Information Integrity for Automated Vehicles: Localization, Maps and Perception

Philippe Bonnifait

Professor at the
Université de Technologie de Compiègne, Alliance Sorbonne Université
Heudiasyc UMR 7253 CNRS, France

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for Automated Vehicles
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SIVALab

This joint laboratory's research focus is on controlling the integrity of navigation information for ADAS functions and autonomous navigation in intelligent vehicles

Main focus on

- Perception
- Localization
- Digital maps

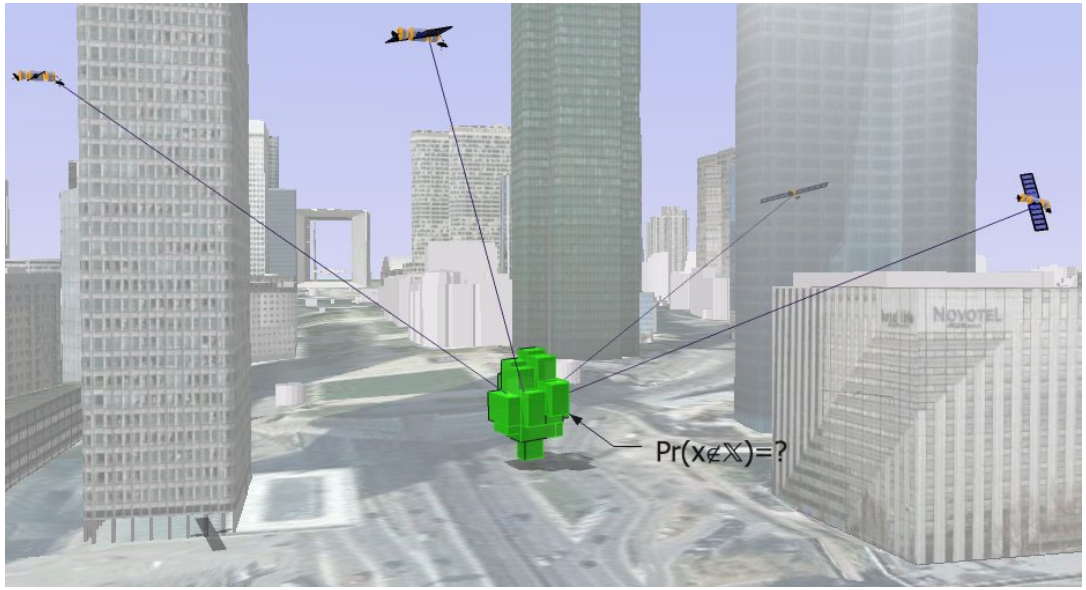
heudiasyc

Renault Group

IEEE ITSC 2023

Complex and opened navigation environments

Information sources can be severely disturbed



Information integrity

" I prefer not to know where I am than to think I am where I am not "

A statement attributed to one of the Cassini brothers,

the famous French geographers

who first mapped France (16th century)

César-François Cassini

A high-integrity system is a system that provides erroneous information at a very low rate

Integrity monitoring depends on the use of the information and therefore on the navigation tasks to be performed

Information integrity

The integrity problem is due to unavoidable uncertainties associated with the information provided by the sources

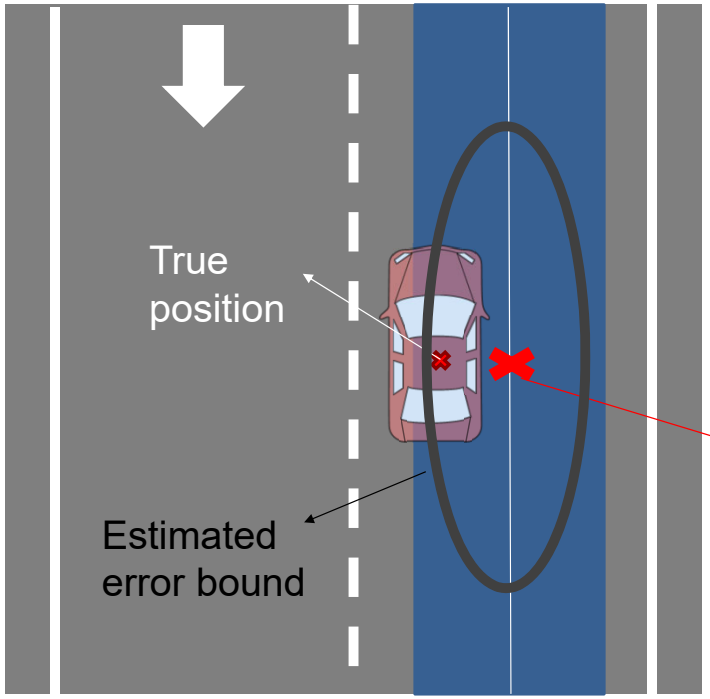
Information has to be

- Accurate enough for the tasks to be performed
- Available at a sufficiently high rate
- Non-misleading and Trustworthy

