AI-assisted Multi-Sensor Fusion for Enhanced Autonomous Vehicle Navigation

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ION GNSS+ 2025
C1: AI-Driven Positioning and Navigation

ANavS® – Advanced Navigation Solutions

Leading company in the development of high-precision positioning systems.

ANavS® positioning system is a modular and flexibly configurable sensor fusion of **GNSS, inertial, odometry, camera** and **lidar measurements**.

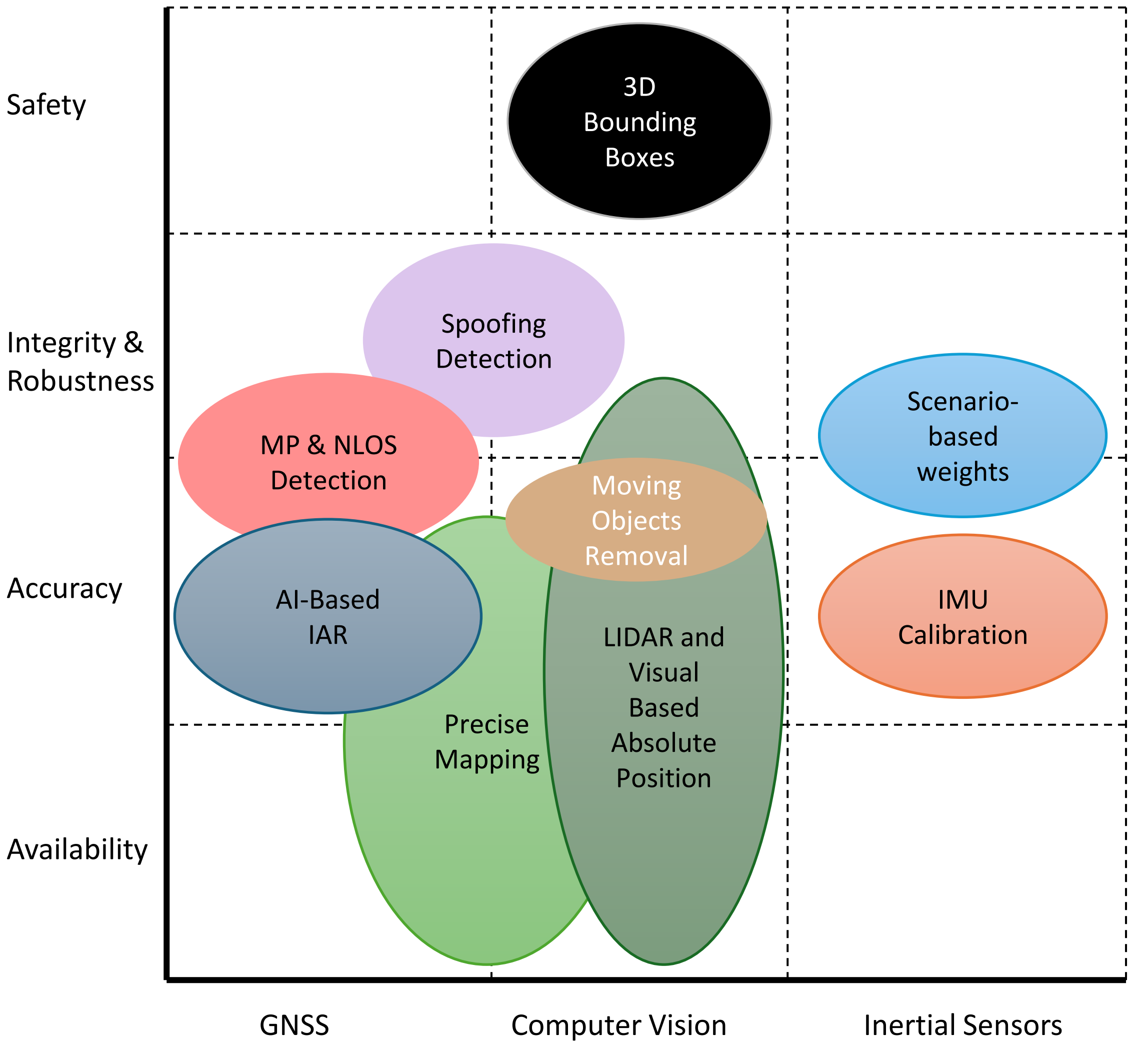
The innovative positioning algorithms have been developed and patented by ANavS® and incorporate the latest **RTK / PPP** technologies (including compatibility with Galileo HAS) as well as state-of-the-art **SLAM** algorithms and **object detection & tracking**.

