Pidur või gaas? Takistuste tuvastamisest.

Edgar Sepp
Isejuhtivate sõidukite labor
https://adl.cs.ut.ee/

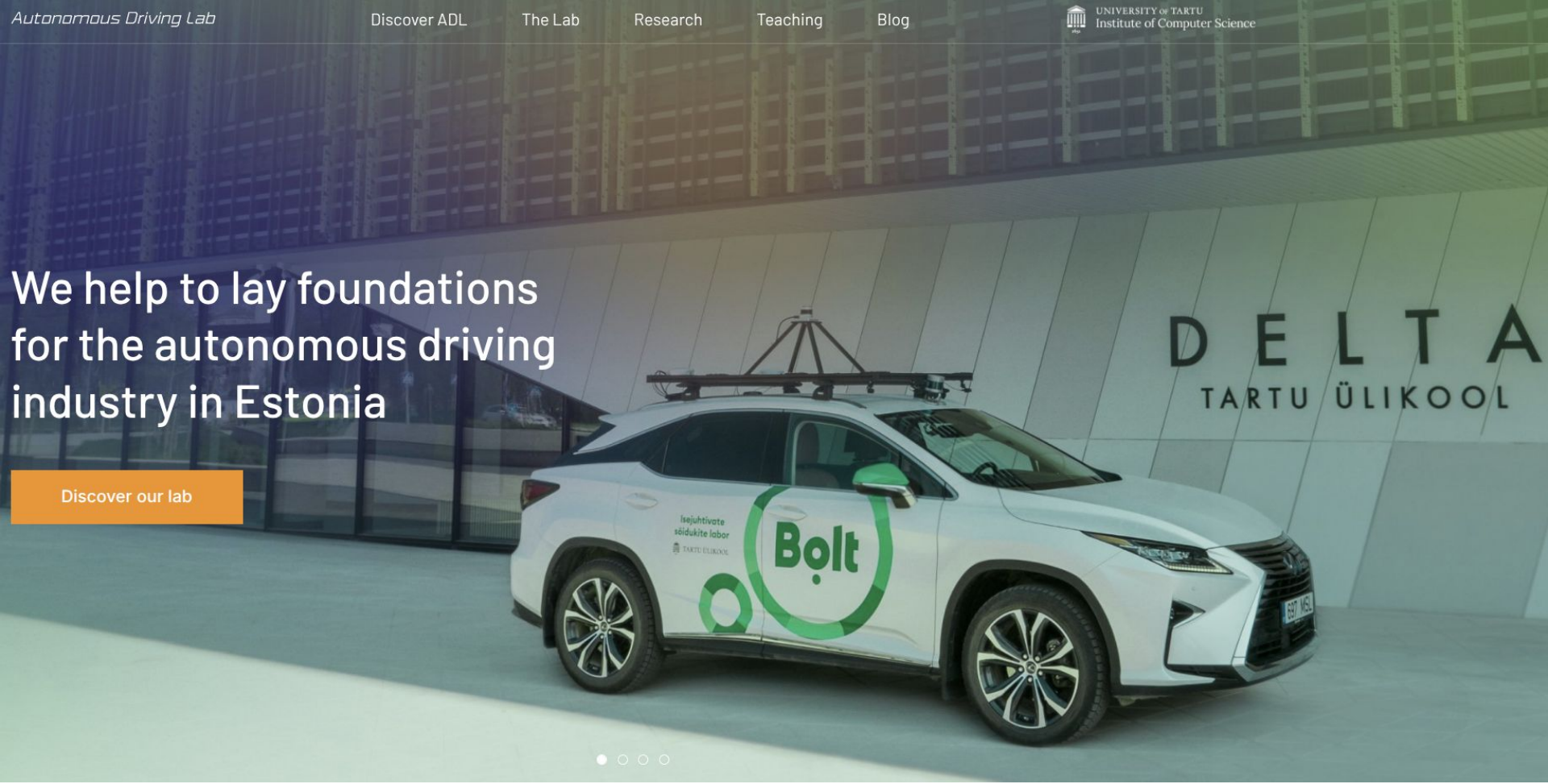
29.10.2025
Tallinn

Bolt

UNIVERSITY OF TARTU
Institute of Computer Science

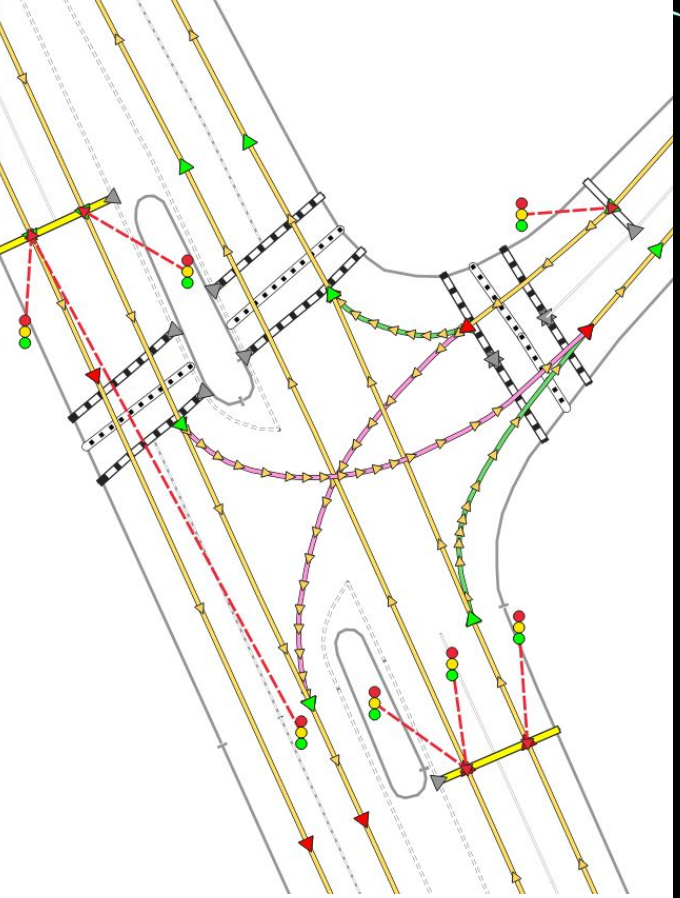
Autonomous Driving Lab

Autonomous Driving Lab



We help to lay foundations for the autonomous driving industry in Estonia

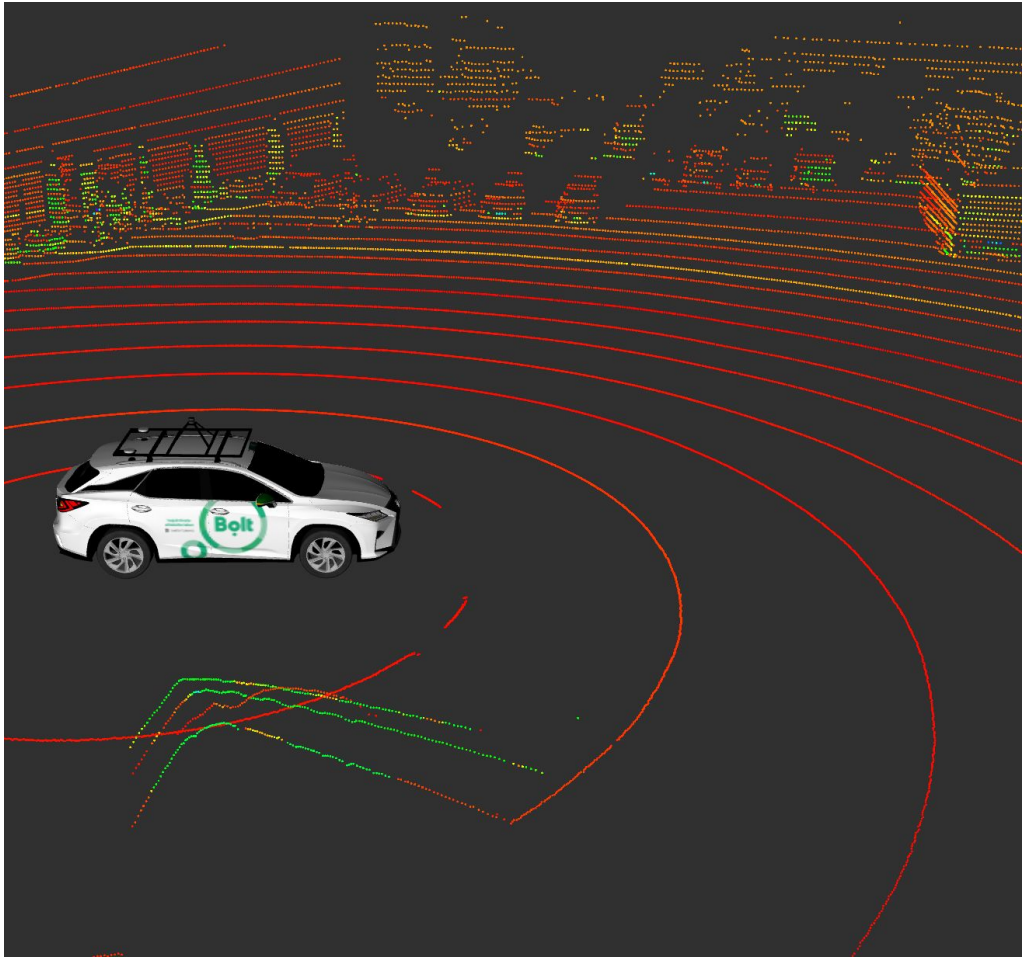
