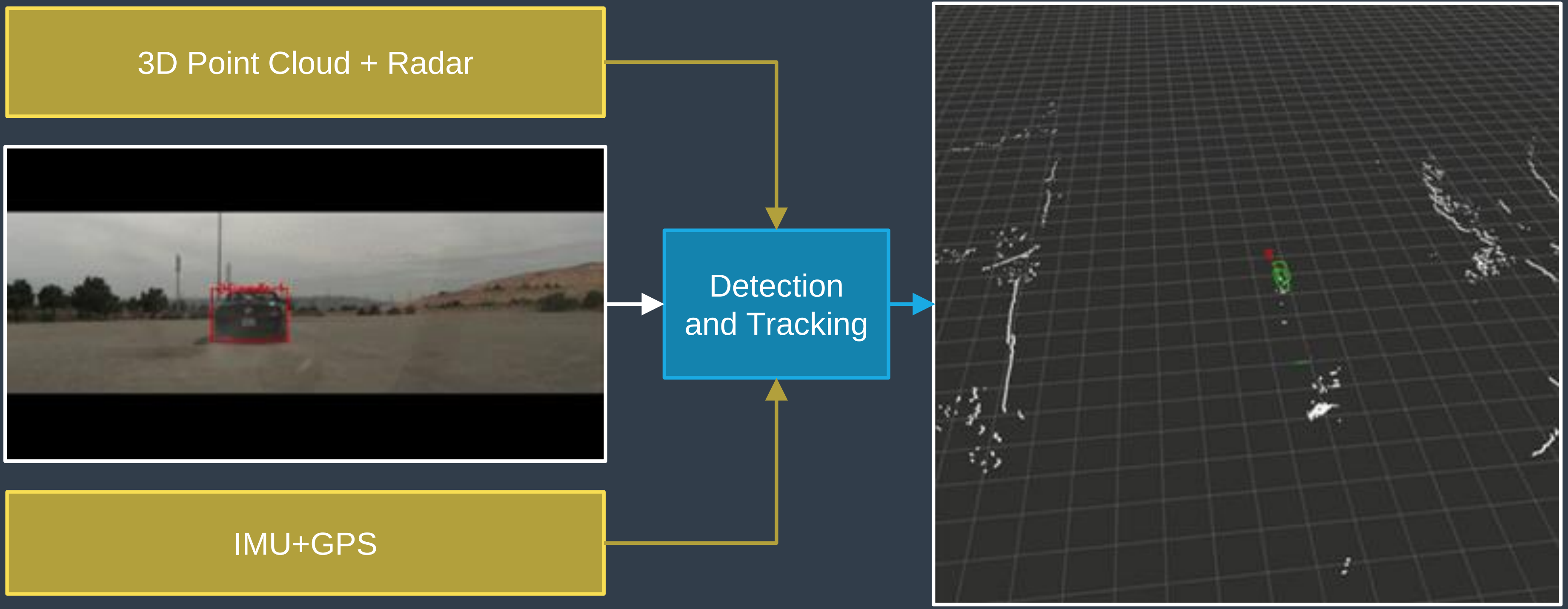
