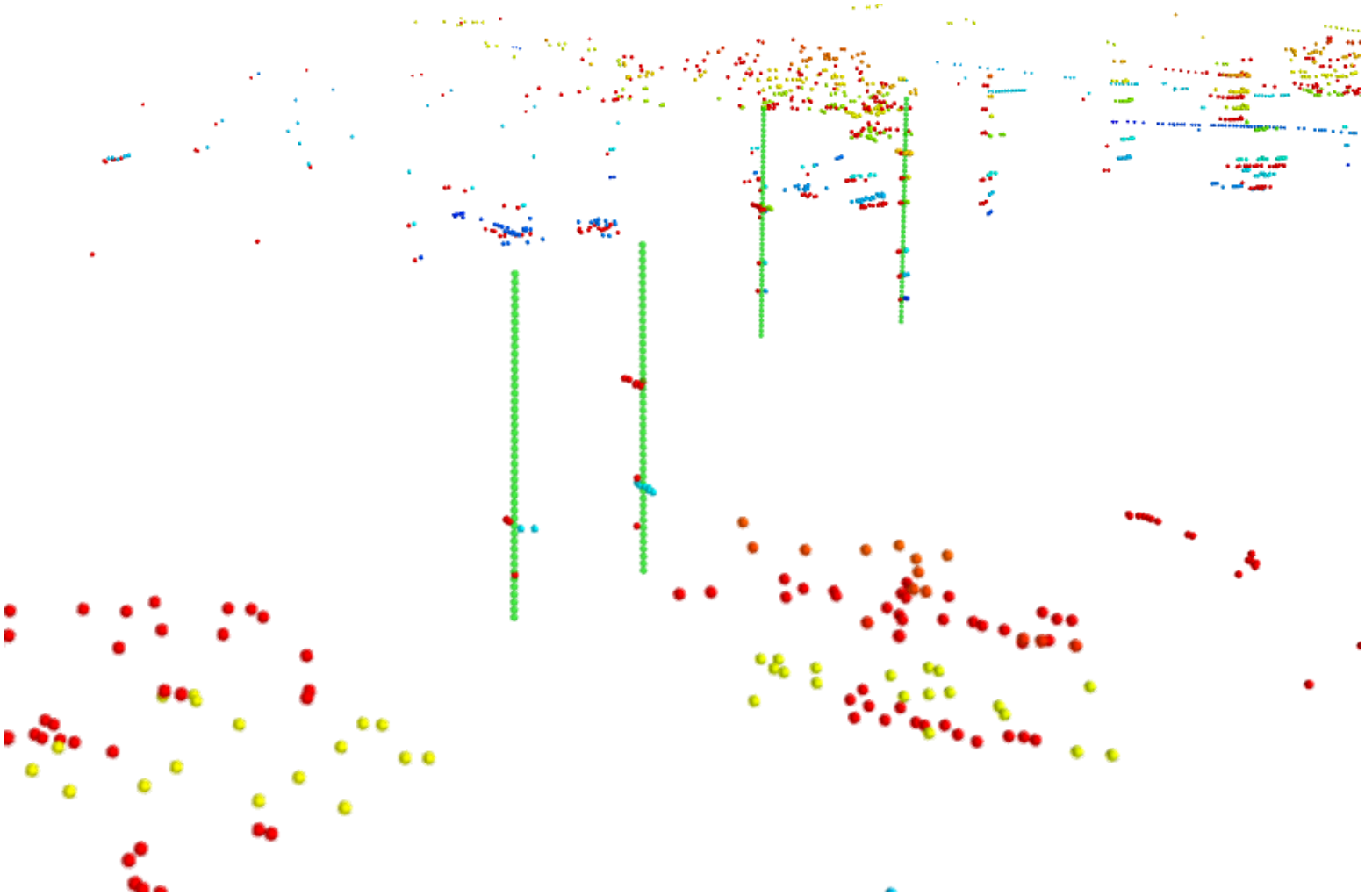


General block diagrams
6-DOF estimation process



Clustering and vertical poles evaluation
6-DOF estimation process

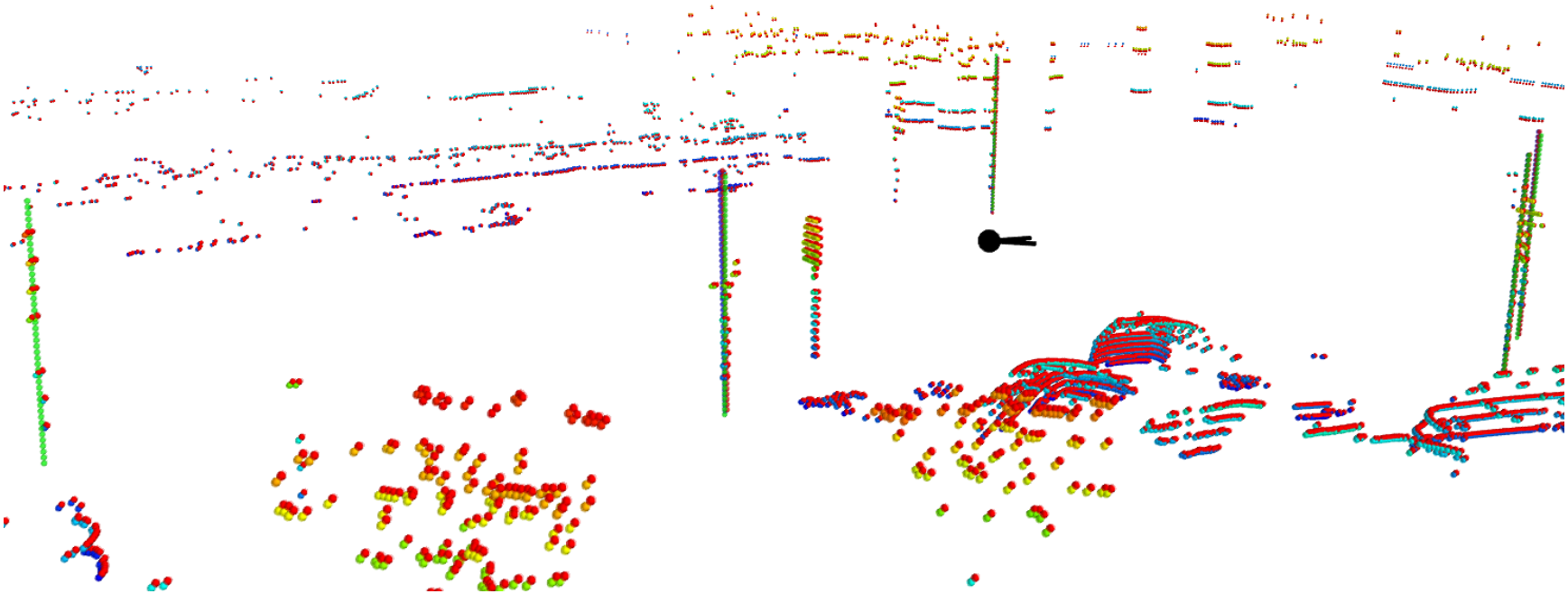
- The clustering process is based on L2 Euclidean distance.
- Lineal model with RANSAC for each previous evaluated cluster.



ICP based 6-DOF point cloud

6-DOF estimation process

- The ICP is applied over two point clouds.
- The point cloud has the set of vertical poles.