Integrity involves combining and merging data from complementary, diversified and redundant sources

- Complementarity for covering all possible situations in a given ODD
- Diversification enables the system to adapt to navigation conditions
- Redundancy is necessary for fault detection and isolation, and is useful for improving estimation quality

Bounding errors for autonomous driving



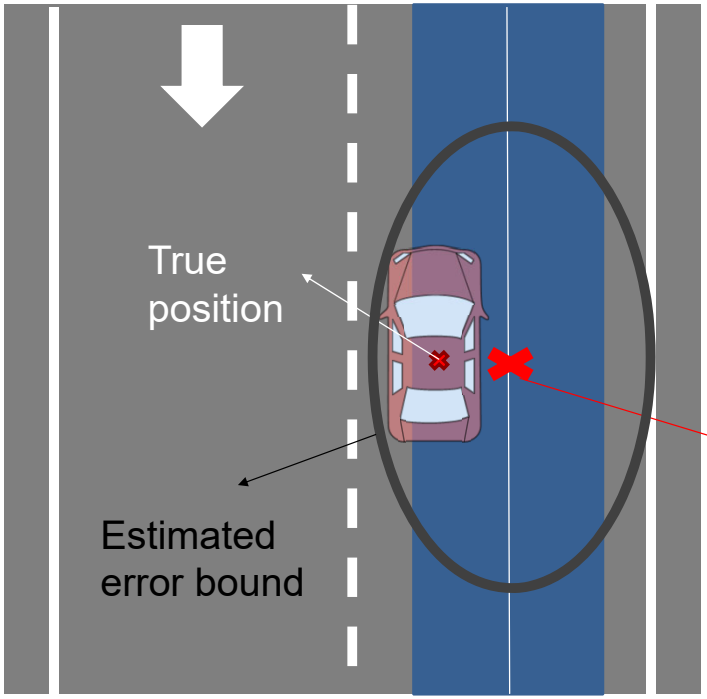
Nominal case e<PL<AL

estimated position

The error is correctly bounded. OK!

The bound is in the limit ➔ use

Bounding errors for autonomous driving



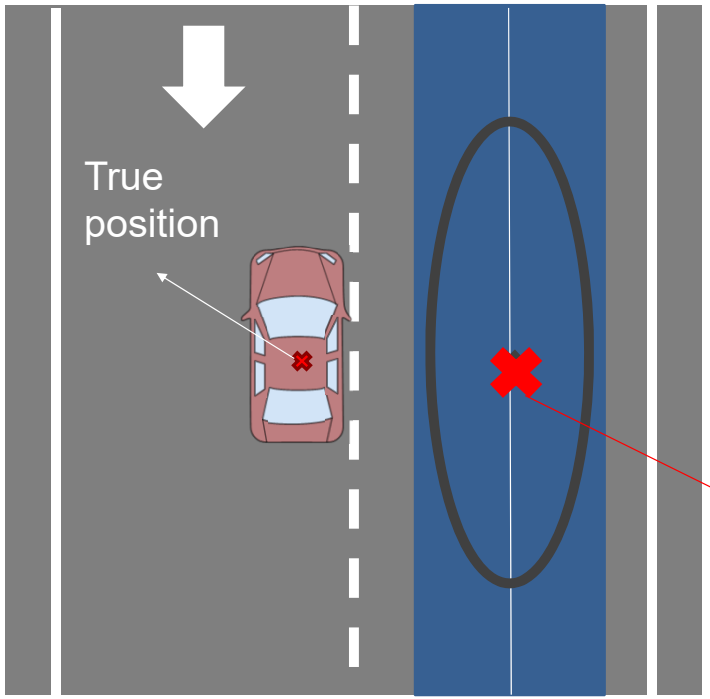
The localization system is unavailable

estimated position

The error is correctly bounded. OK!