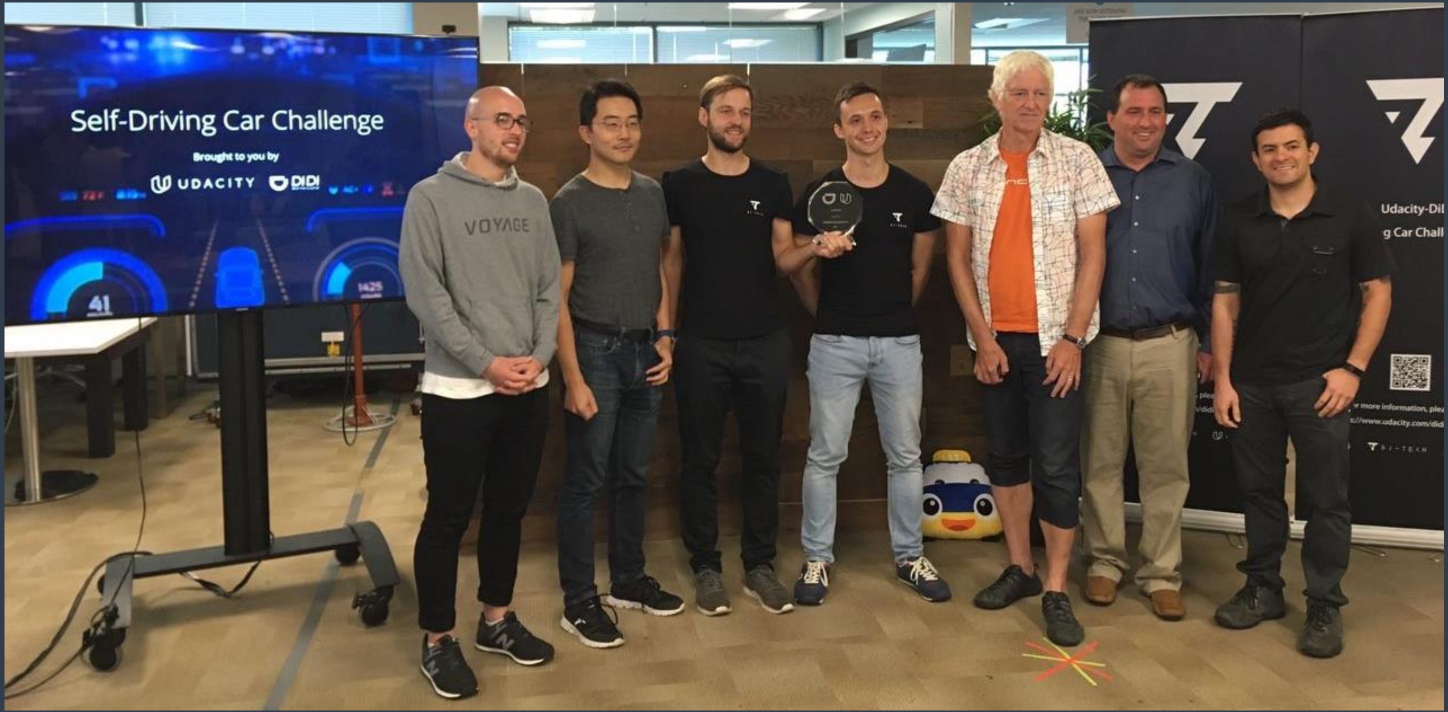
Didi-Udacity Challenge