Discover our lab



Autonomous Driving Lab

Lidar auto katusel

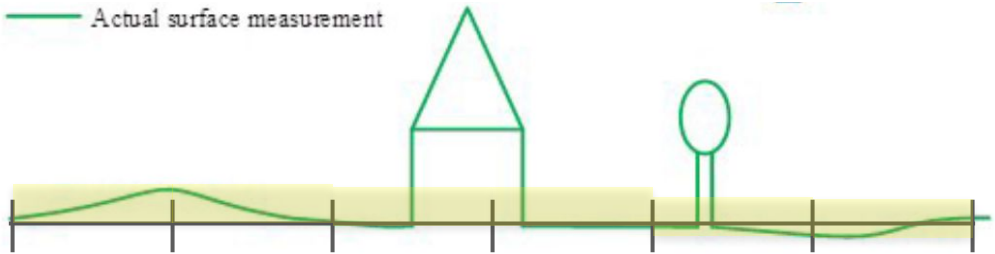
demo



Objektid (takistused)

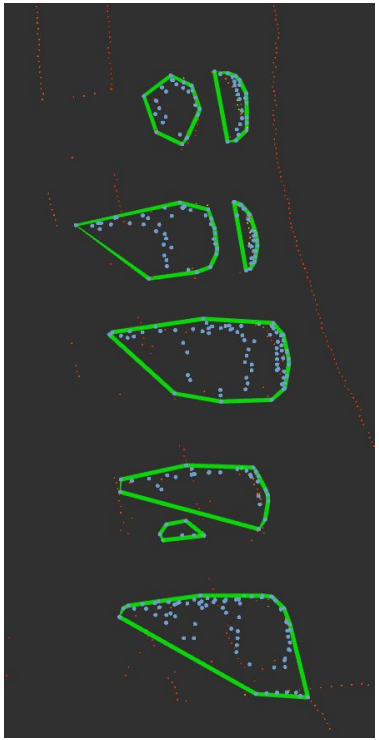
Maapinna eemaldus - lihtsustatud

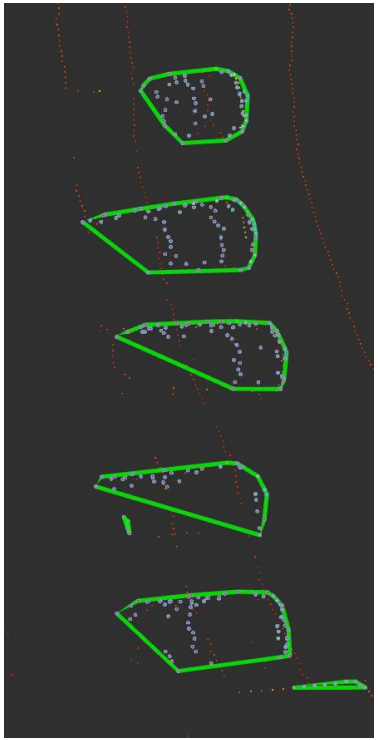
1. Jagame ümbruse ruutudeks (2D)
2. Leia iga ruudu kõige madalam punkt
3. Määra sellest z puhvri sisse jäävad punktid maapinnaks
4. Kõik teised punktid on mingid takistused (mitte maapind)