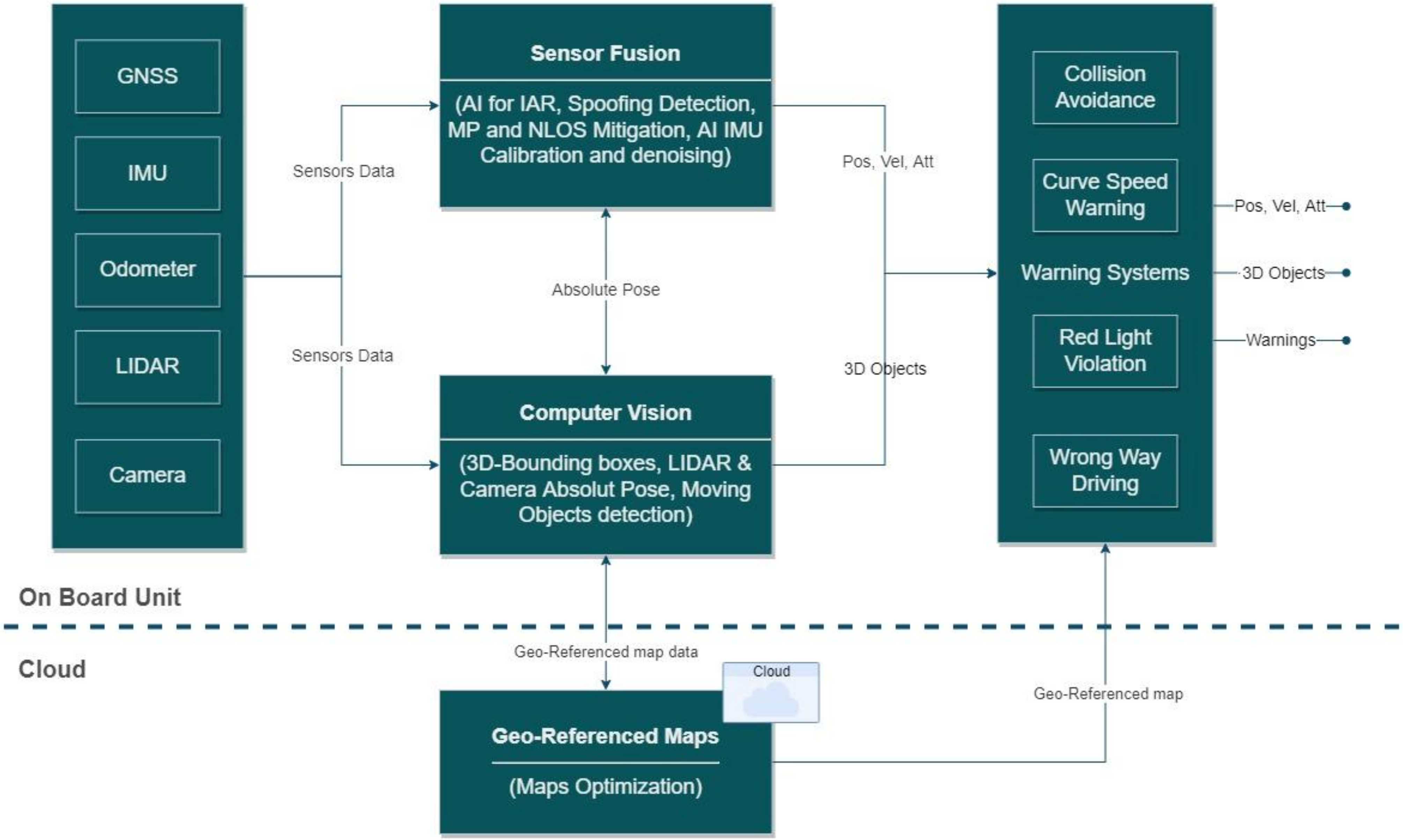
Products Lines:

- **A-ROX:** GNSS-INS tightly coupled positioning for dynamic automotive, railway and maritime applications.
- **V-ROX:** Extension of A-ROX system with a powerful 128-channel LiDAR and a stereo camera, enabling e.g. SLAM-based localization for indoor or GNSS-denied environments
- **G-ROX** RTK reference station without service provider costs. It includes a cloud based RTCM service.

DREAM Project

- DREAM aims to address the stringent requirements of **ADAS** systems in challenging urban environments by developing advanced AI solutions.
- **AI** techniques to detect **spoofing**, **multipath** and NLOS situations and ensuring correct **ambiguity resolution**
- For improved localization in GNSS denied scenarios, AI-driven methods will be applied for **IMU calibration and denoising**, as well as **LiDAR/Visual SLAM** (enhance with AI-based moving objects removal)
- It also features **3D bounding boxes** for object detection and **geo-referenced maps** supporting LiDAR/Visual localization and improving situational awareness.




GNSS
IMU
Odometer
LIDAR
Camera
Sensors Data
Sensors Data
Sensor Fusion
(AI for IAR, Spoofing Detection, MP and NLOS Mitigation, AI IMU Calibration and denoising)
Absolute Pose
Computer Vision
(3D-Bounding boxes, LIDAR & Camera Absolut Pose, Moving Objects detection)
Pos, Vel, Att
3D Objects
Collision Avoidance
Curve Speed Warning
Warning Systems
Red Light Violation
Wrong Way Driving
Pos, Vel, Att
3D Objects
Warnings
On Board Unit
Cloud
Geo-Referenced map data
Cloud
Geo-Referenced Maps
(Maps Optimization)
Geo-Referenced map