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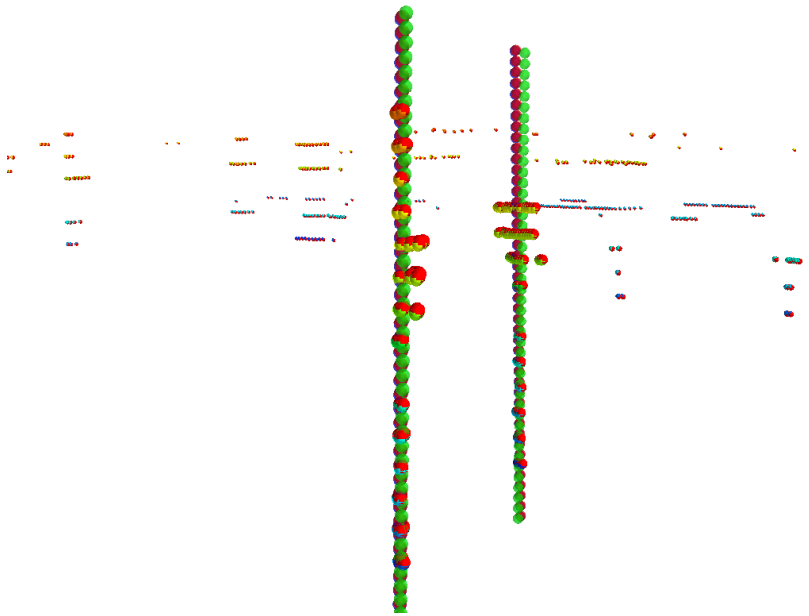
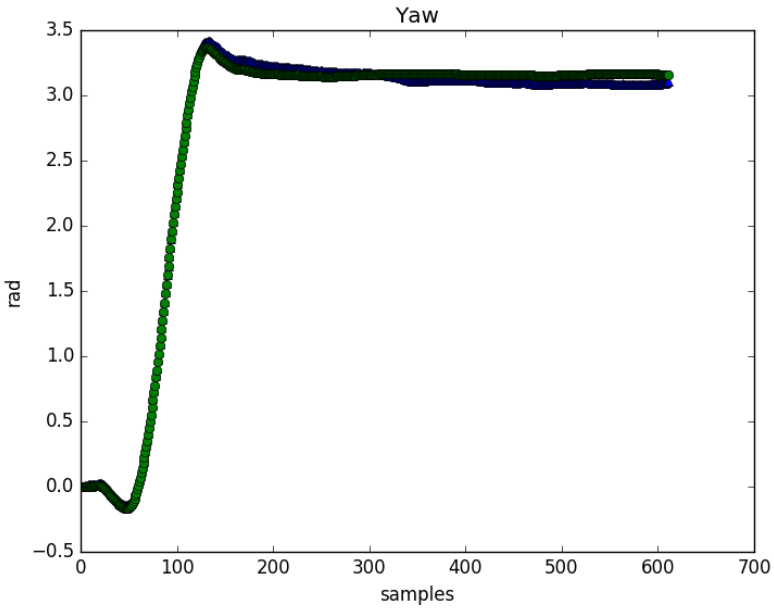
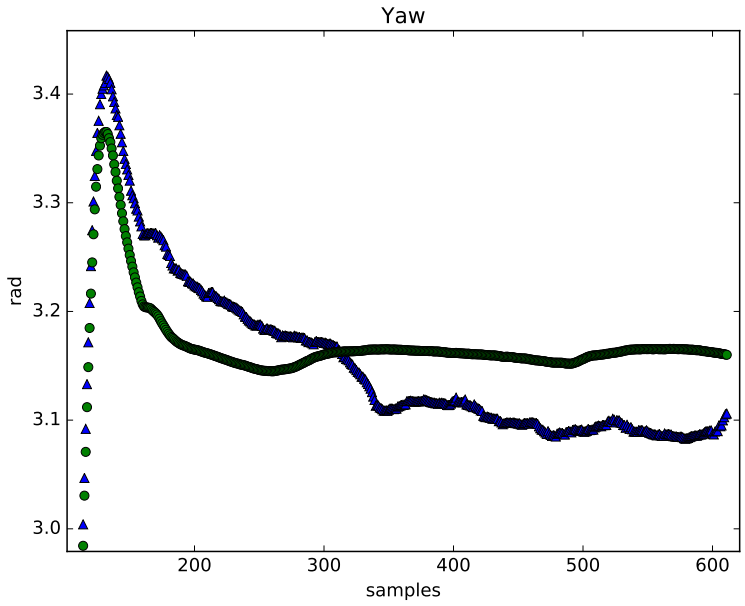


Current research line

- Mapping process with direct 6-DOF measurement. Based on LiDAR odometry.