The bound is out of the limit ➔ Don’t use

Bounding errors for autonomous driving



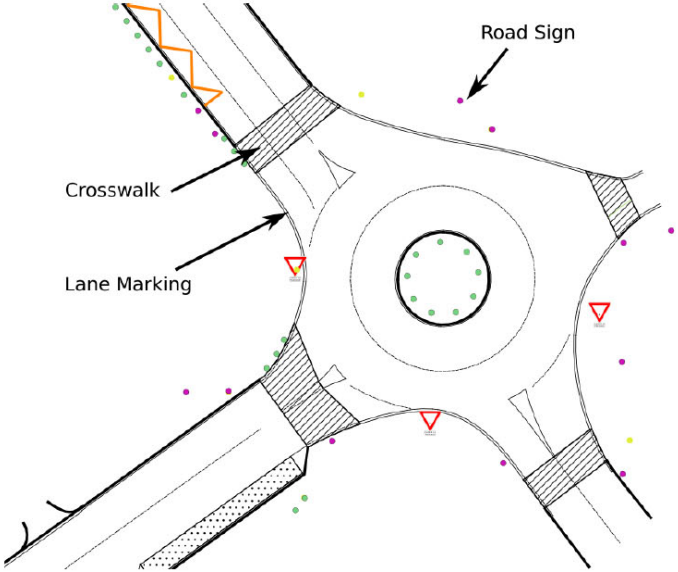
This is a situation of **misleading information**