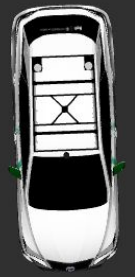
Klasterdamine – DBSCAN algoritm – 2D

- Ei pea täpsustama klastrite arvu
- 2 hästi interpreteeritavat parameetrit
  - Minimaalne punktide arv
  - Kaugus
- Oskab kasutada ruumi indekseid
- Saab hästi hakkama müraga
- Ei tekita ühenduslülisid läbi üksikute punktide





Objektid



unknown 52 (0 km/h)

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unknown 64 (0 km/h)

wn 21 (0 km/h)

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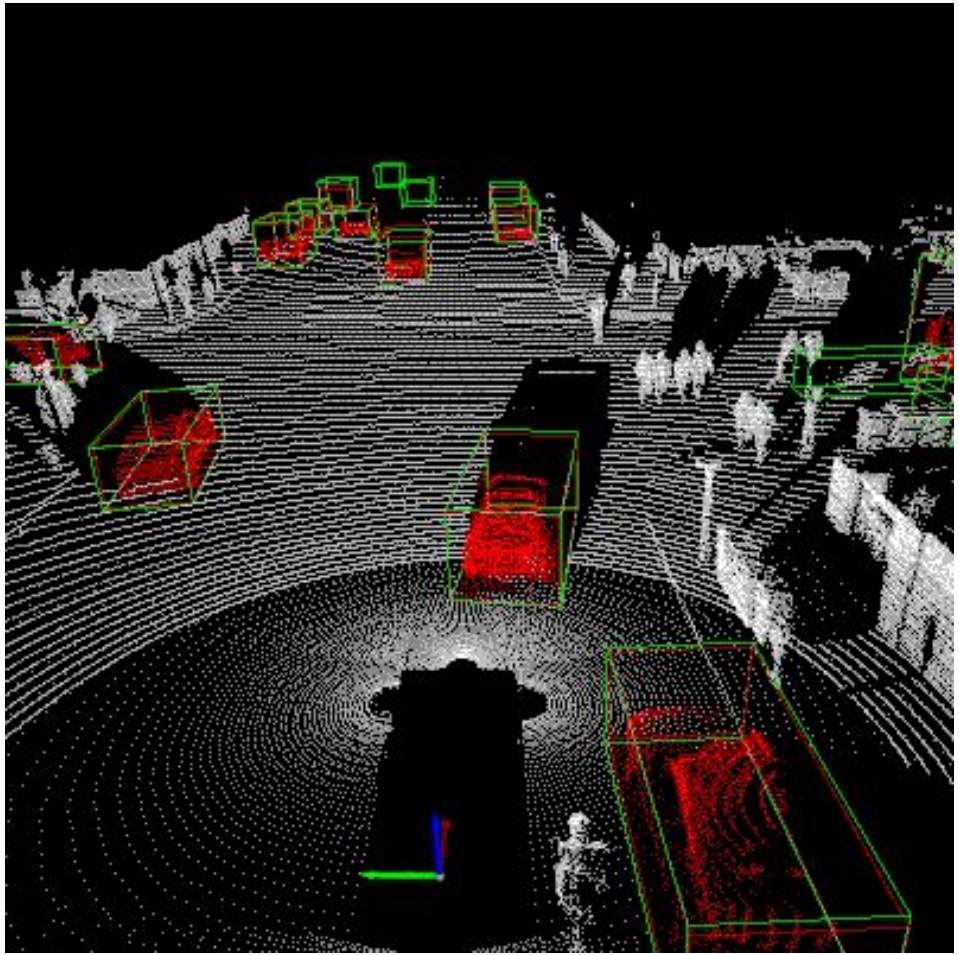
unknown 66 (0 km/h)

Masinõpe vs algoritmiline lähenemine

- Programmeerimine
  - Kood (ja parameetrid) vs andmed
- Tundmatu objekti / klassi probleem
- “Avatud ukse” probleem



Pilt: https://learnopencv.com/3d-lidar-object-detection/

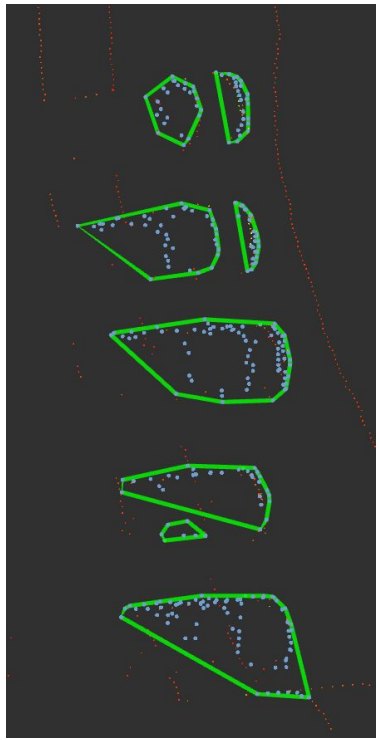
Algoritmiline lähenemine
Kuidas parandada?

