Precise Positioning for Autonomous Driving in Areas with both Indoor and Outdoor Environments

Patrick Henkel, Robert Bensch,
Sai Parimi, Jan Fischer, Ulrich Mittmann,
ANavS GmbH

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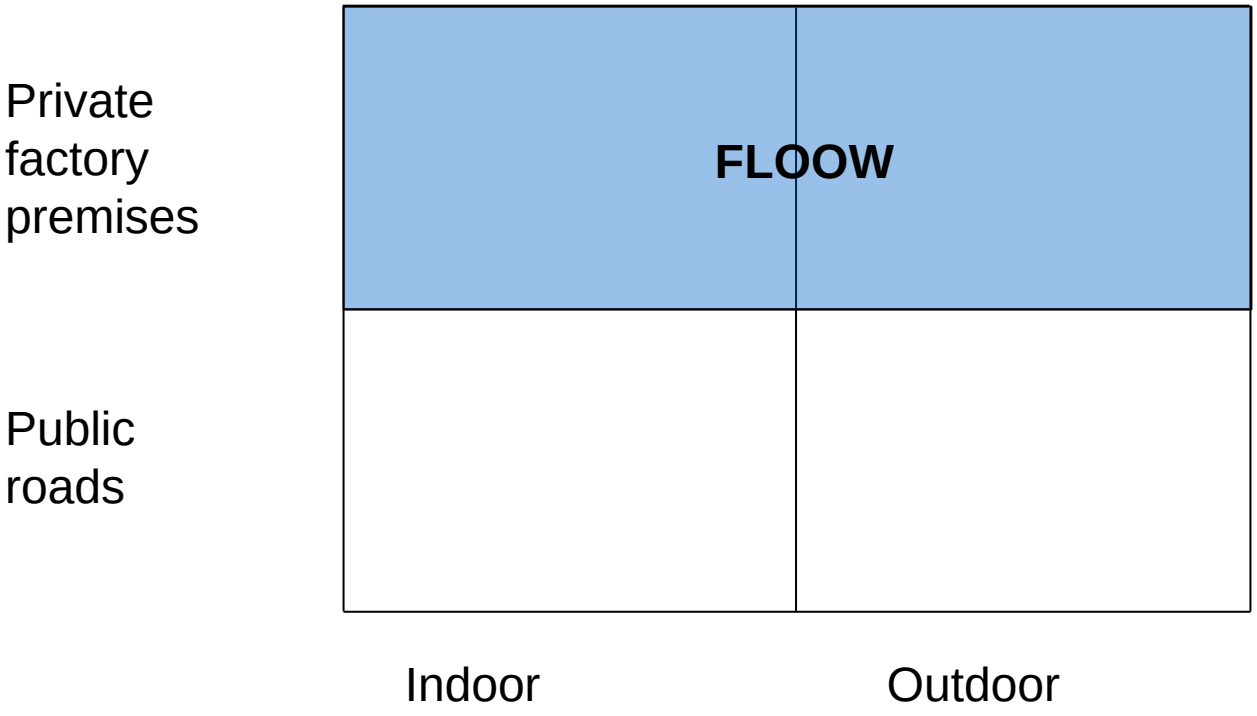
Flexible Mobility and Cargo System for factory works traffic (FLOOW)

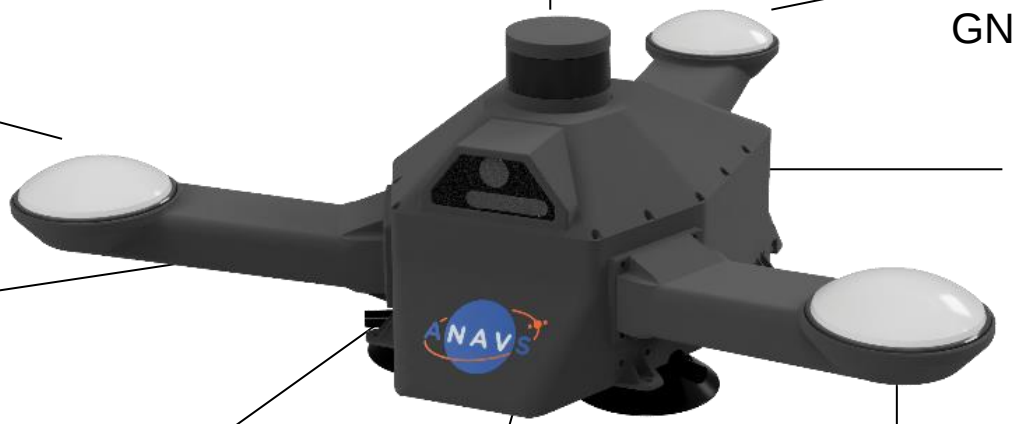


Integrated Sensor Platform (ISP) of ANavS

3D Lidar:
- measurement range: 100 m
- measurement accuracy: +/- 3 cm
- Field of view (horizontal): 360°
- Field of view (vertical): 30°

Multi-frequency GNSS antenna

Multi-frequency GNSS antenna



6-core Nvidia ARM:
GPU with
384 Nvidia Cuda cores
and
48 tensor cores

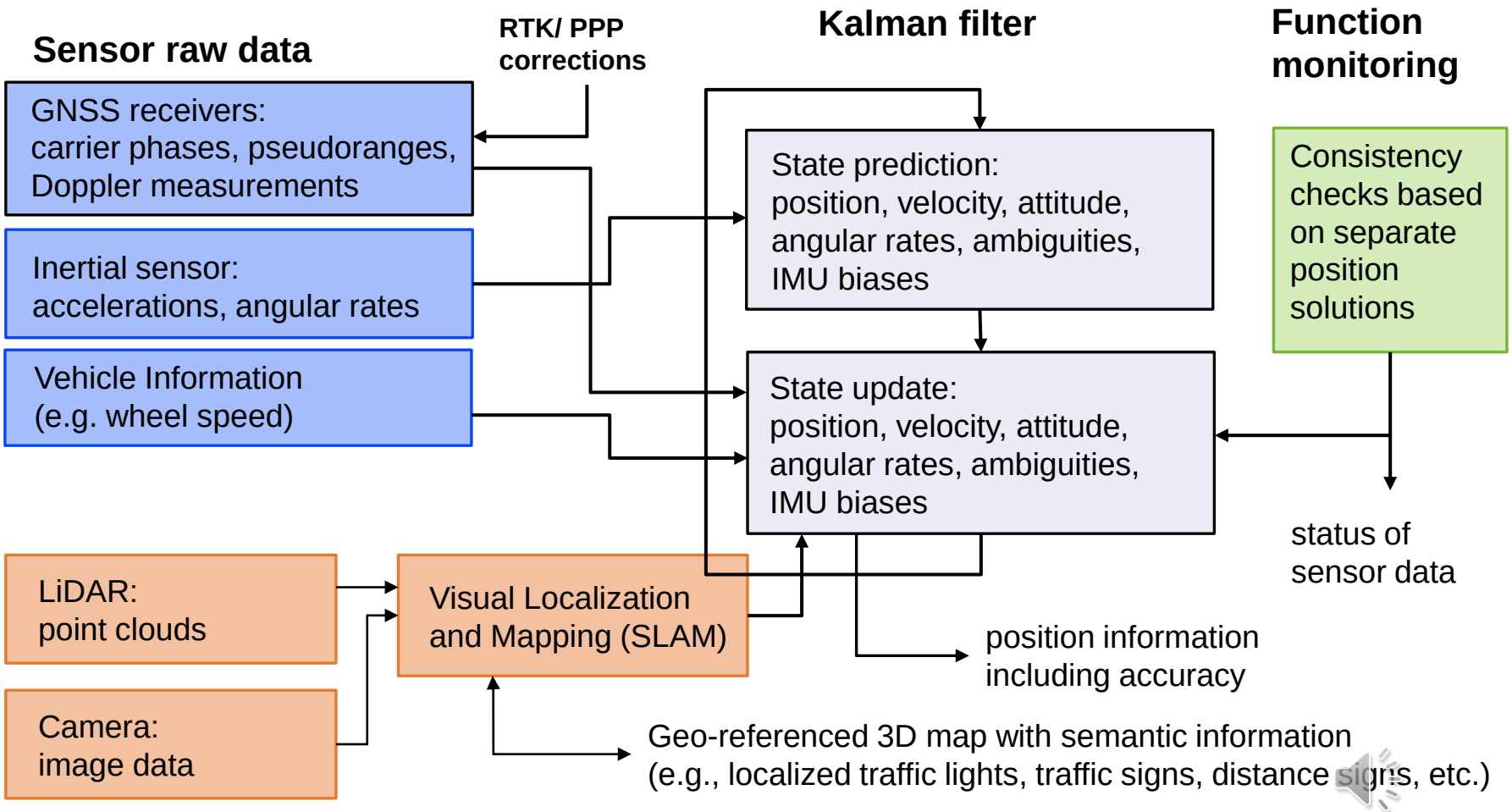
LTE

FLIR Grasshopper 3:
- 163 frames per second
- 1920 x 1200 resolution
- global shutter