Innopolis University Team
2nd place

innopolis university

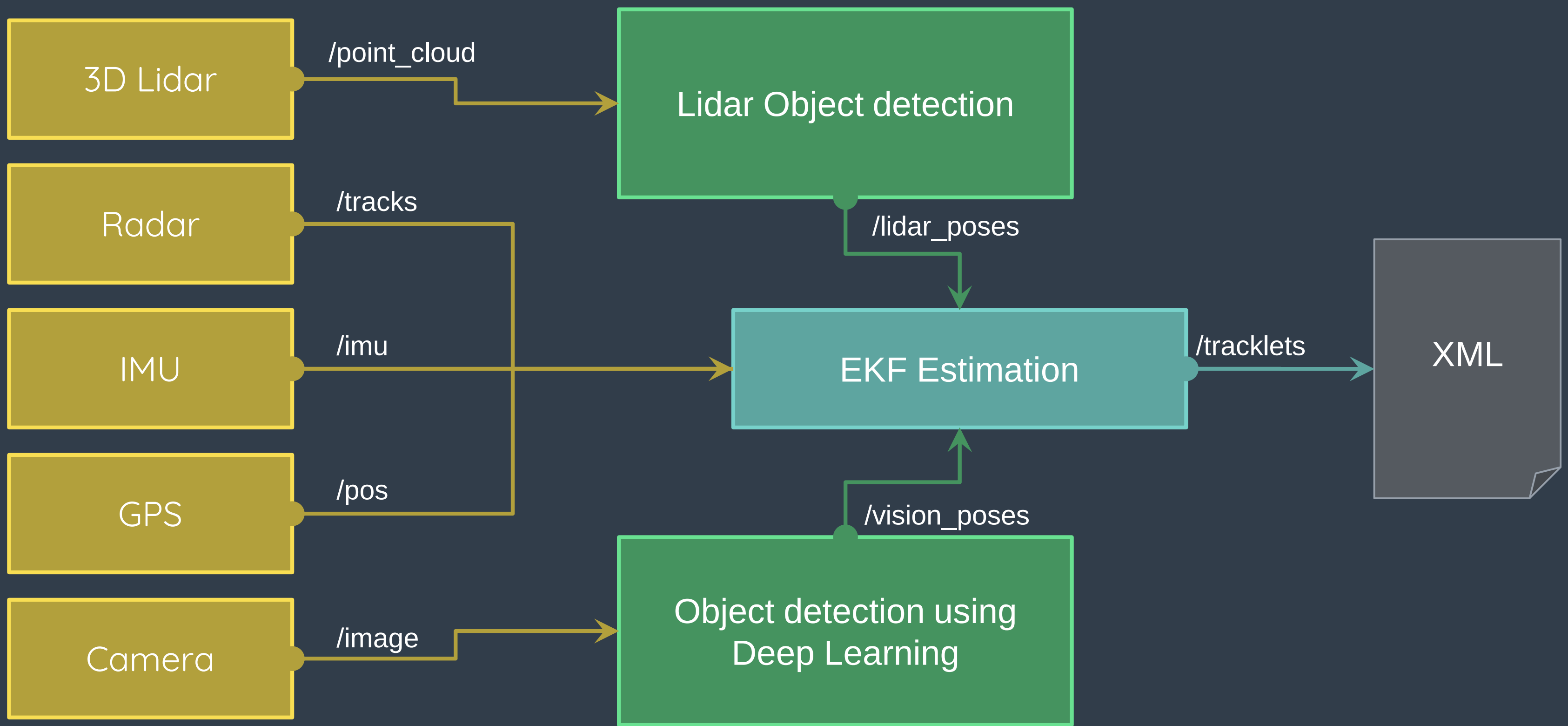
Examples: Car I





Oliver Cameron	**CEO, Voyage**
Zhaoyin Jia	**Principal Engineer, DiDi Research Lab**
Ilya Shimchik	**Innopolis University**
Ruslan Mustafin	**Innopolis University**
Peter Norvig	**Research Director, Google**
David Silver	**Self-Driving Car Lead, Udacity**
Anthony Navarro	**Self-Driving Product Lead, Udacity**

Architecture



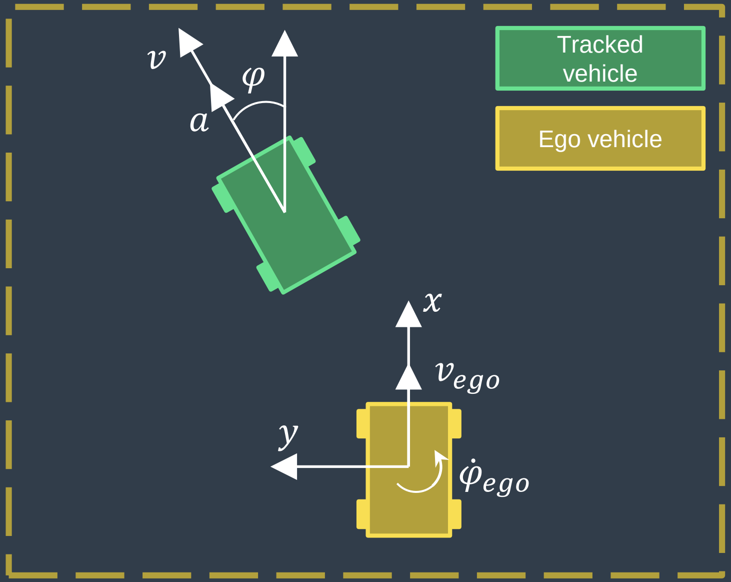
EKF Estimation

State vector:

$$x, y, \varphi, v, a, v_{ego}, \dot{\varphi}_{ego}, a_{ego}$$

System model:

$$
\begin{aligned}
x &= \left(v\cos(\varphi) - v_{ego}\right)dt + x\cos\left(\dot{\varphi}_{ego}dt\right) - y\sin\left(\dot{\varphi}_{ego}dt\right)\\
y &= v\sin(\varphi)dt + x\sin\left(\dot{\varphi}_{ego}dt\right) - y\cos\left(\dot{\varphi}_{ego}dt\right)\\
\varphi &= \varphi - \dot{\varphi}_{ego}dt\\
v &= v + adt\\
a &= a\\
v_{ego} &= v_{ego} + a_{ego}dt\\
\dot{\varphi}_{ego} &= \dot{\varphi}_{ego}\\
a_{ego} &= a_{ego}
\end{aligned}
$$