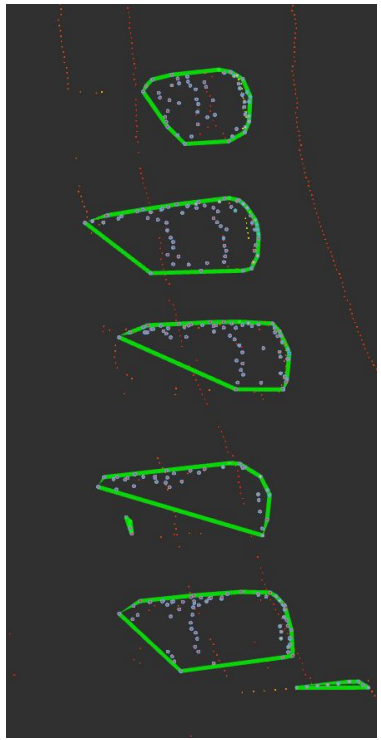
Lisame juurde 2. Lidari

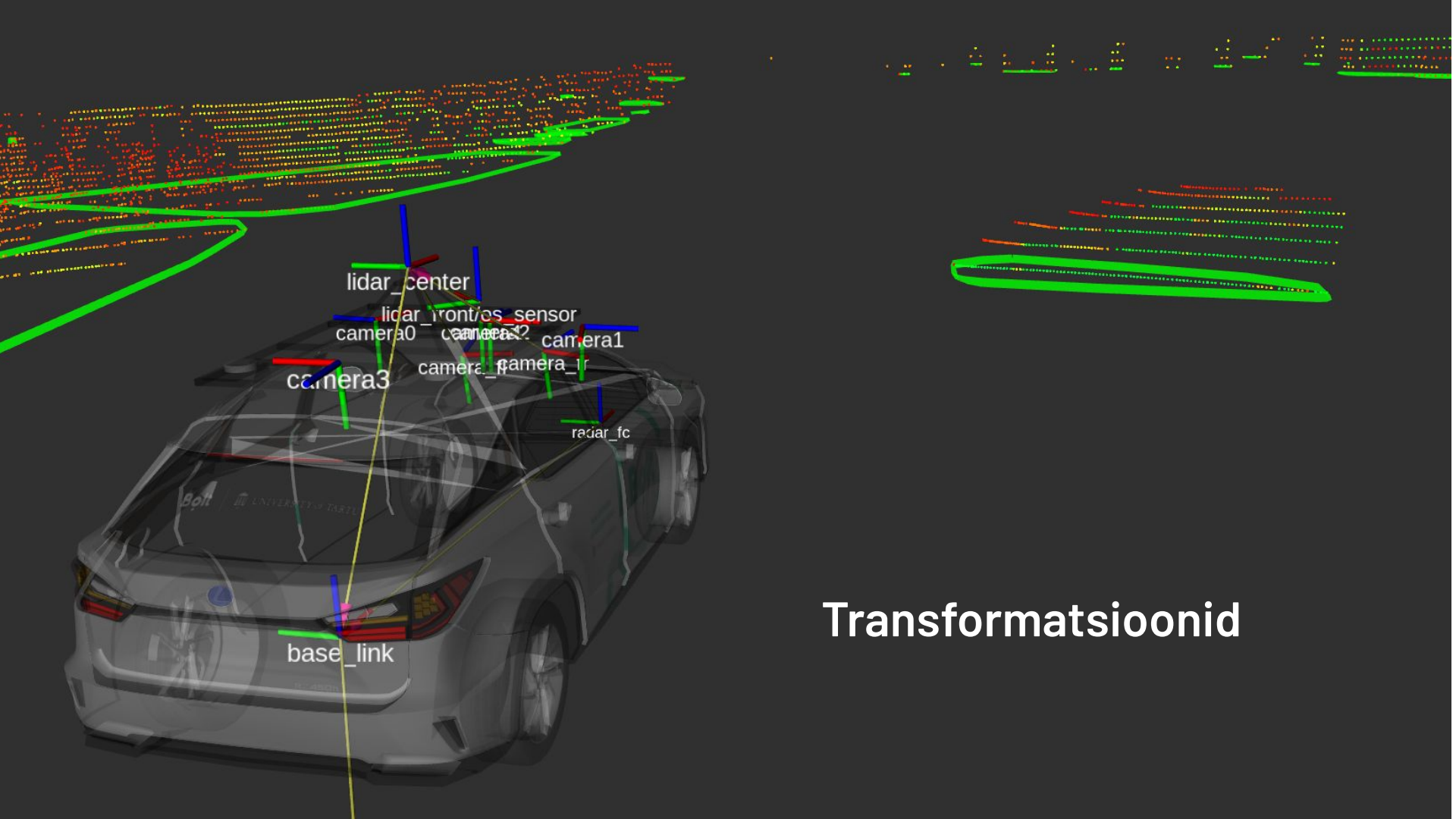
Saame tihedama punktipilve

- Ajaline sünkroniseerimine
- Skaneerimise algussuund
- Transformatsioonid

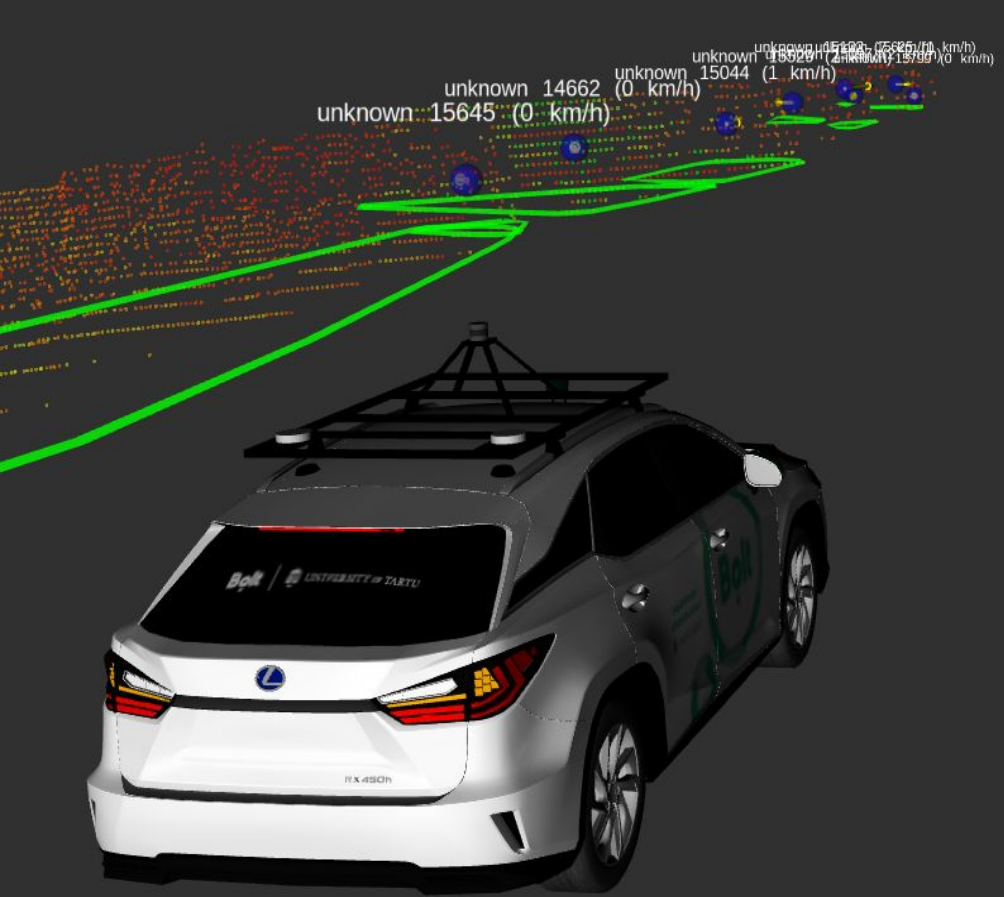
- Auto liigub ja kõigub
- Probleemid maapinna eemaldamisel