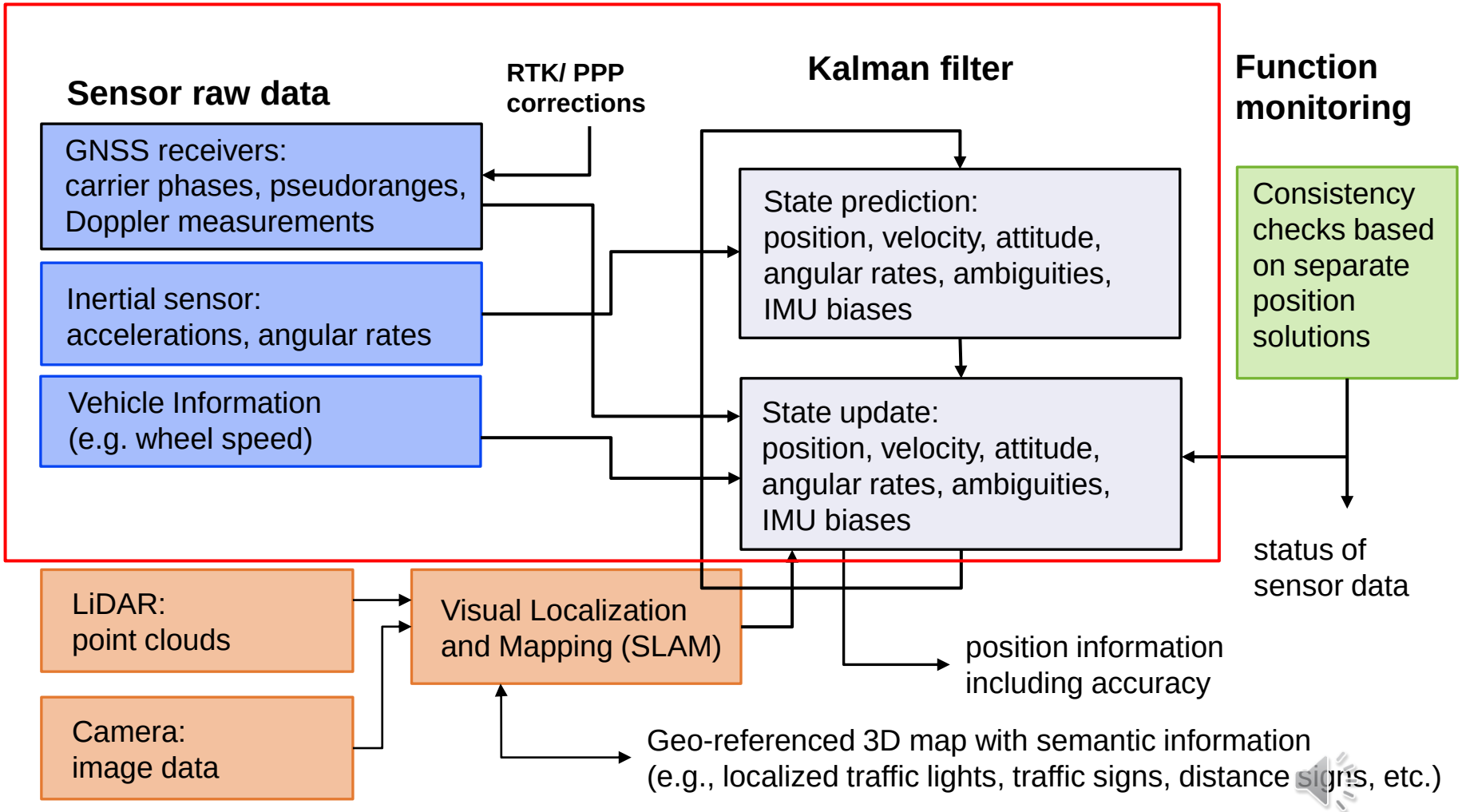
IMU with
0.8 deg/h bias stability

Multi-frequency GNSS antenna

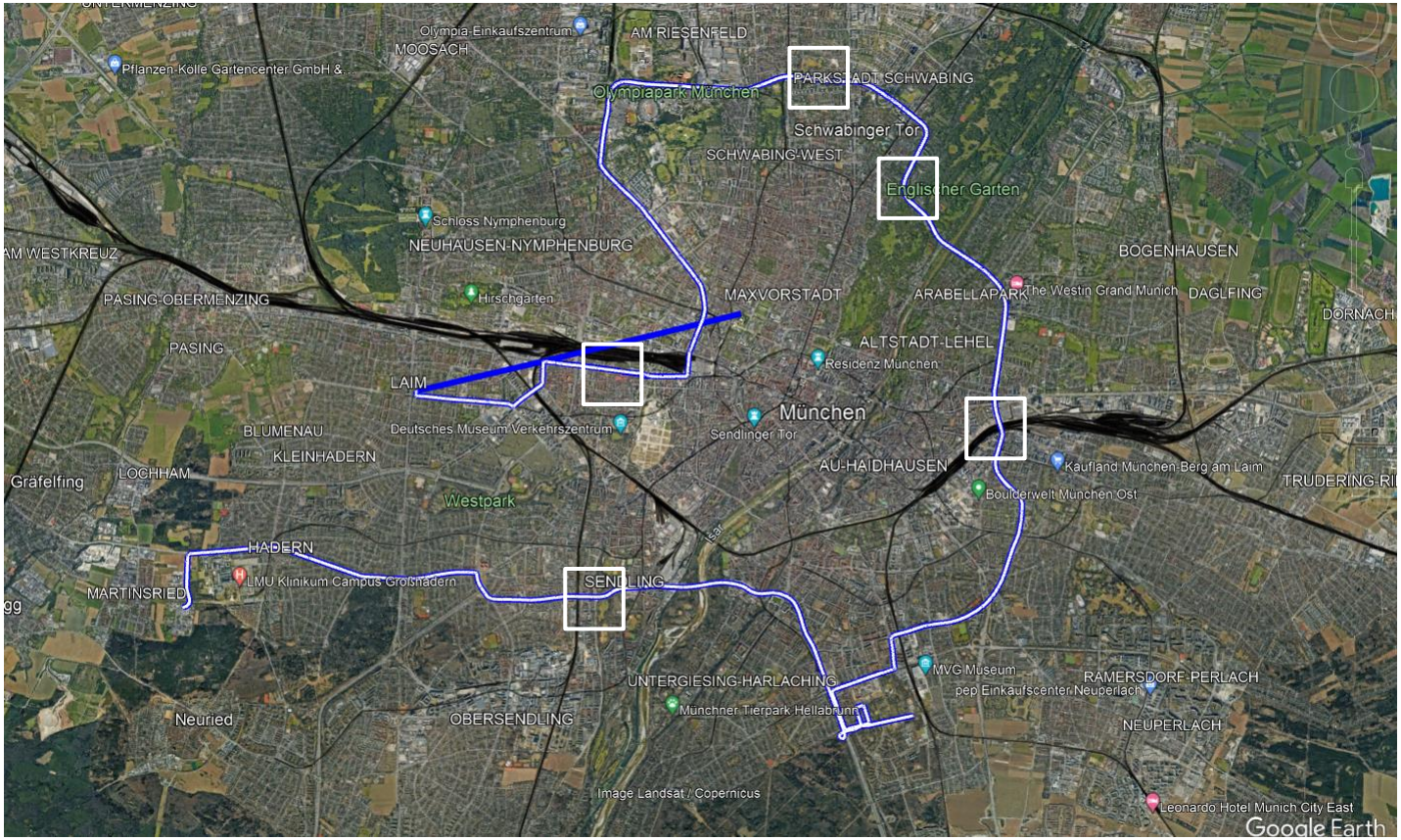
ANavS Architecture for Sensor Fusion



ANavS Architecture for Sensor Fusion



RTK + INS + ODO tightly coupled positioning in challenging environments (Interior Highway Circle in Munich, Germany, “B2R”)