Spoofing Detection

Input features

Signal Characteristics

Gain + Average CN/0

\+

GNSS Measurements

Carrier-ratio + Double differenced Phase Measurements

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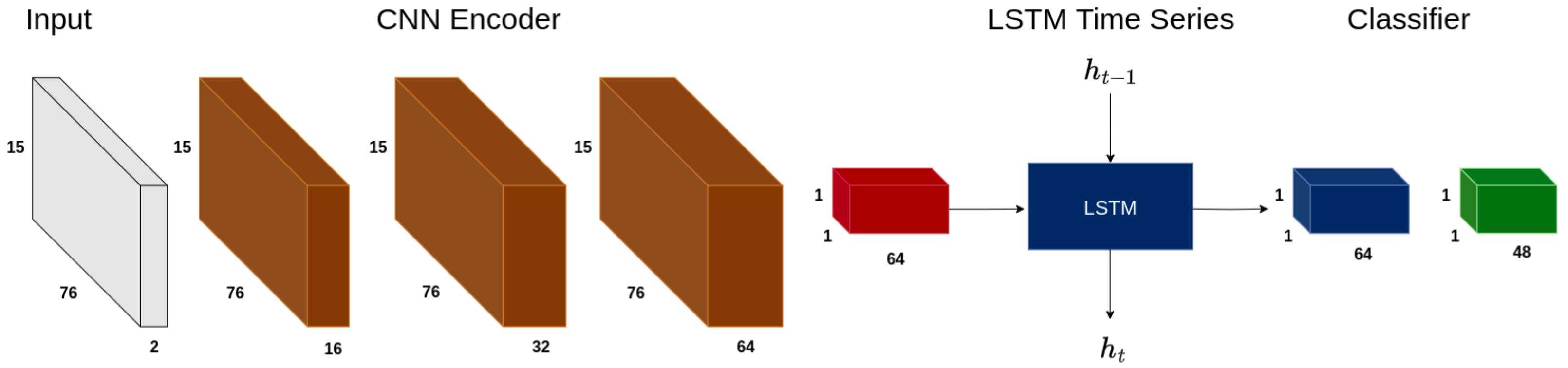
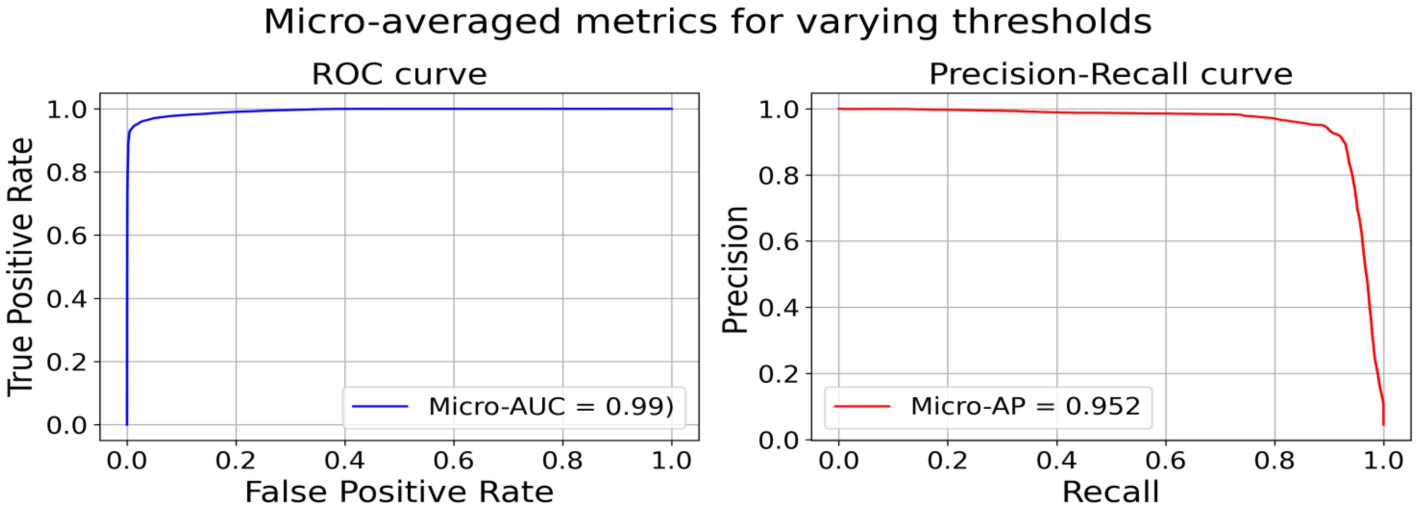
Multi-Sensor Information