Worst case scenario that can lead to an accident

The error is NOT correctly bounded

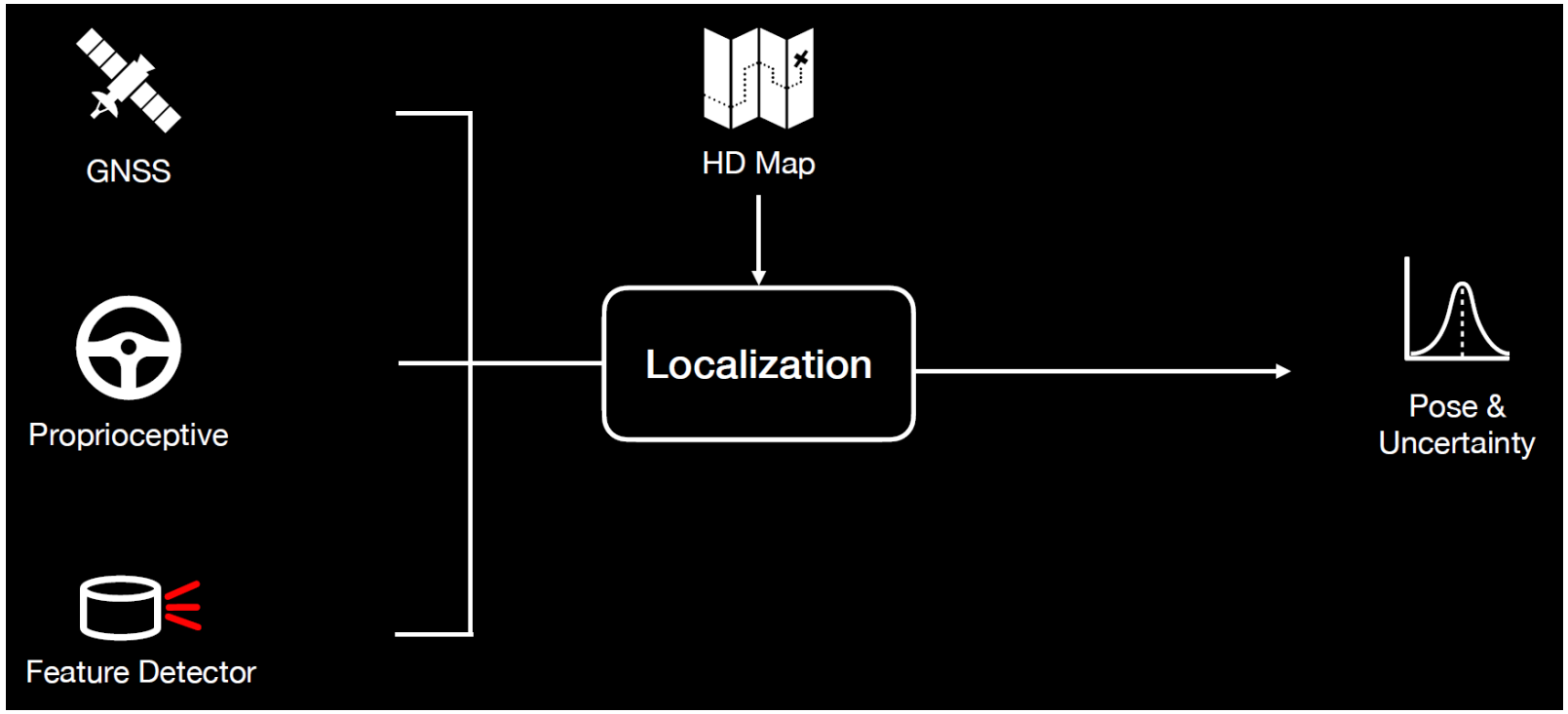
The bound is in the limit ➔ use

Map-aided localization

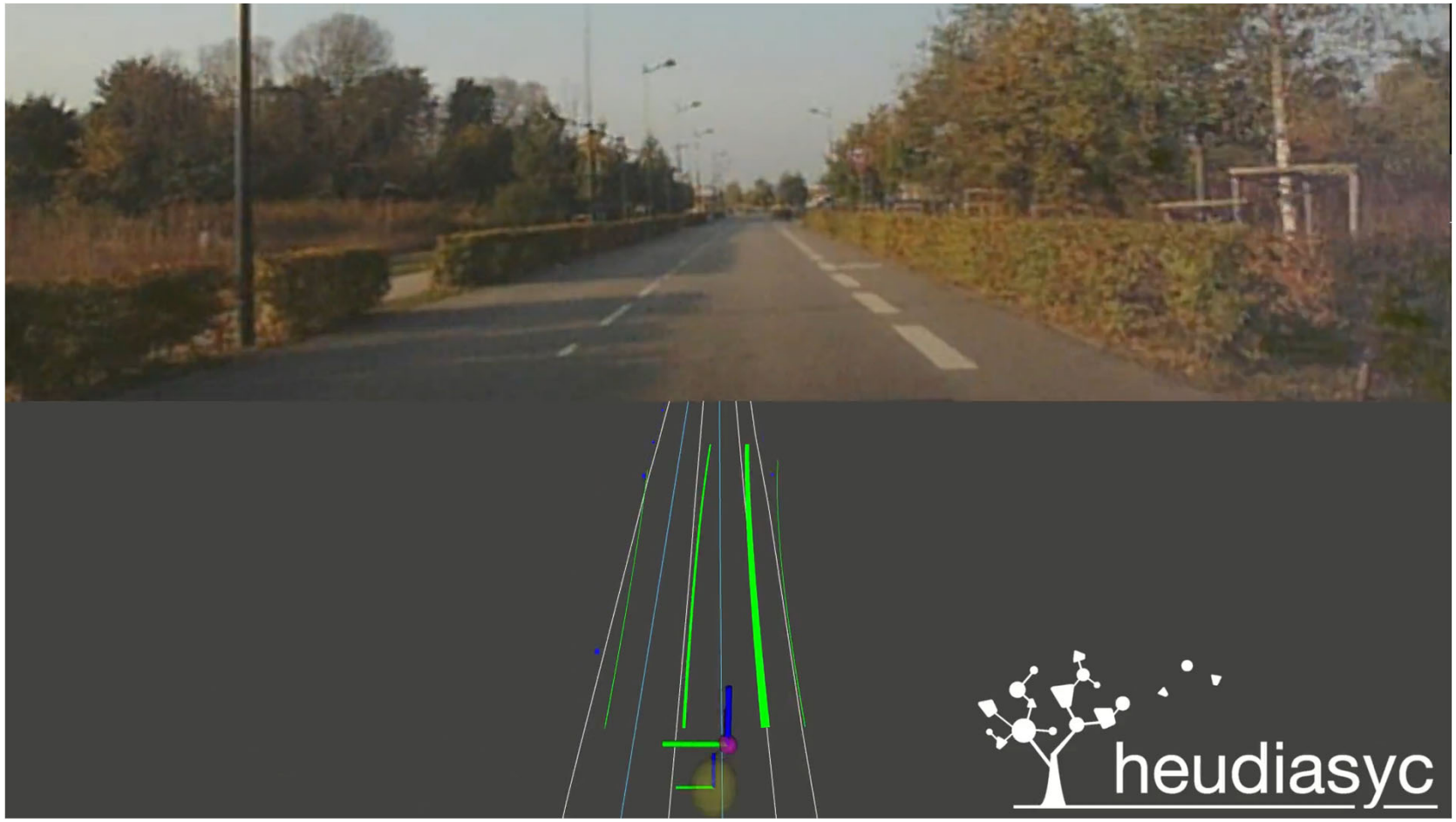


HD map

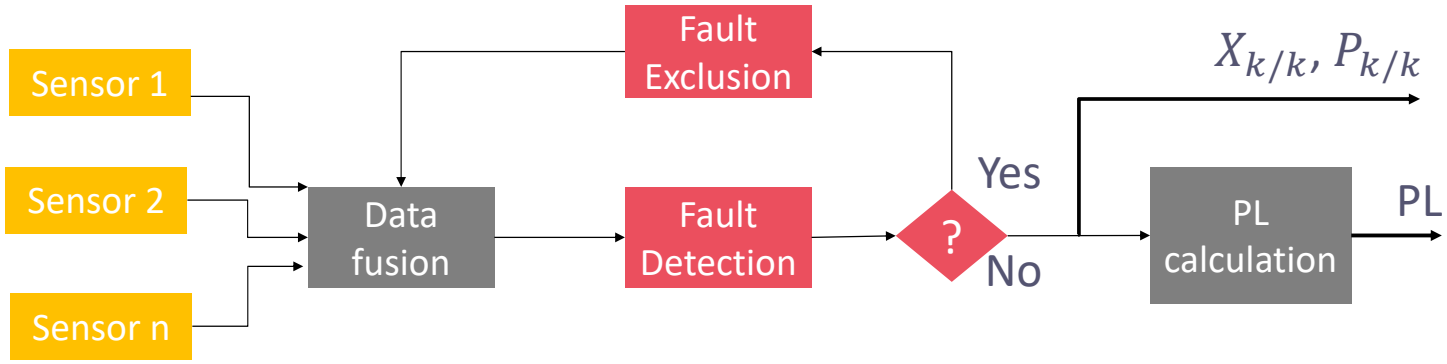
Localization Architecture



Localization with multi-lane camera measurements