white: ANavS
blue: OXTS

RTK + INS + ODO tightly coupled positioning in challenging environments

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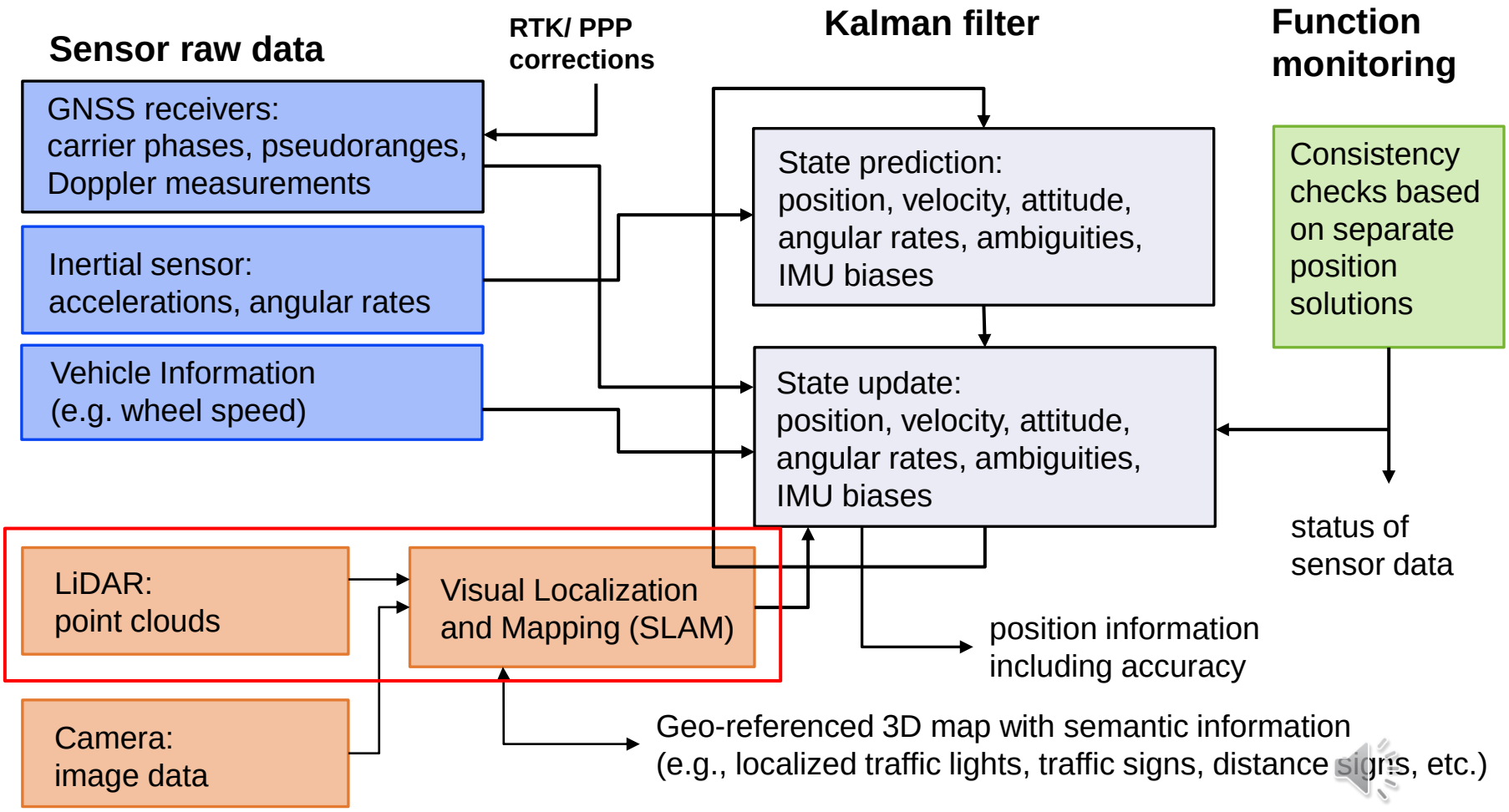
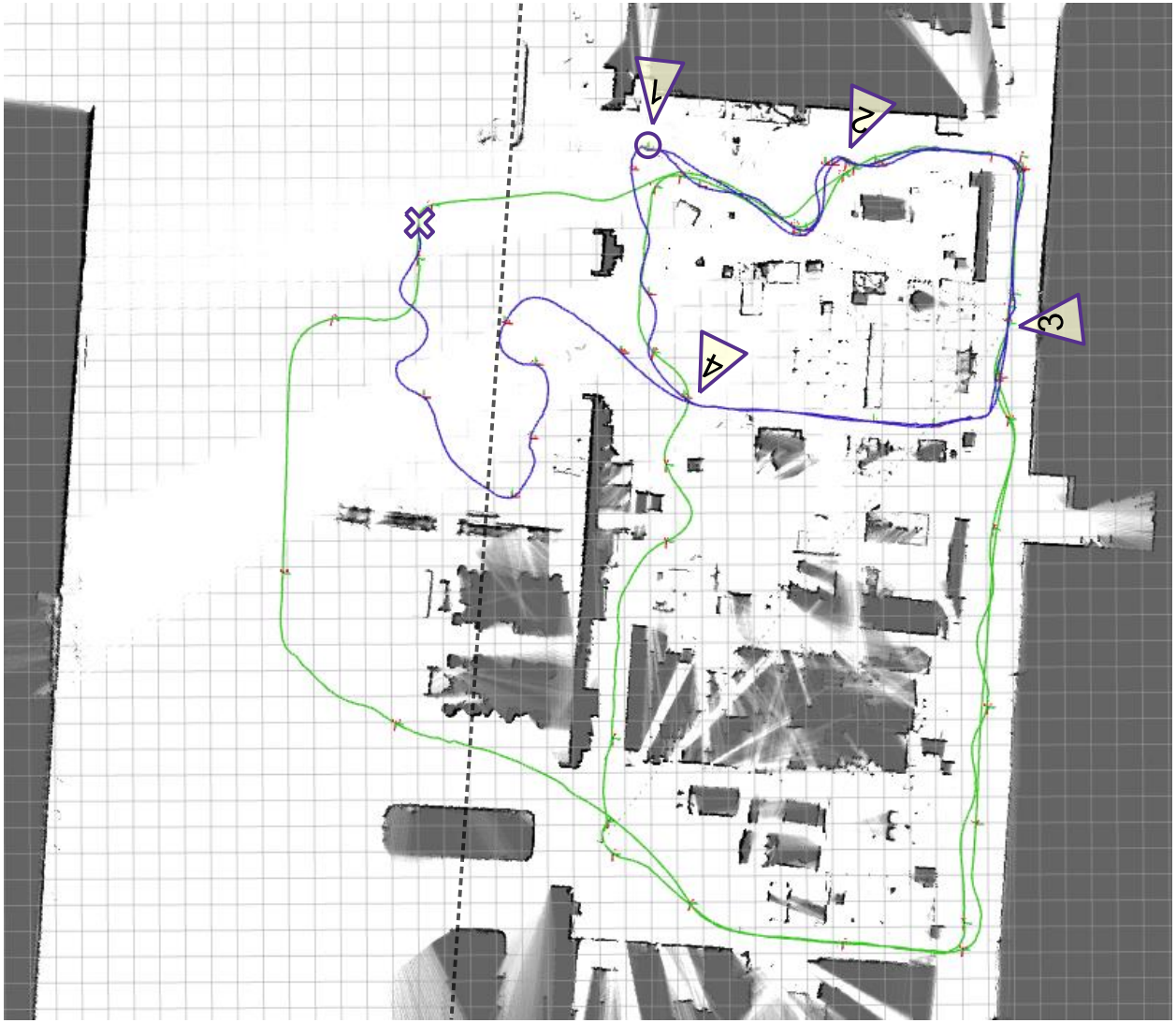
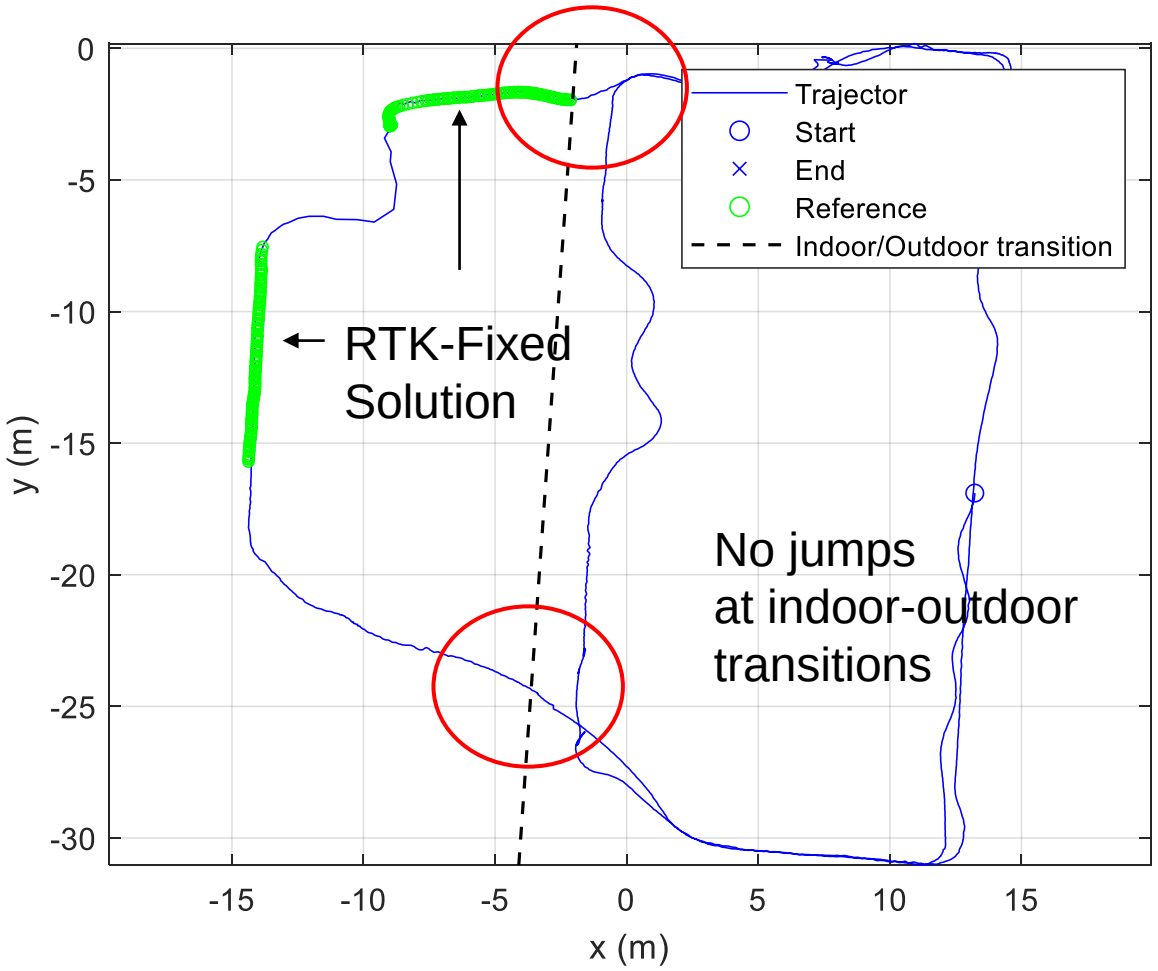