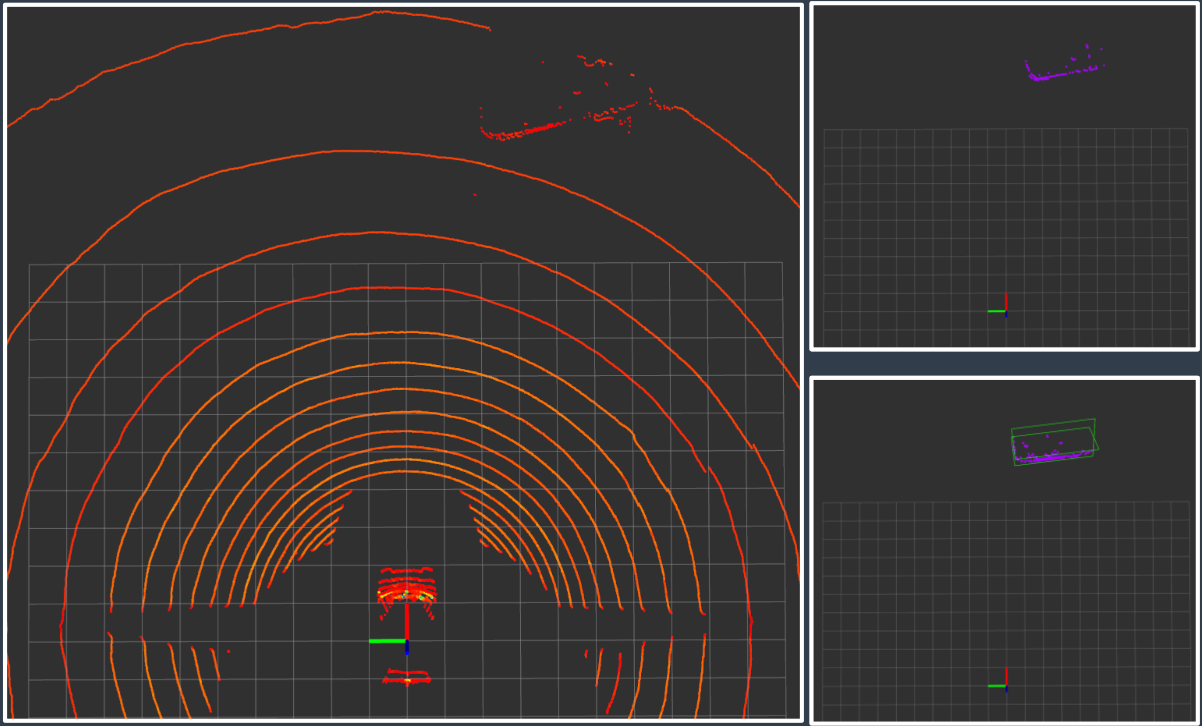


Main features:

- Speed and rotation of a vehicle is considered
- Delay of sensors data is taken into account

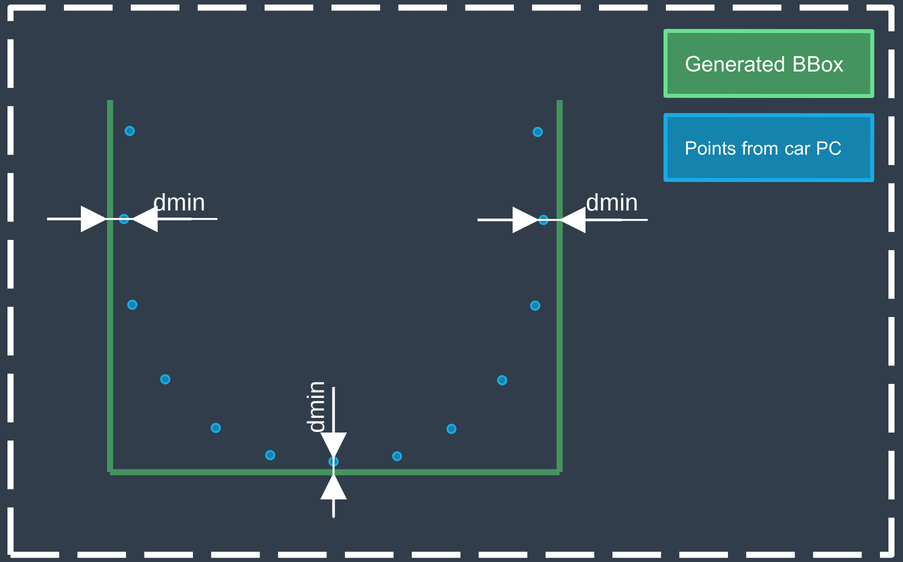
Lidar Object Detection

- Lidar
- Remove EGO Vehicle
- Find and remove Ground Plane
- Clusterization
- Select a cluster related to vehicle
- Shape alignment around the cluster