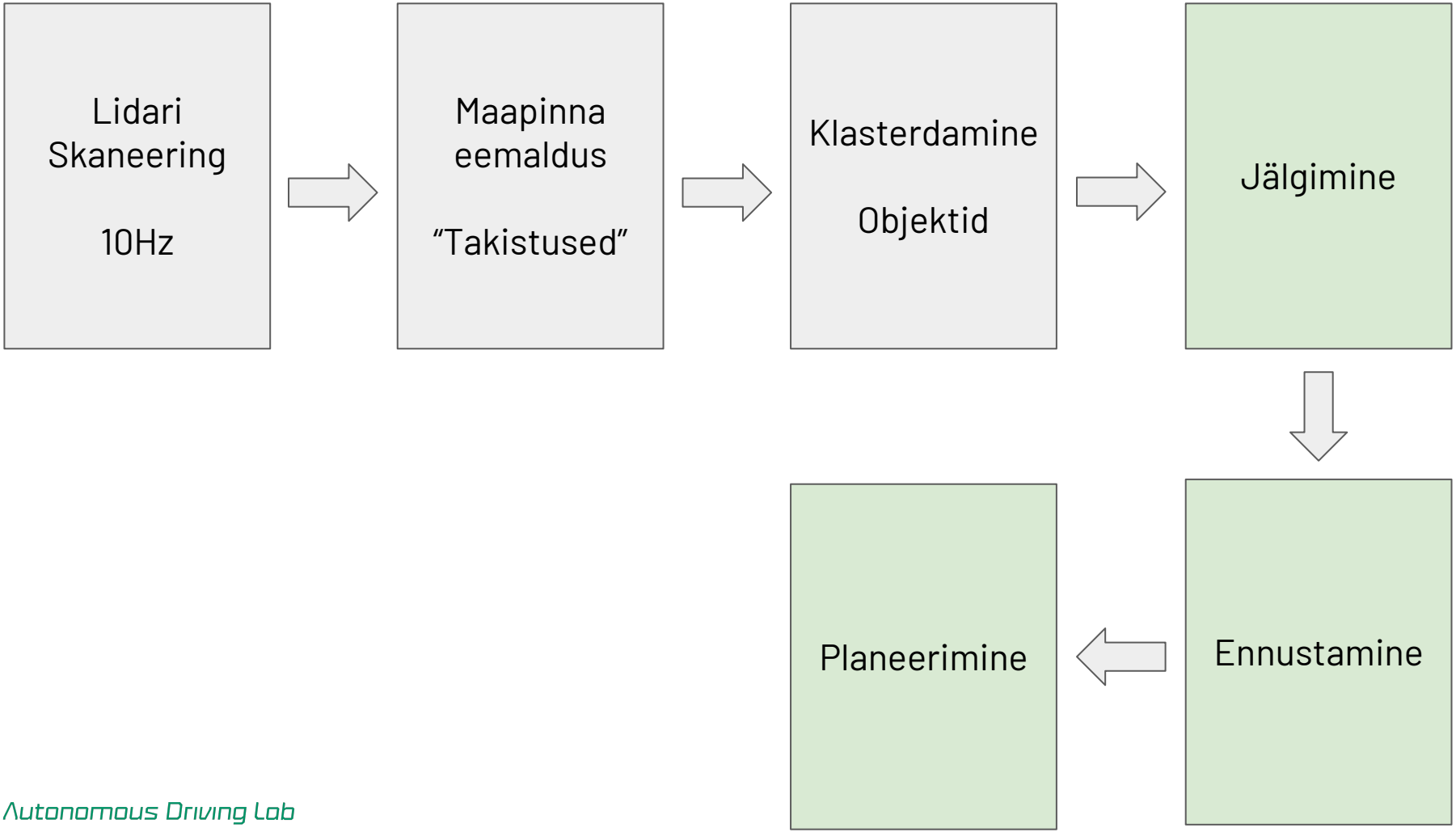




Transformatsioonid

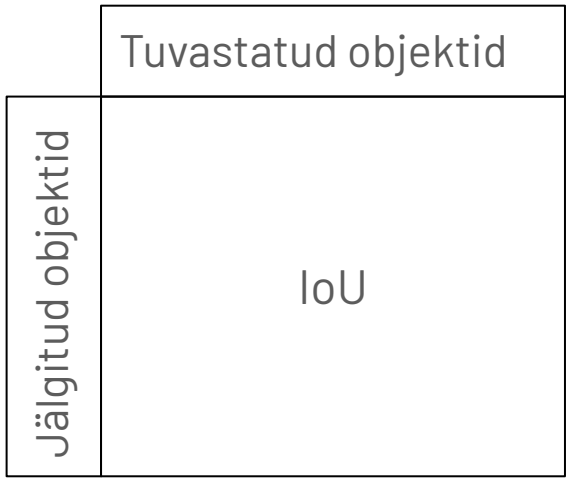


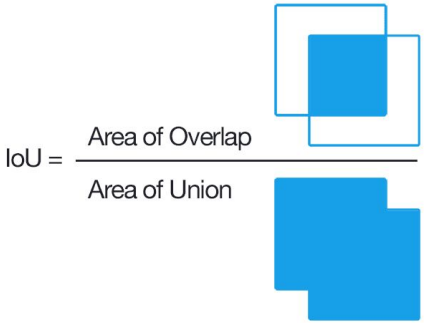
Mida tahame objektide kohta veel teada?


Lidari
Skaneering
10Hz
Maapinna
eemaldus
“Takistused”
Klasterdamine
Objektid
Jälgimine
Ennustamine
Planeerimine

"Tracking" – Jälgimine

- Lihtsustus ja arvutuslik kiirus – *Axis Aligned Bounding Box*
- *Intersection over Union*
- Ungari meetod
- Objektide liikumisega arvestamine