Outdoor

Indoor



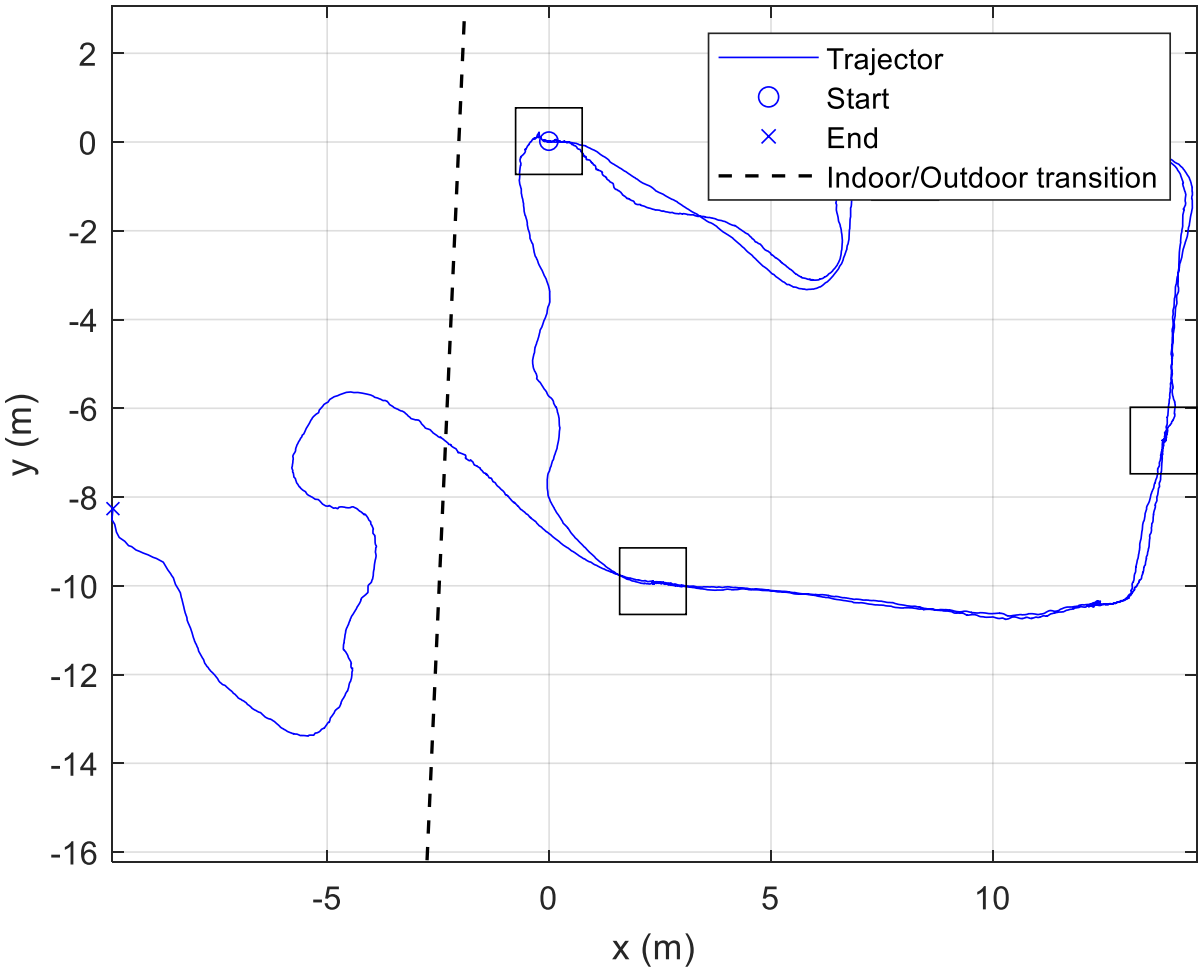
Outdoor LiDAR positioning accuracy using GNSS + INS tightly coupled RTK reference



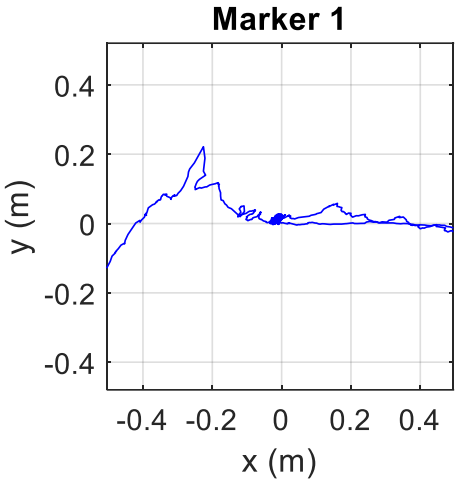
Position deviations between LiDAR and RTK reference:

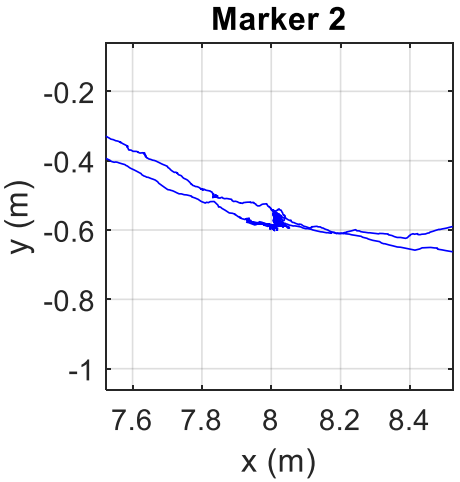
max	0.194 m
mean	**0.083** m
median	**0.067** m
min	0.003 m
rmse	0.095 m
stddev	0.045 m

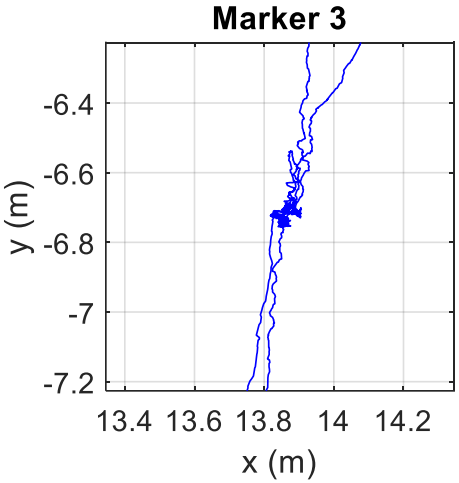
LiDAR-based positioning in combined indoor/ outdoor environment

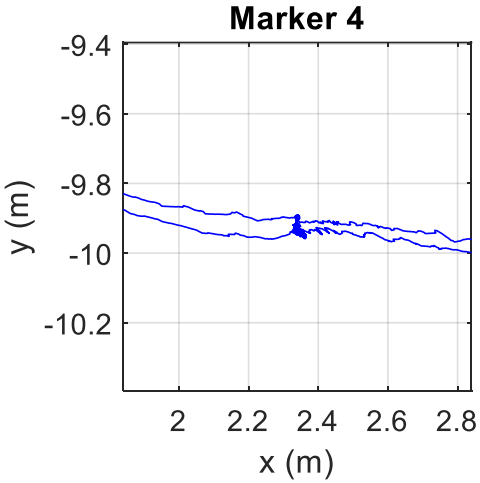


Analysis of positioning accuracy at reference markers









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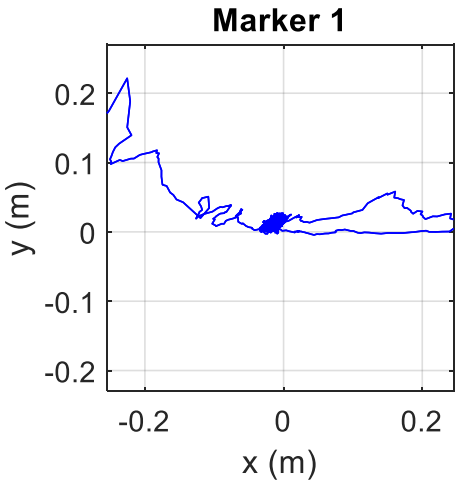

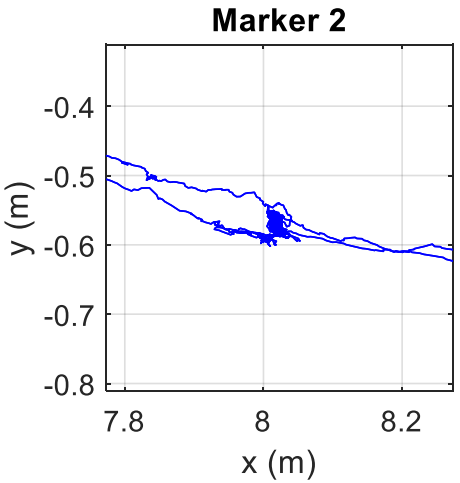

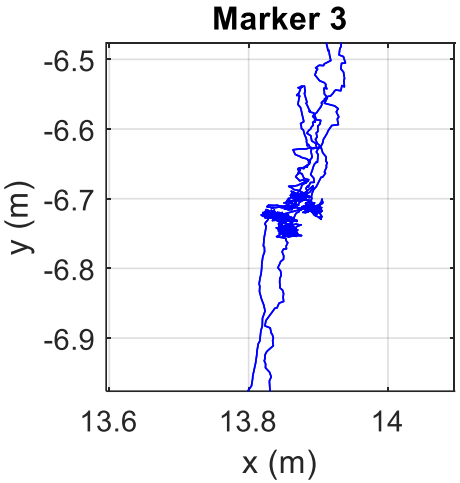

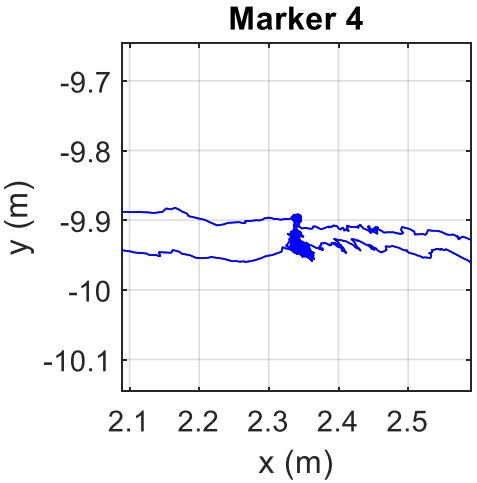

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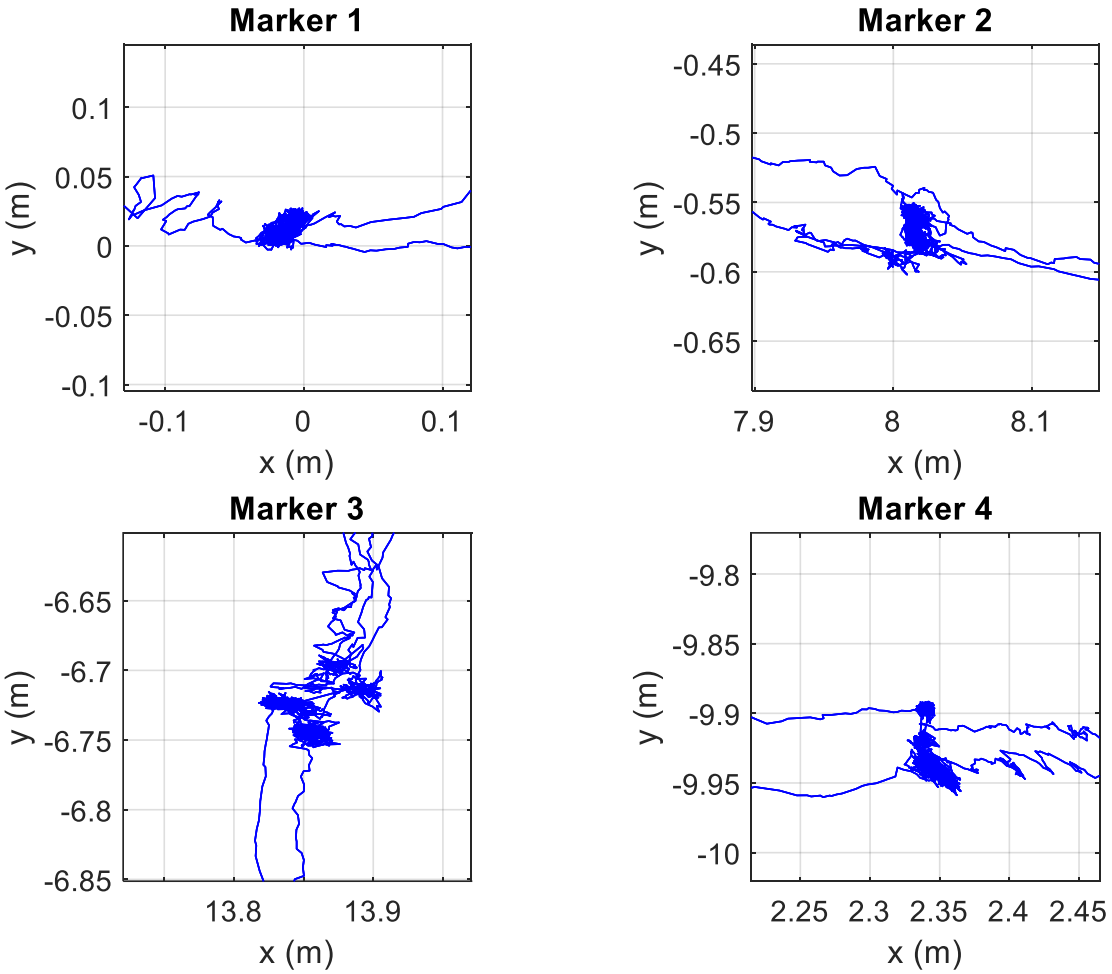