Robust multi-sensor data fusion with FDE and PL computation



Faults are due to:

- GNSS NLOS
- Data association errors with the HD map
- Errors in georeferenced features

J Al Hage, N Salvatico, P Bonnifait, High Integrity Localization of Intelligent Vehicles with Students t Filtering and Fault Exclusion. IEEE ITSC 2023. Session [AGP03] Wednesday 27. 3 PM.

Map Error Detection

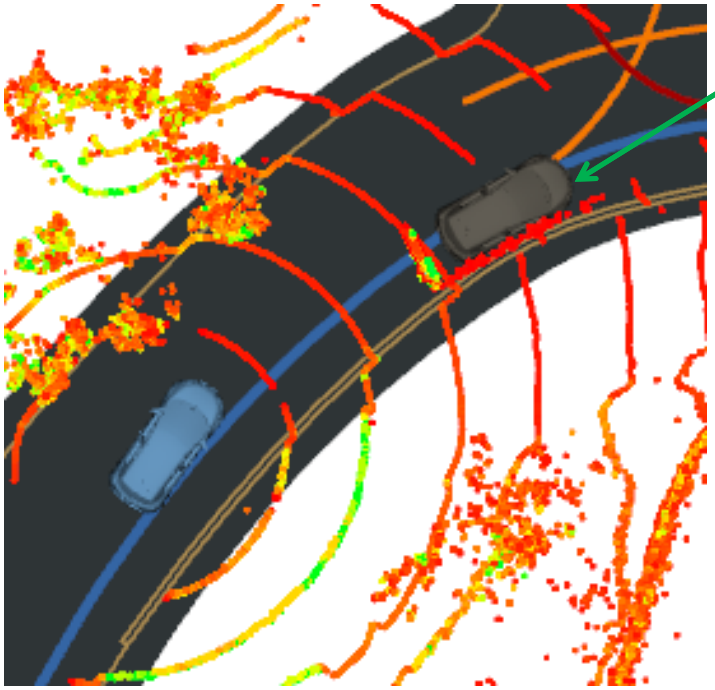
Map features (always) change

— They can be modified and they can get damaged

Proposed solution: post-processing of multiple drives using smoothing and residuals

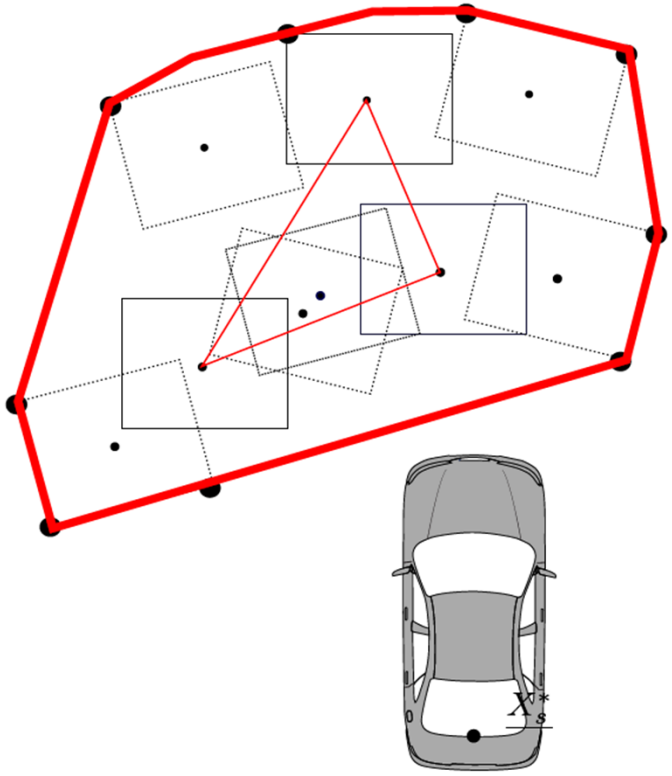
A Welte, P Xu, P Bonnifait, C Zinoune, HD Map Errors Detection using Smoothing and Multiple Drives, IEEE IV 2021