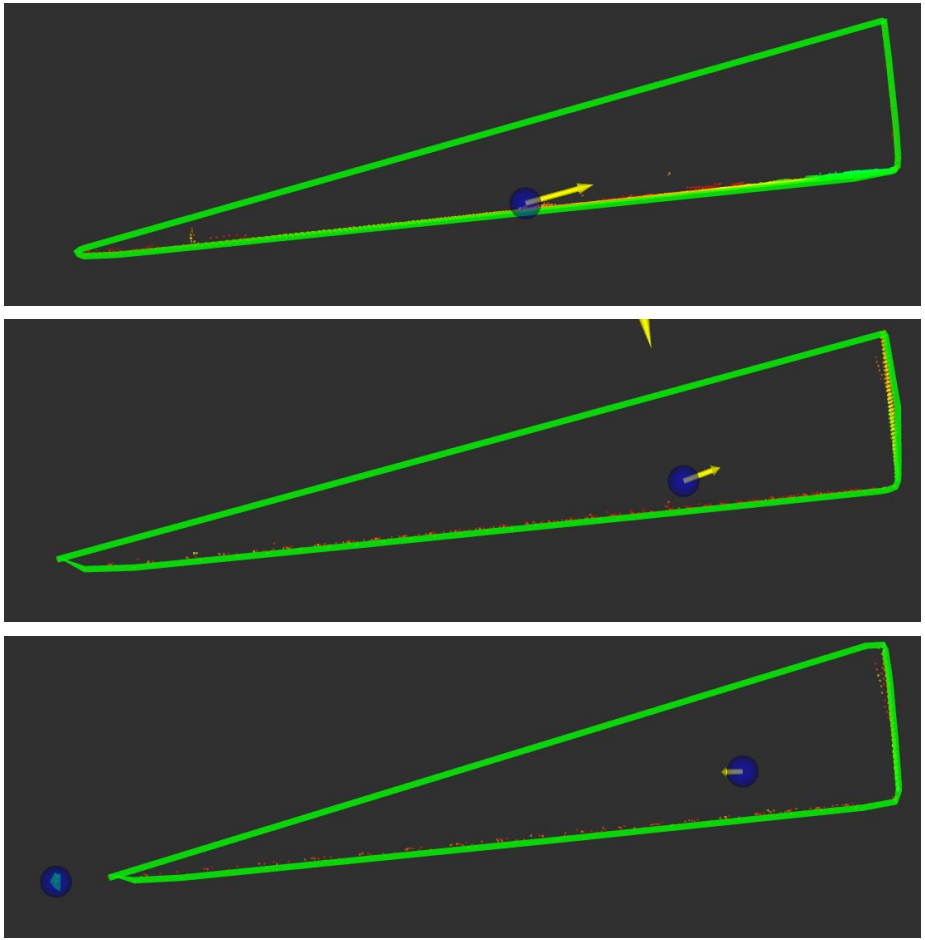
Objekti kiirus

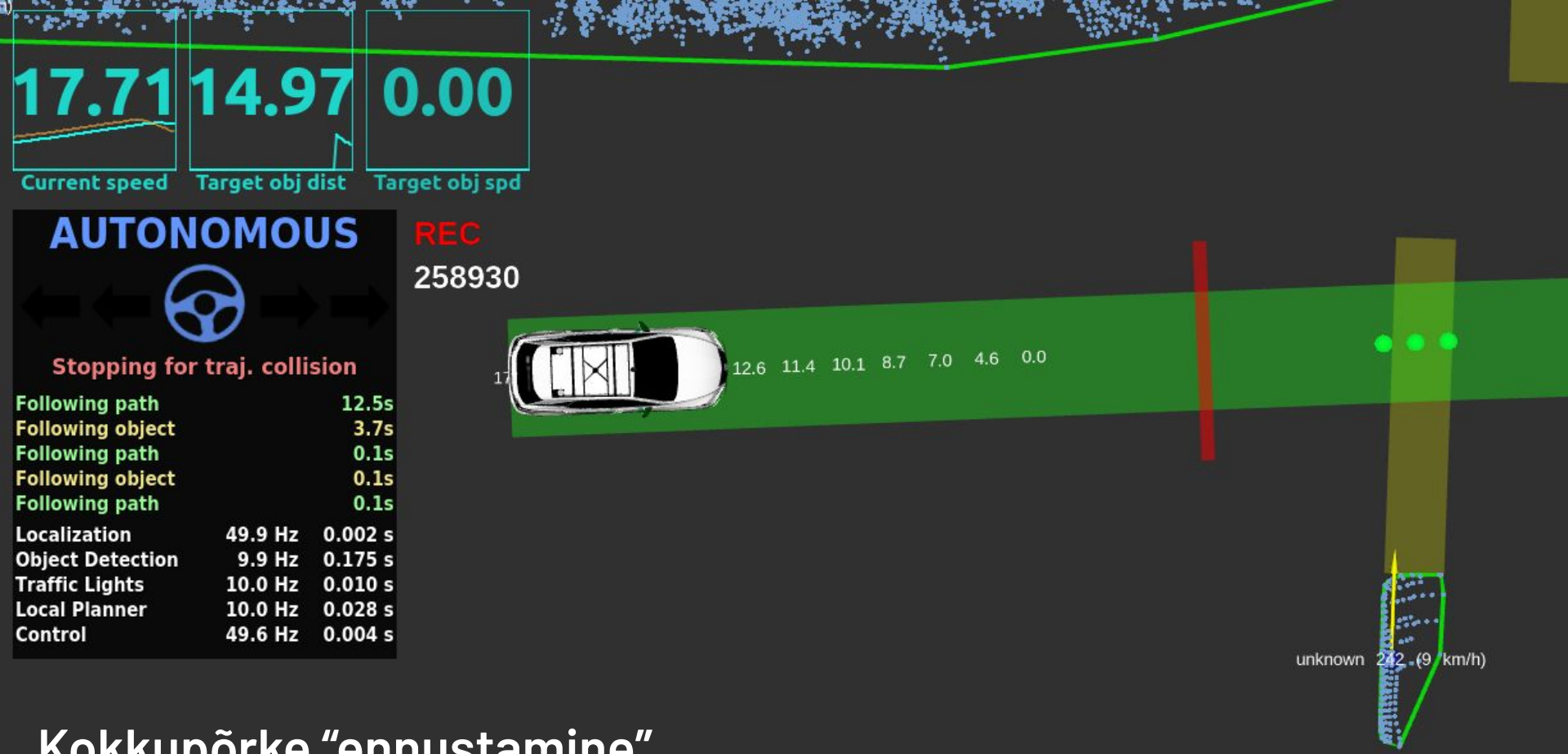
Objekti esinduspunkt

- Klastri keskpunkt (*convex hull*)
- lidari punktide (filtreeritud / filtreerimata) keskmine