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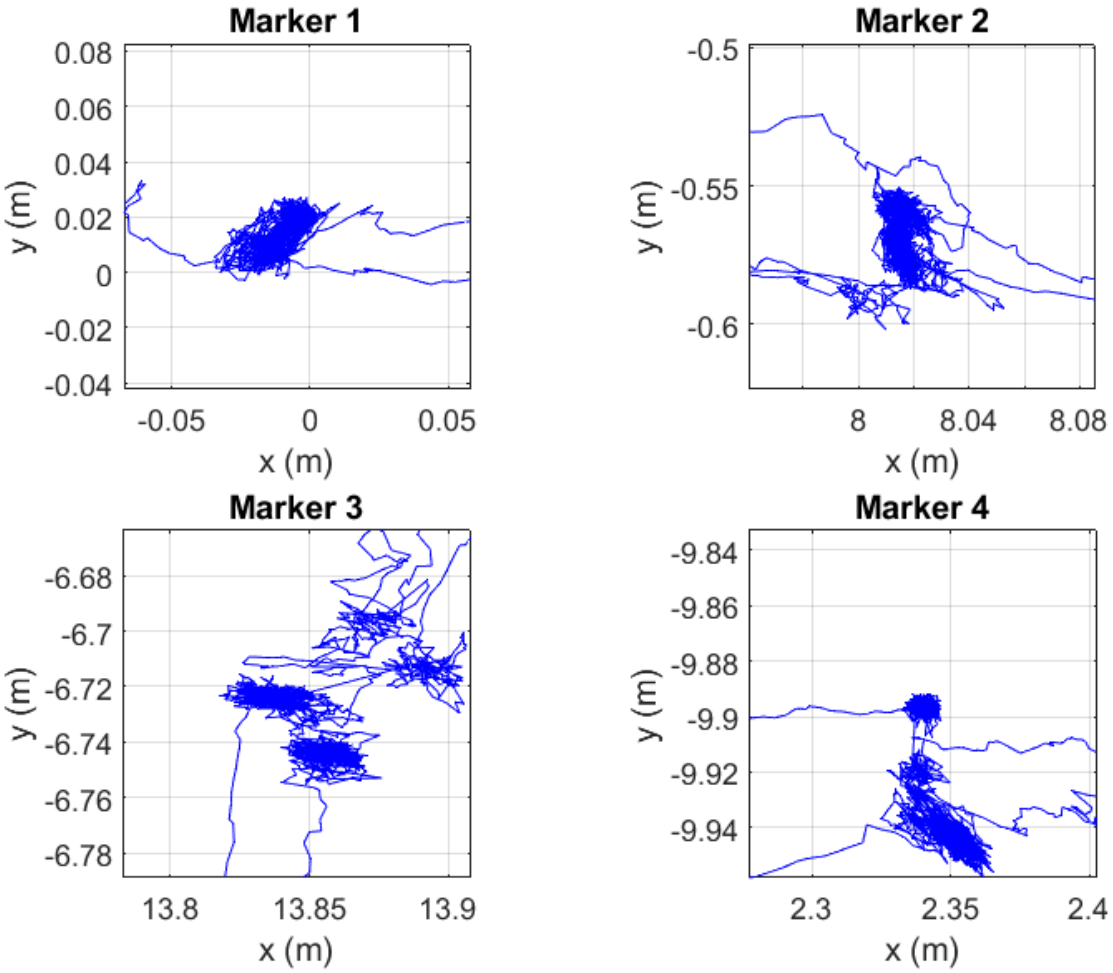
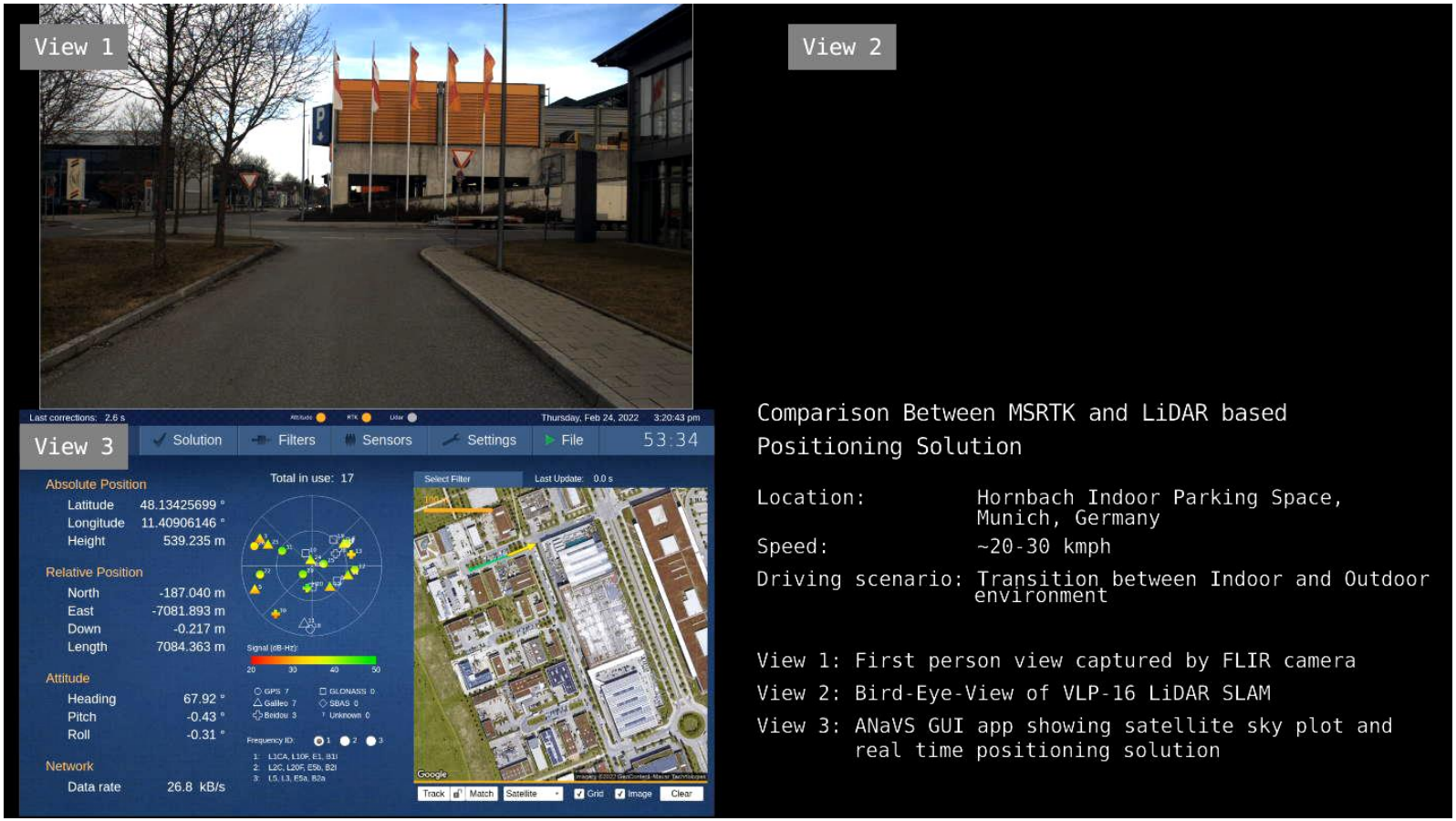
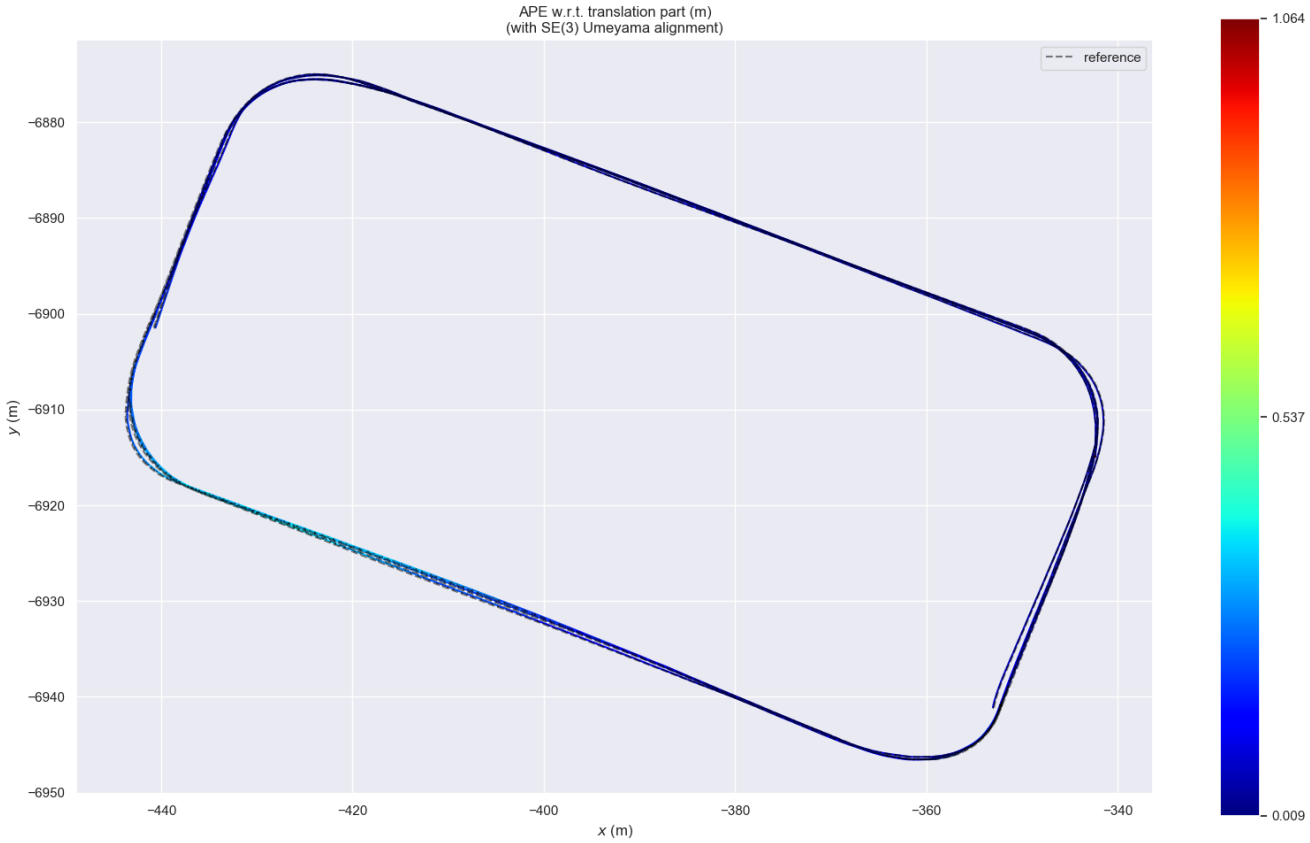