Localization Uncertainty Propagation on Perception

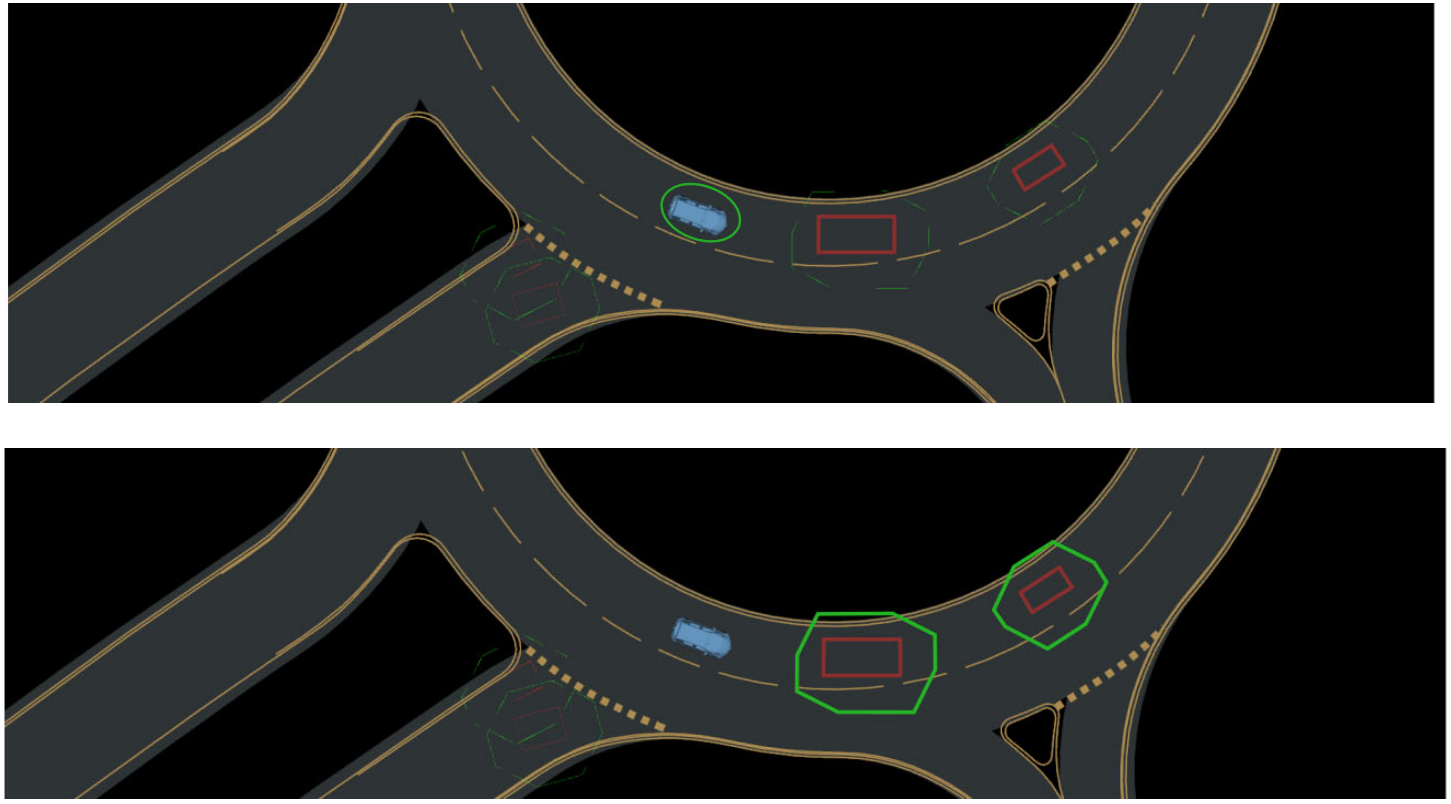


Lidar point cloud

Detected vehicle

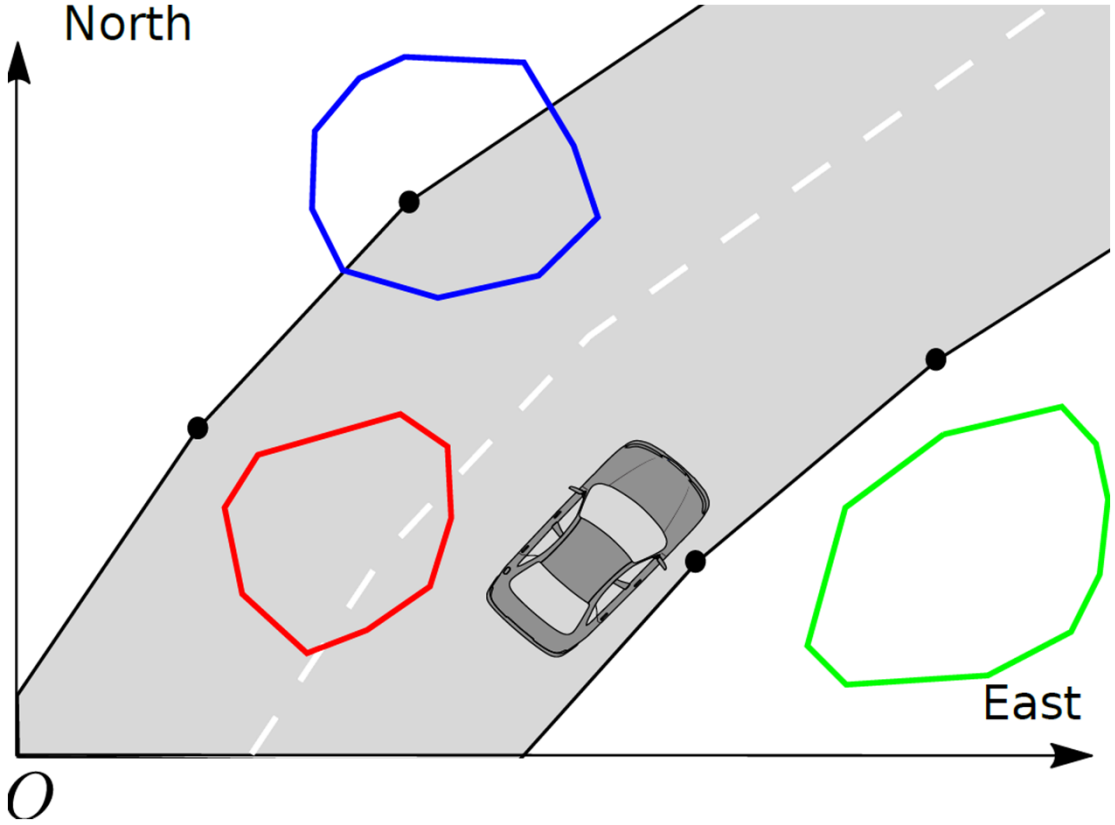


Perception Uncertainty Propagation



Map-filtering

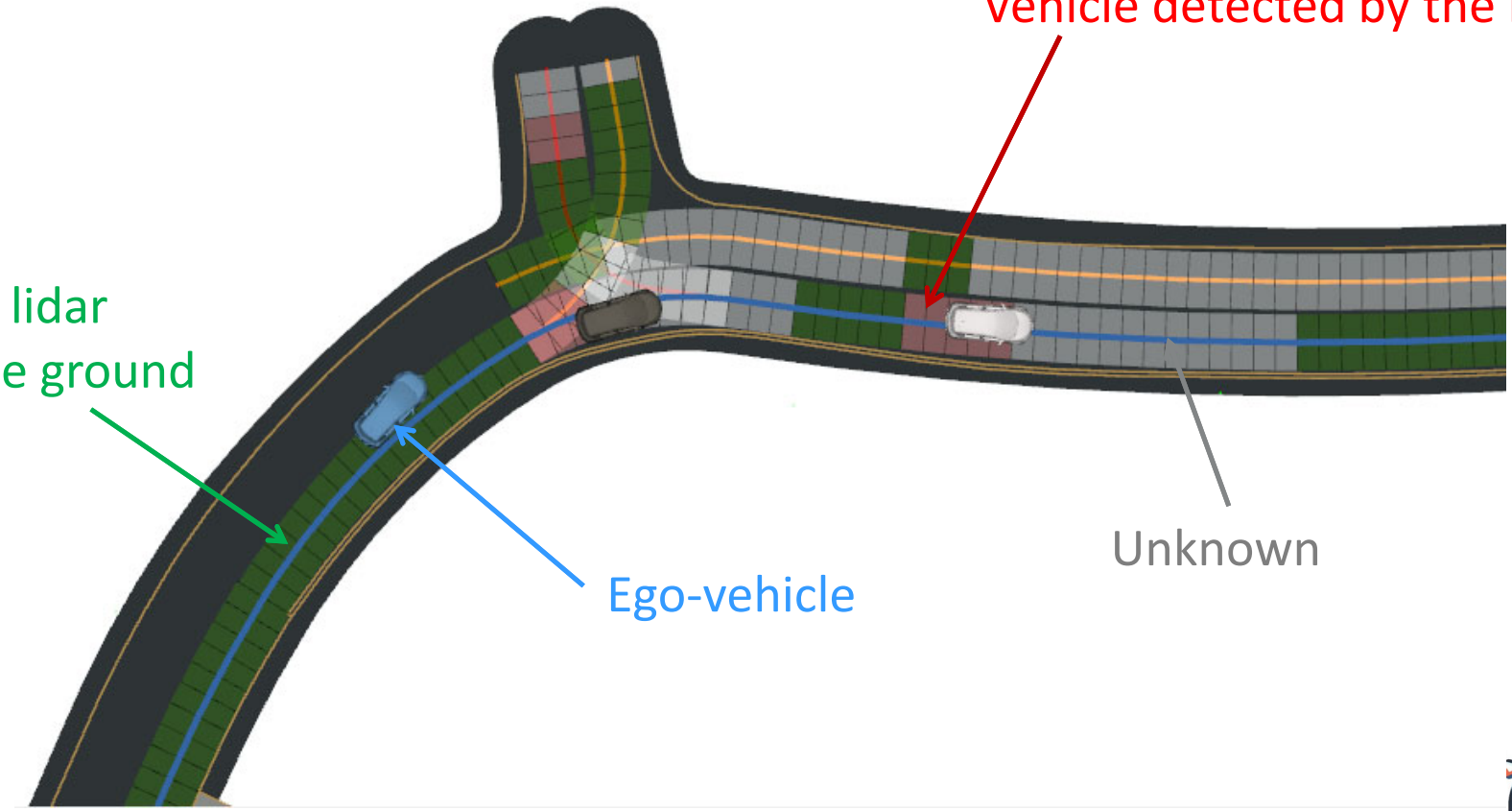
Input: bounding polygons in the vector map frame



- Road objects
- Overlapping or uncertain objects
- Non road objects

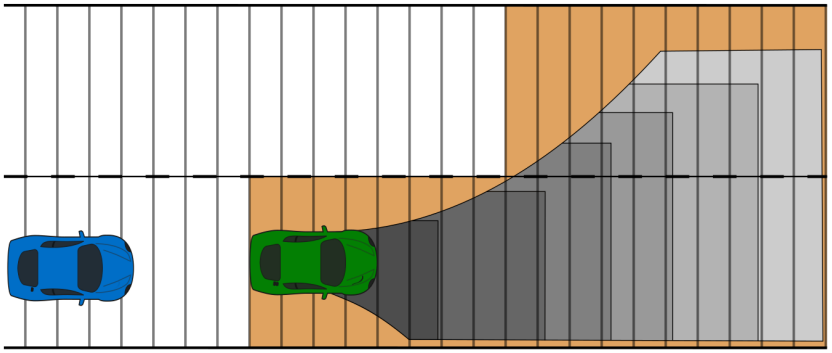
Lane Grid Map

A lane level grid representation of the areas of interest



Integrity of LGM Predictions

A predicted LGM is a discretized reachable set



Non reachable	Reachable	
Free (F)	*Occupied* (O)	*Unknown* (U)

True	Predicted $LGM(t\|t_0)$	
$LGM(t)$	Reach.	Non-reachable
Occupied	Non-Misleading (1)	Hazardous (2)
Free	Non-Hazardous (3)	Non-Misleading (4)

Integrity table

C. Sanchez, P Xu, P Bonnifait.
Integrity Management of the Reachable Space With Lane Grid Maps
IEEE Transactions on Intelligent Vehicles 2022

Roundabouts crossing with Integrity

Experiments in Rambouillet on roads with opened traffic

S Masi, P Xu, P Bonnifait, Roundabout crossing with interval occupancy and virtual instances of road users, IEEE Transactions on Intelligent Transportation Systems. 2021.

Have a nice iLoc Workshop!

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