Shape alignment

- Each particle is a parallelepiped with different parameters: x, y; width, length, height
- We generate a particle in the center of a found cluster using normal distribution
- Each parallelepiped plane has a different weight. The nearest plane has the maximum weight

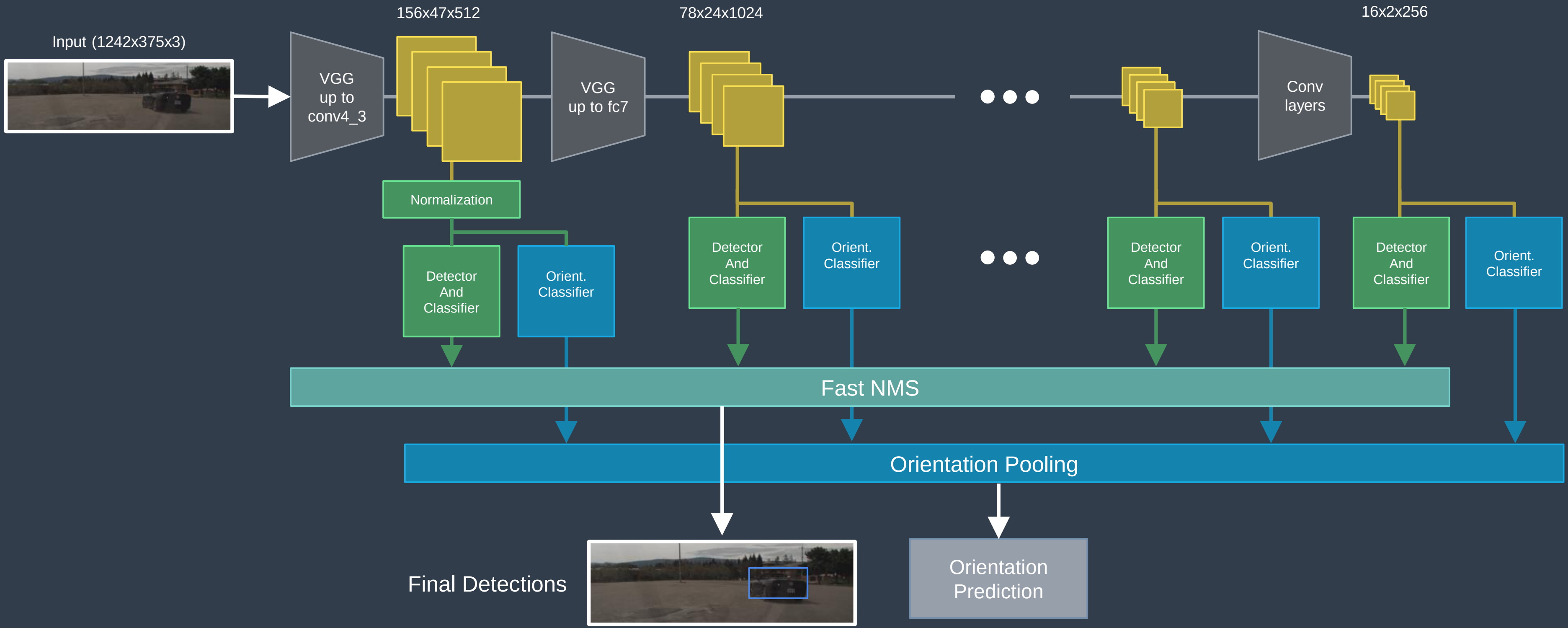


Particle weight is

$$w = \sum_{i=1}^{n} w_{pl} e^{-\frac{d_i^2}{2\sigma}}$$

where $\boldsymbol{w_{pl}}$ stands for the weight of the nearest plane,
d_i is the distance to the nearest plane from the point i,
n is the number of points inside the parallelepiped
σ is the weight coefficient of each cloud point