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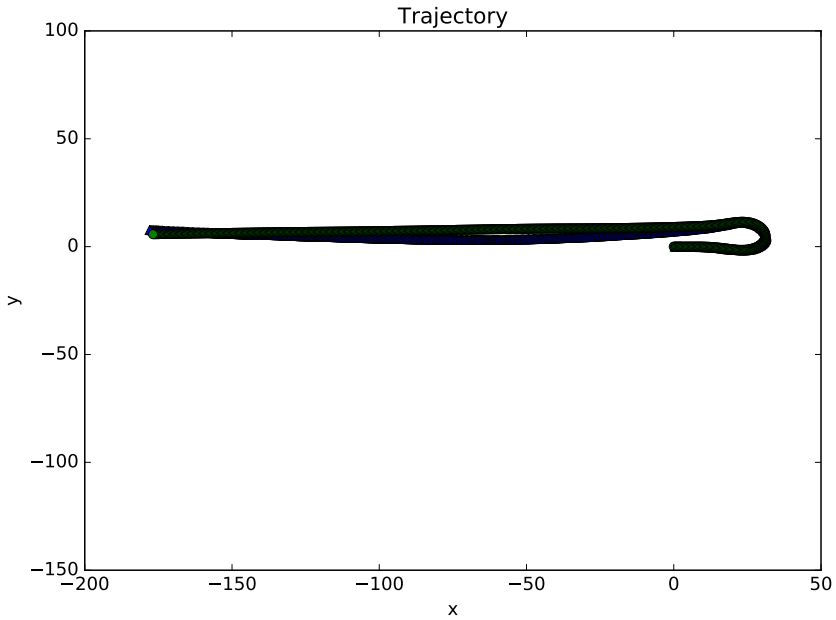