Esinduspunkti nihkumine läbi aja (0,1 sek)

Kiiruse keskmistamine
(*Exponential moving average*)



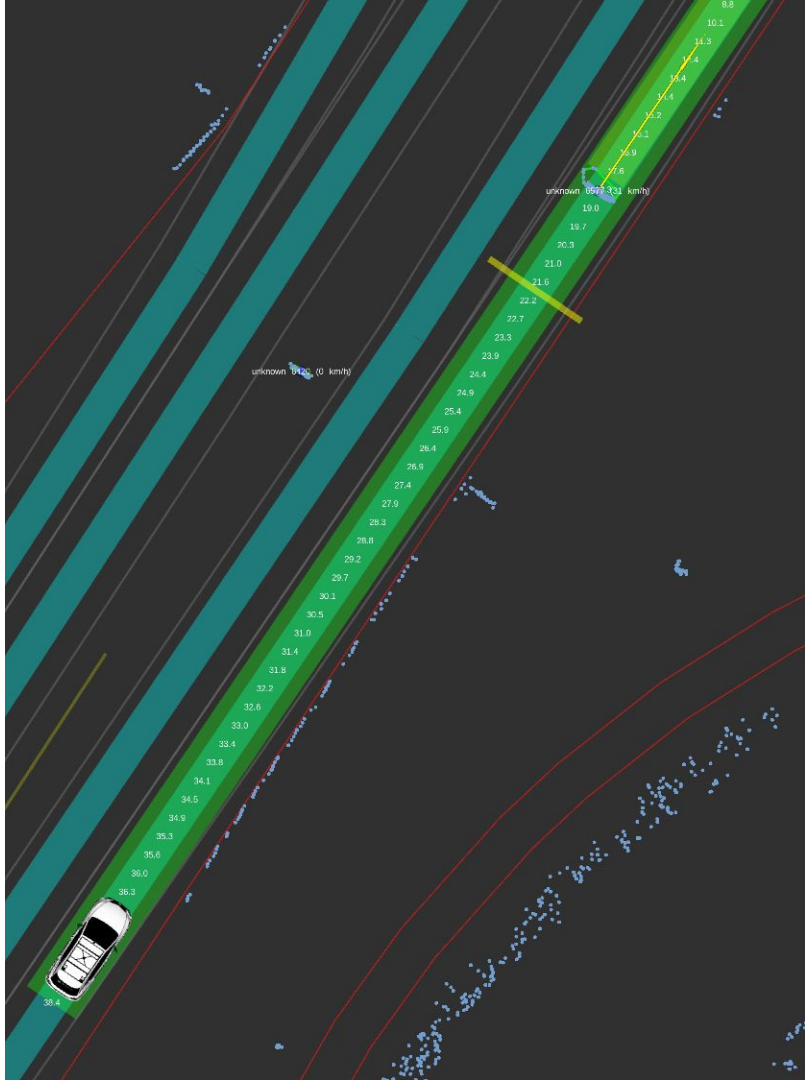


Kokkupõrke “ennustamine”