GNSS + INS + ODO-RTK and Lidar-SLAM (LIO-SAM) in Combined Indoor- and Outdoor Environment



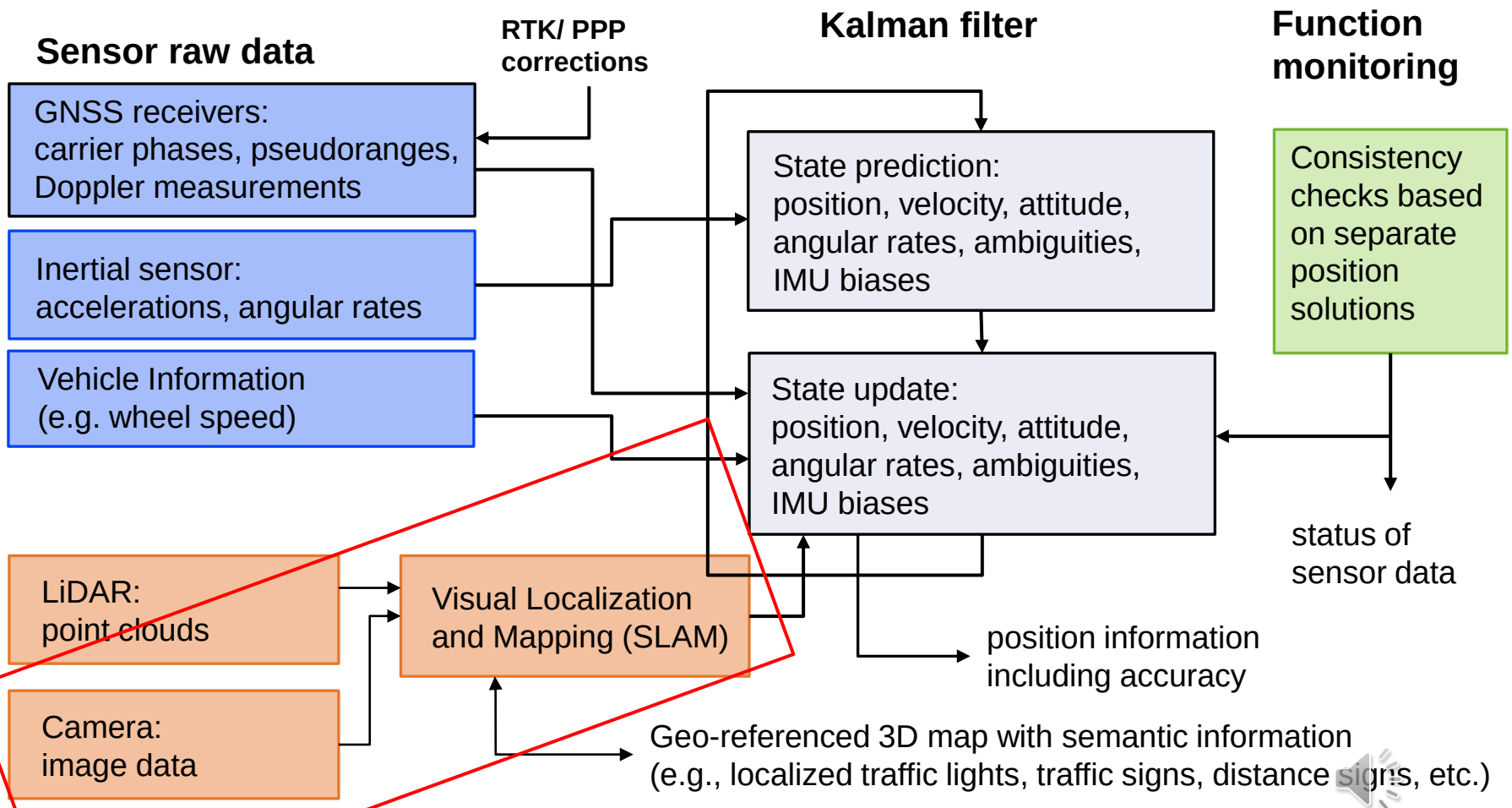
Indoor Localization Accuracy using Laser Scanner-based Ground Truth



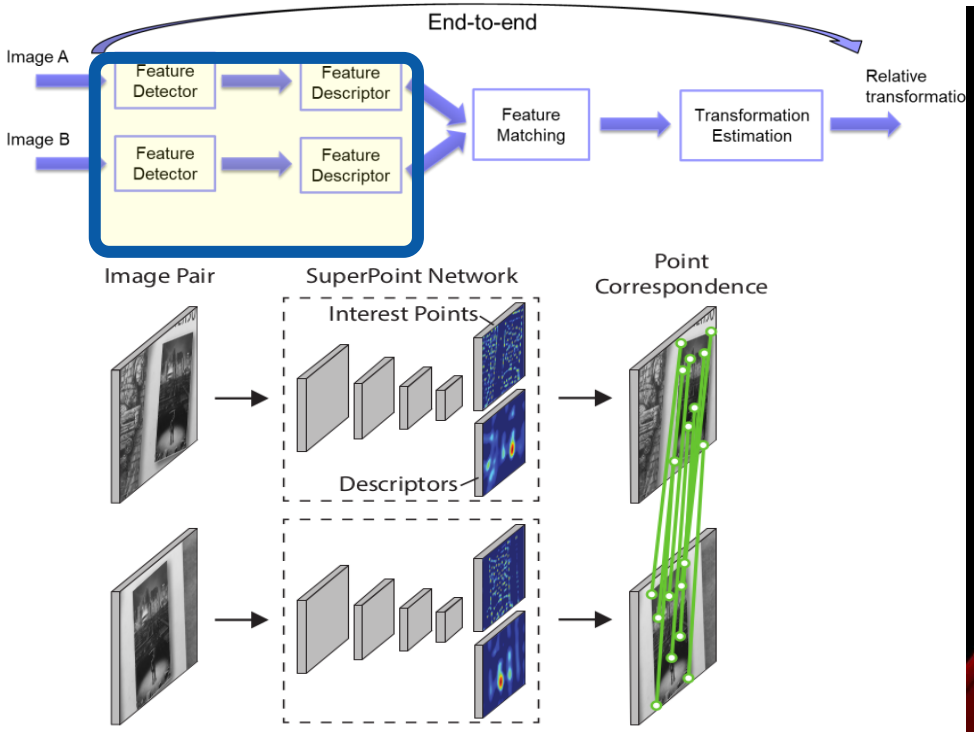
Positioning deviations between Lidar and ground truth from laser scanner:

max	1.064 m
mean	**0.122** m
median	**0.089** m
min	0.009 m
rmse	0.148 m
std	0.084 m

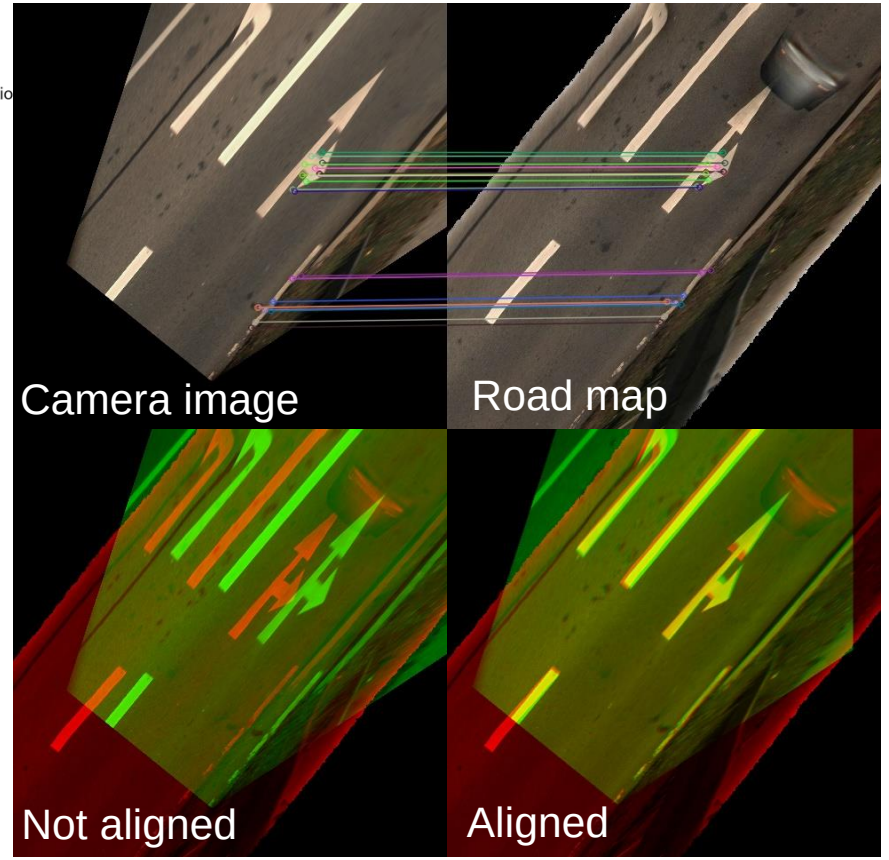
ANavS Architecture for Sensor Fusion



Visual Camera-based Positioning with AI-based Feature Matching



SuperPoint [1] AI-based feature detector and descriptor computation.

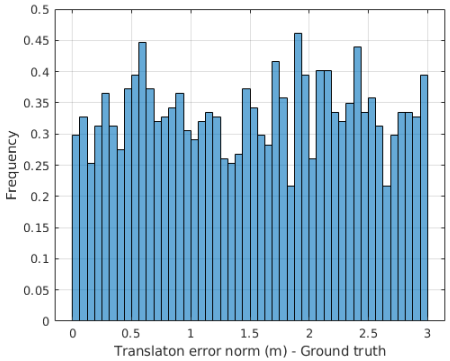


Localization on Road maps: AI-based feature matching based-on SuperPoint [1].

[1] D. DeTone, T. Malisiewicz, and A. Rabinovich. "**SuperPoint:** Self-Supervised Interest Point Detection and Description ", in CVPR Workshop on Deep Learning for Visual SLAM, 2018.

Visual Camera-based Positioning with AI-based Feature Matching

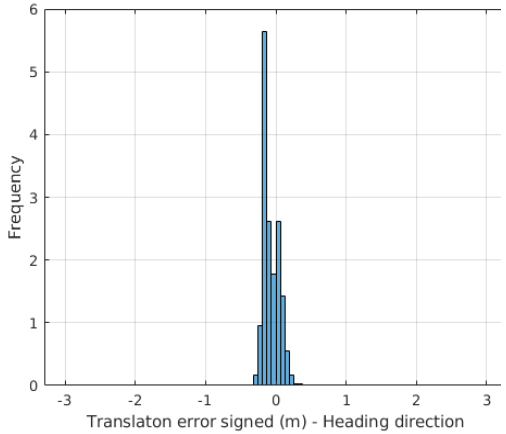
AI-assisted Localization on Road Maps (Validation)

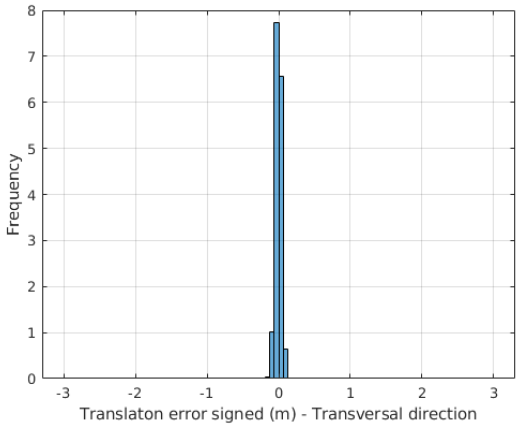


Simulated 2D translation.
Random orientation, largest magnitude 3 m..

Apply localization approach

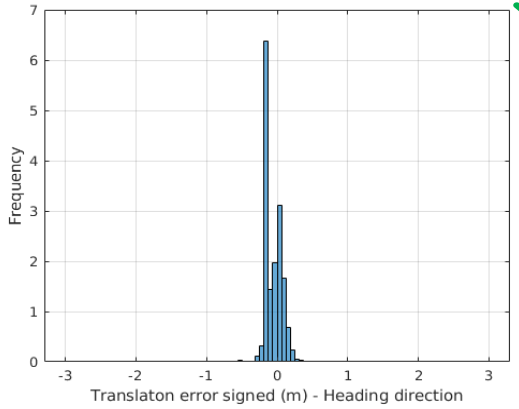
Distribution of translation error after localization: error in heading versus transversal direction

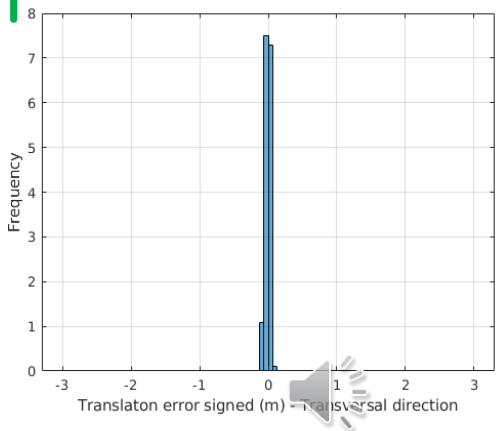




Nominal scenario.
Ground truth pose.

Apply localization approach





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FLOOW

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Contact data

ANavS GmbH
Gotthardstraße 40
80686 München
Germany

Advanced Navigation Solutions

We are the Collaborative Change Makers.

Managing directors: Dr. Patrick Henkel
Phone numbers: +49 - (0)89 - 890567 - 21
Emails: patrick.henkel@anavs.de
Web: www.anavs.de