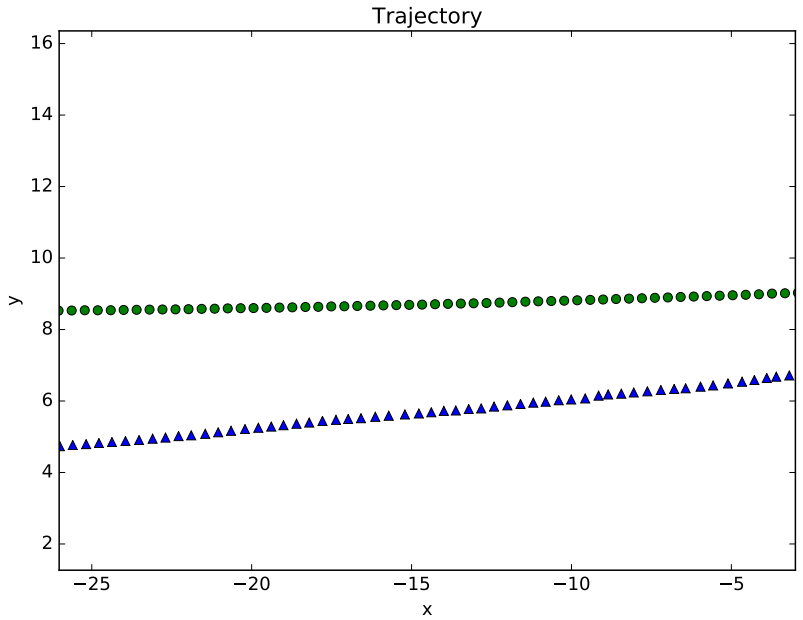

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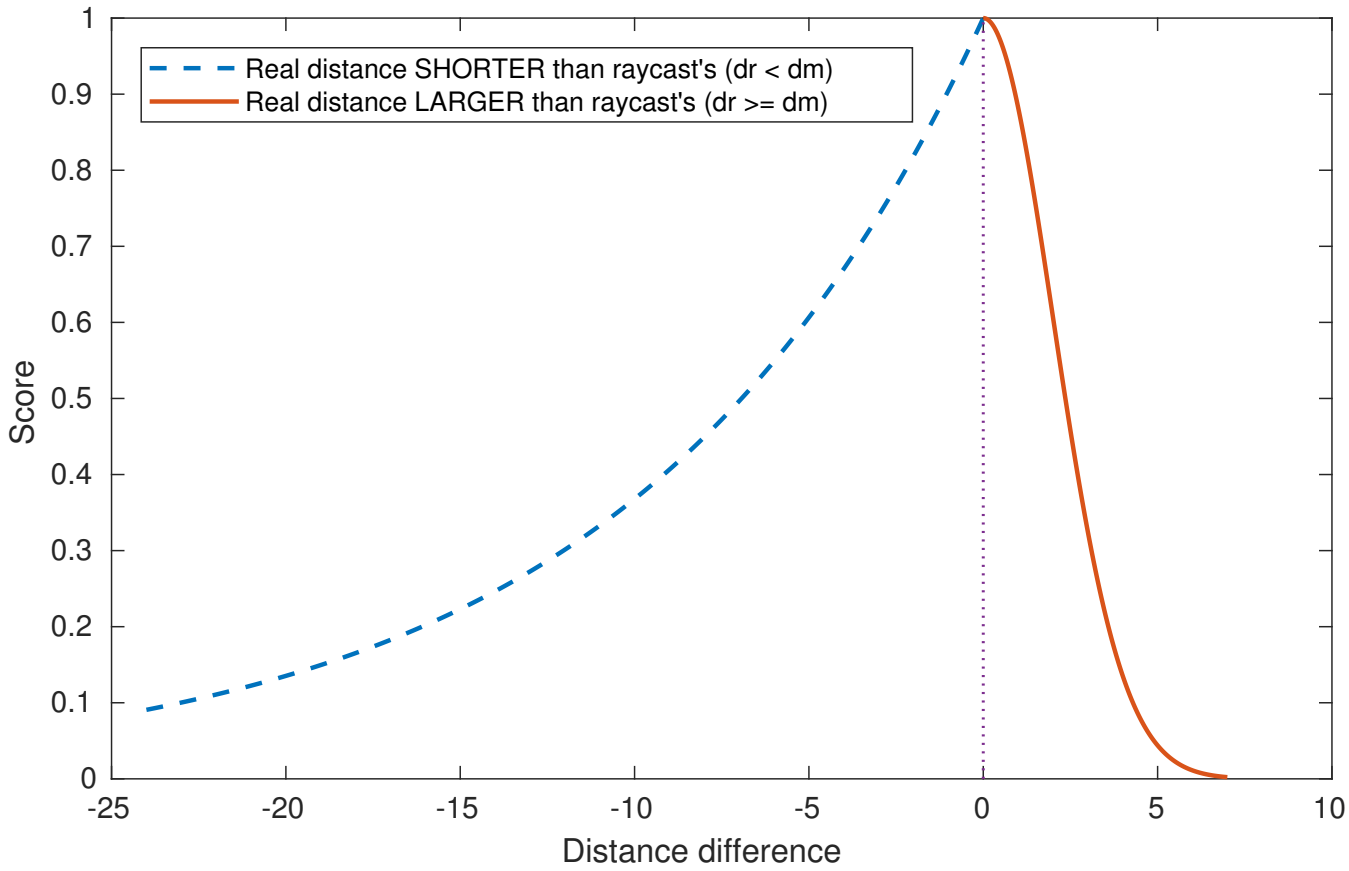
Localization

- The Particle Filter is adapted to use high definition 3D maps.
- Ray casting model to evaluate the fitness of the point cloud over the 3D map is used.