Olukord 1

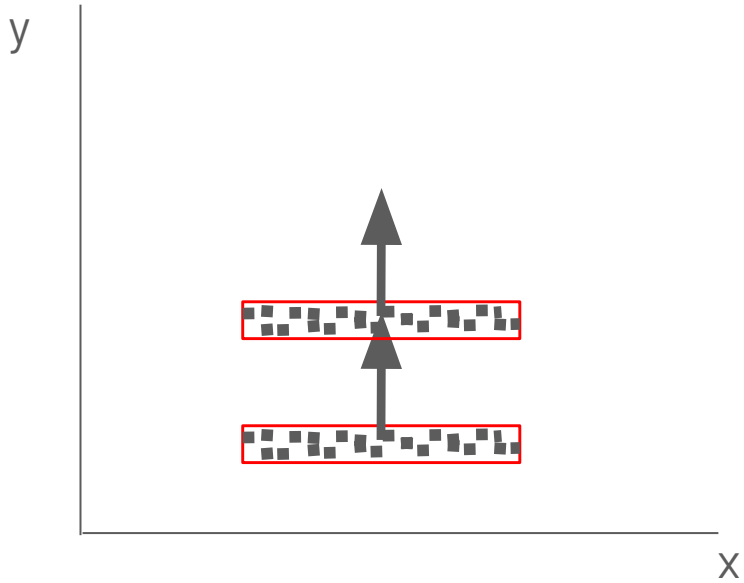
demo

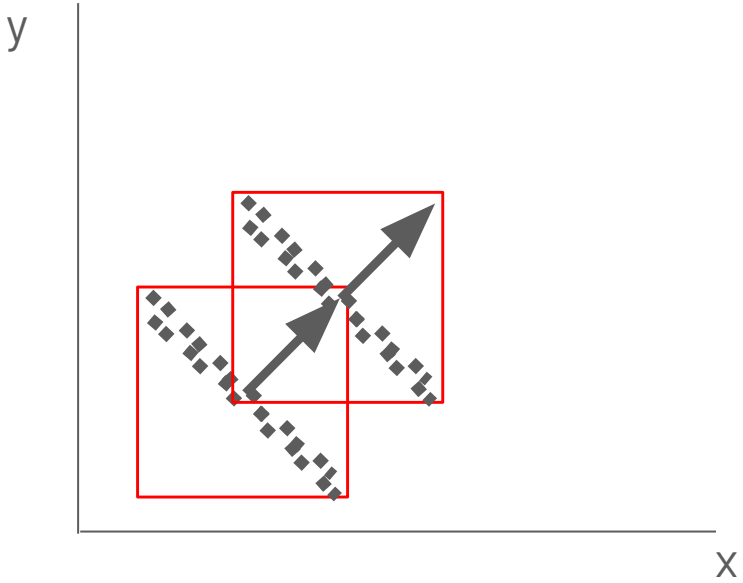
- Reageerimine eesolevale autole



Kaardivõrk ja objektide sobitamine

- Axis-aligned bounding box
- IoU





Radar

- Ajaline sünkroniseerimine ja transformatsioonid
- Radari kiirus vs kiiruse vektor

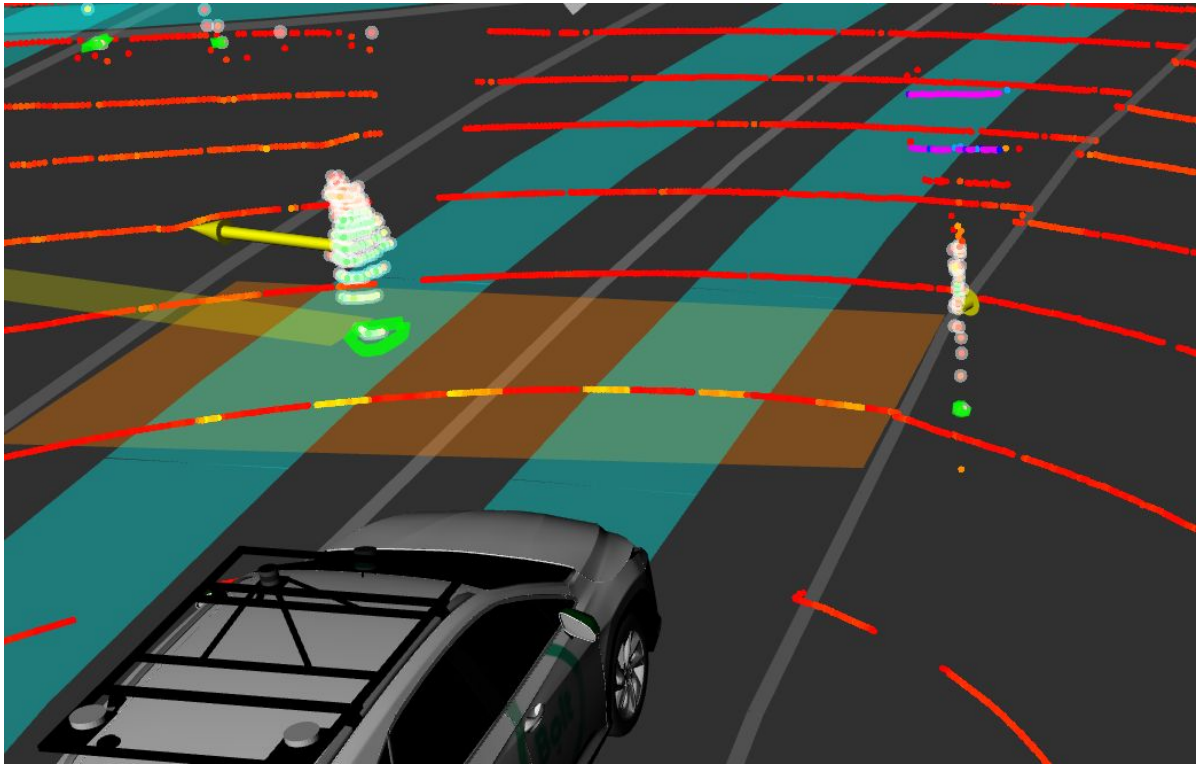
Jälgija: objekti tekitamine ja elus hoidmine

`demo`

Olukord 2

demo

- Jalakäija tuvastamine



Aitäh!

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