Object detection using Deep Learning (Camera)

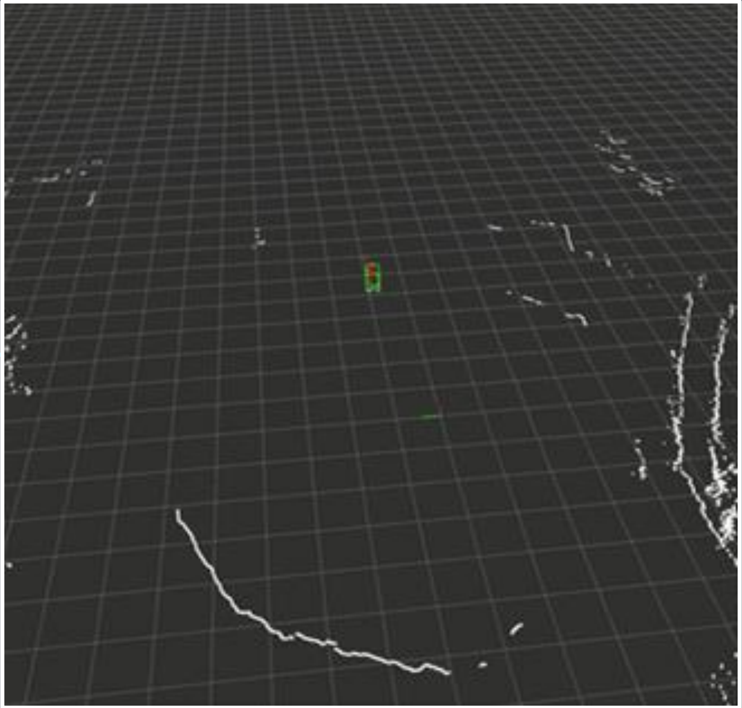


Examples: Car II

3D Point Cloud + Radar

IMU+GPS

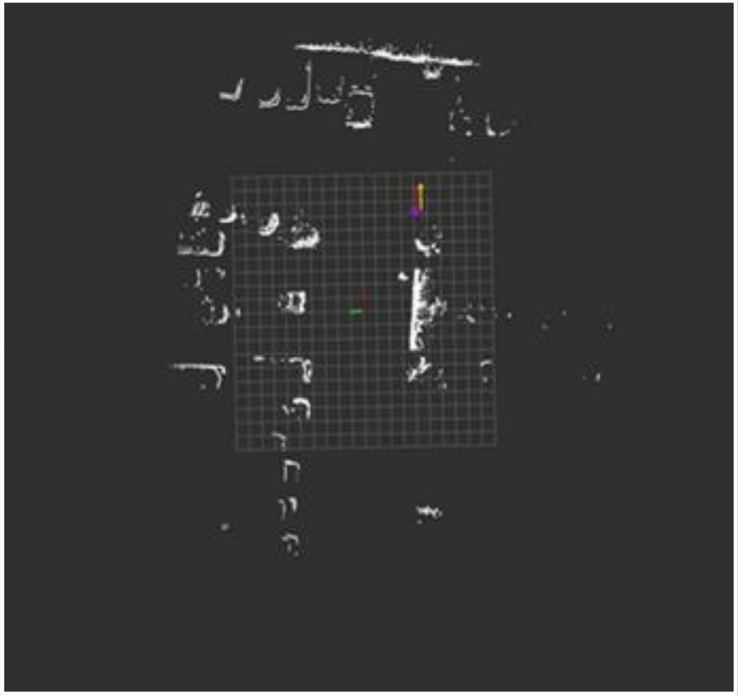
Detection and Tracking



Examples: Pedestrian

3D Point Cloud + Radar

Detection and Tracking



IMU+GPS

Team

Background:
Research in the field of Robotics at Innopolis University

- Nonlinear MPC for a race car
- Getting ready for a competition of autonomous racing cars

Reflections

Tried different approaches and neural networks

Increased performance thanks to reducing the number of cloud points

Added orientation to SSD network instead of using a separate CNN for orientation

Speeded up the development process due to the access to the high-performance GPU

Future work

Improve detection with lidar and stay in realtime

Use a larger training dataset to improve the quality of visual detection

Detect steering wheels position of a car

Multiple object tracking in realtime

Thank you!