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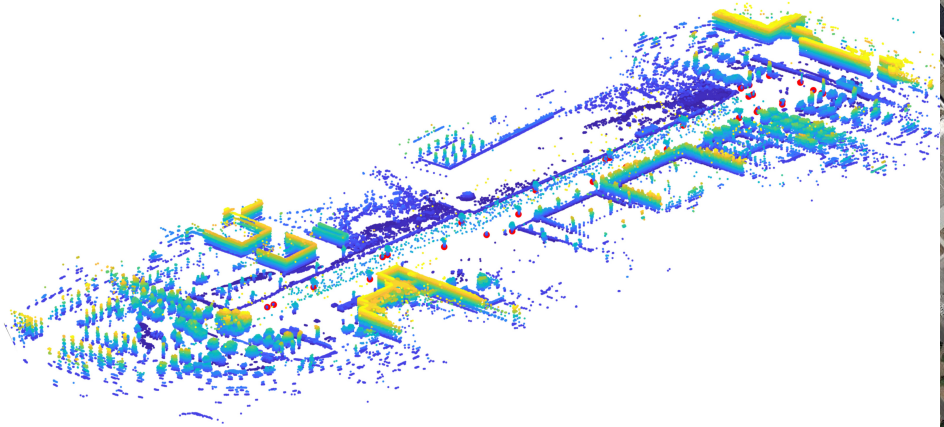
Set-Up
Experimental results

- For mapping: street poles positions were manually measured (RTK-GPS).
- For localization: RTK-GPS trajectory.



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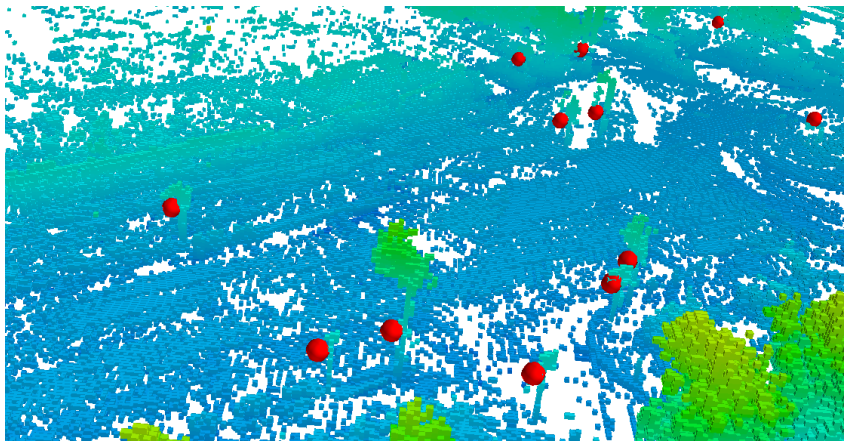


Mapping and localization
Experimental results

- Mean Euclidean Distance Error and Variance of the poles positions.

	Mean Euclidean Distance Error	Variance
3-DOF EKF map	22.30 cm	6.00 cm
6-DOF LIDAR map	9.74 cm	4.16 cm

- Mean Localization Distance Error and Variance (cm).

	Lateral	Longitudinal	Total
3-DOF EKF map	14.86 ± 0.89	20.65 ± 5.23	28.27 ± 4.60
6-DOF LIDAR map	13.63 ± 1.85	21.13 ± 2.42	27.83 ± 2.85

Mapping
Experimental results

- Octomap library is used to build the accurate 3D map.
  - Cube size: 20*cm*
  - Hit probability: 0.9
  - Miss probability: 0.4

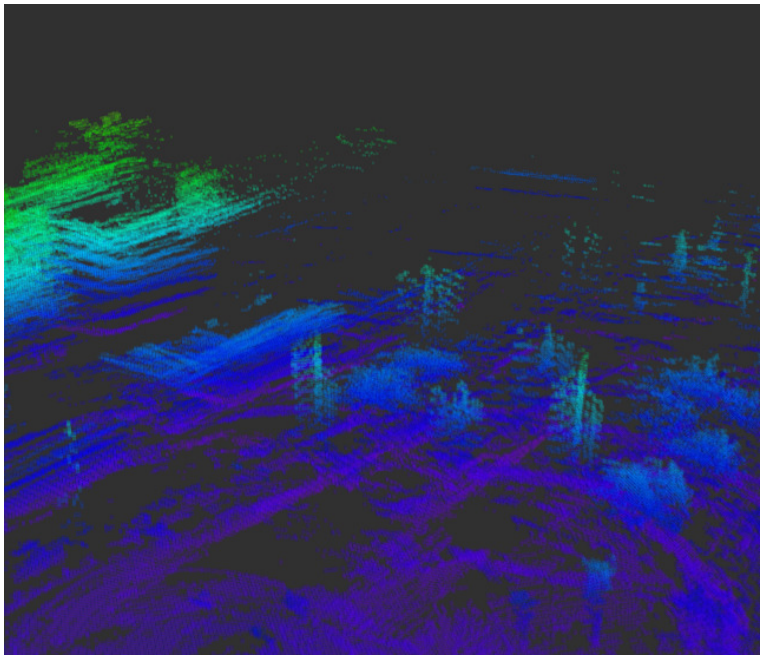


Figure: 3-DOF map

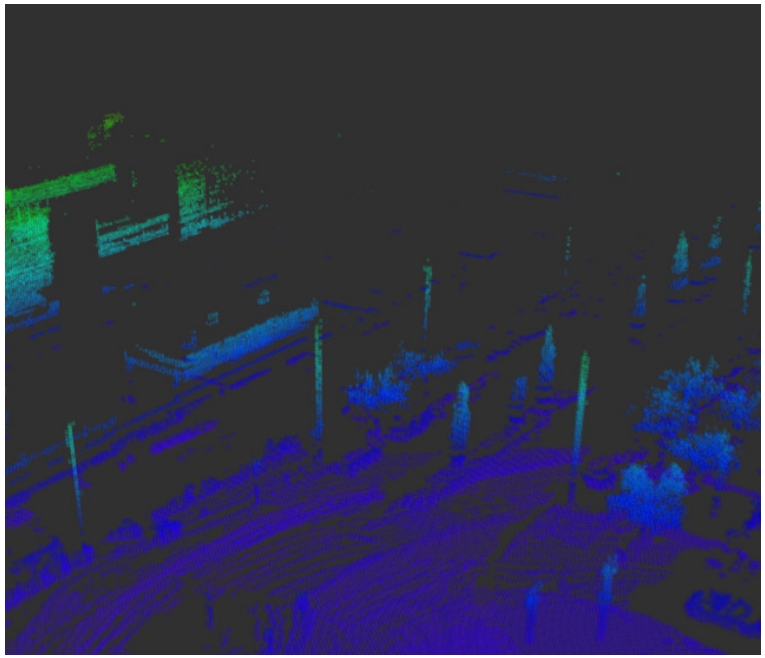
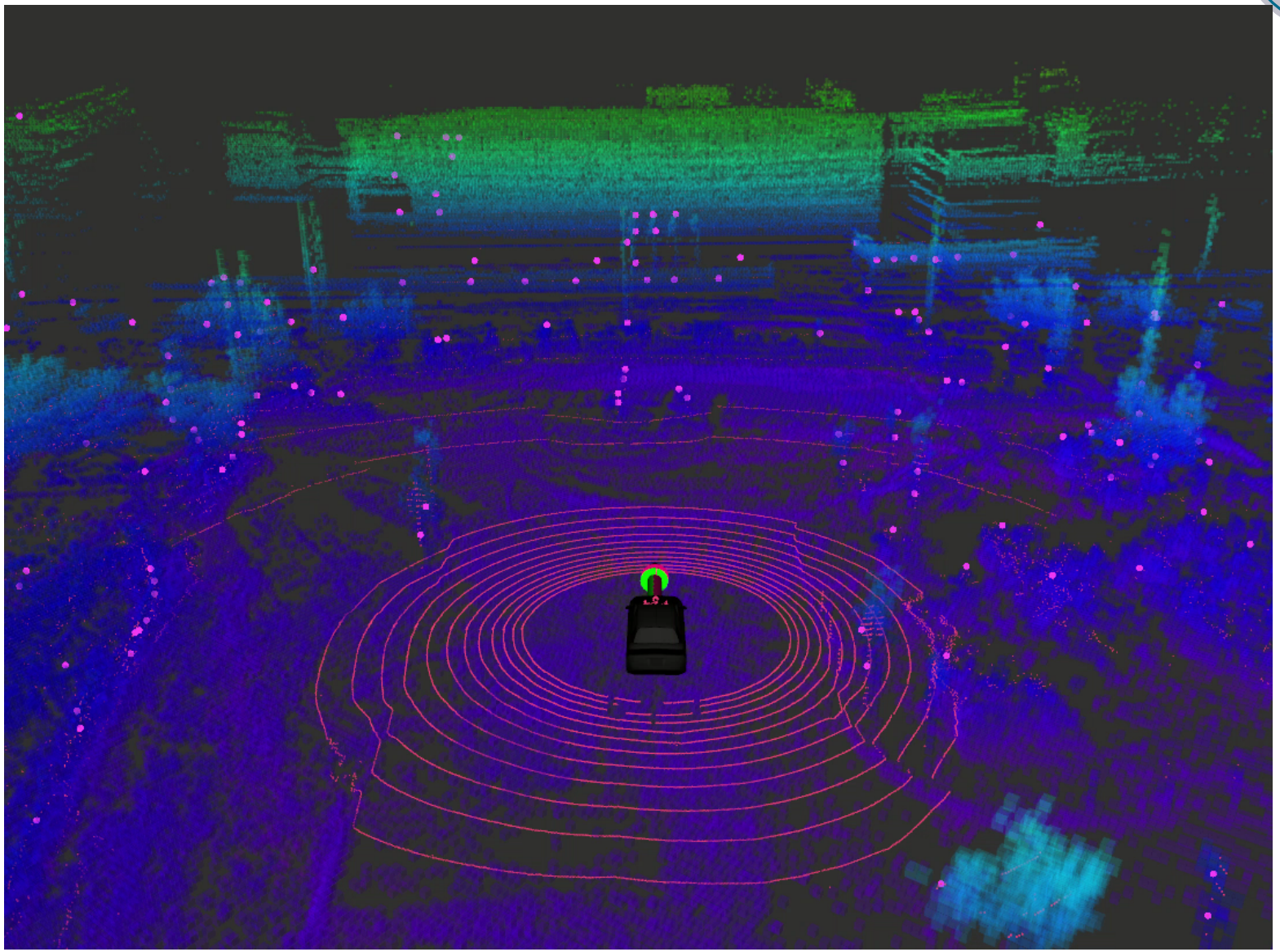


Figure: 6-DOF map

Localization
Experimental results



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Conclusions

- Accurate laser-based mapping method depends of the estimated pose precision.
- The estimated 3-DOF pose, measured by the localization system base on D-GPS and EKF, causes the following issues:
  - Linear error, bellow 5*cm*, does not affect to the 3D map accuracy.
  - Angular error, beyond 5*mrad*, affects drastically over the 3D map accuracy.
- ICP or any optimization algorithms are needed to increase the 3D map accuracy because improve the estimated pose with the 6-DOF evaluation.
- According with the depicted results, our mapping technique increases the mapping accuracy by a factor of two.
- In the other hand, the performance on localisation doesn't improve.

Future works

- Mapping process with direct 6-DOF measurement base on LiDAR odometry.
- Robust localization with on-line mapping modification.

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Thank you for your attention! Questions?

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