Raw angular rate & acceleration (IMU) + [optionally]: Odometry

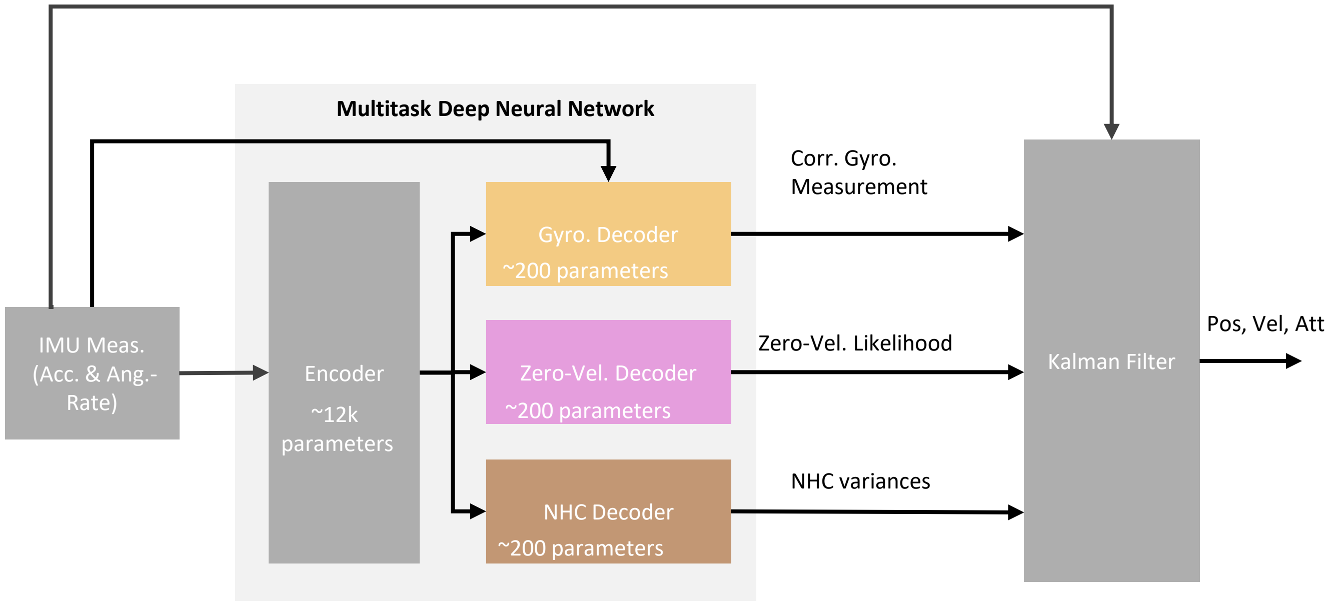


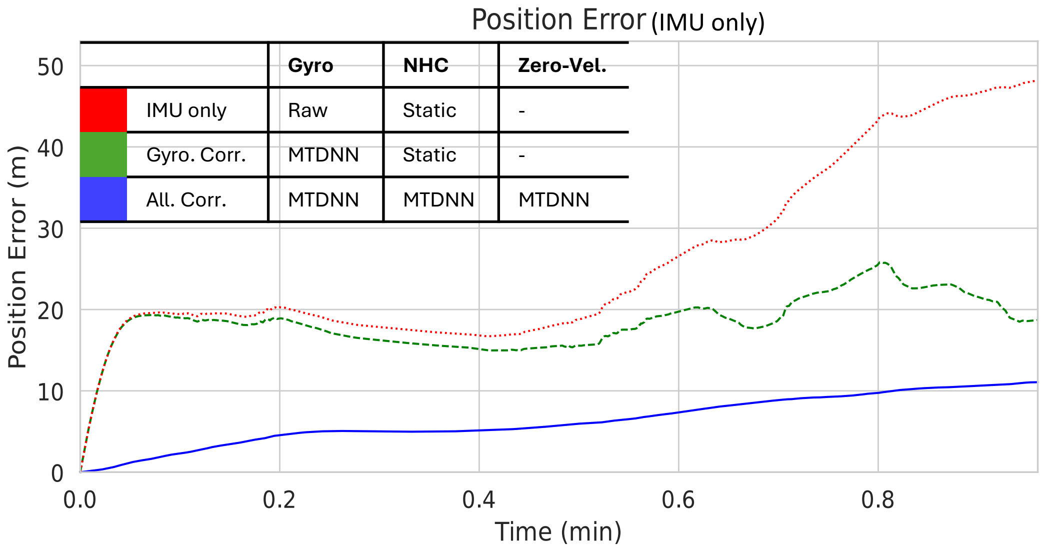


For further information, refer to "Detection and Mitigation of Jamming, Meaconing, and Spoofing based on Machine Learning and Multi-Sensor Data" (Session B4a, Thursday, Sep. 11, 4:46 p.m.)

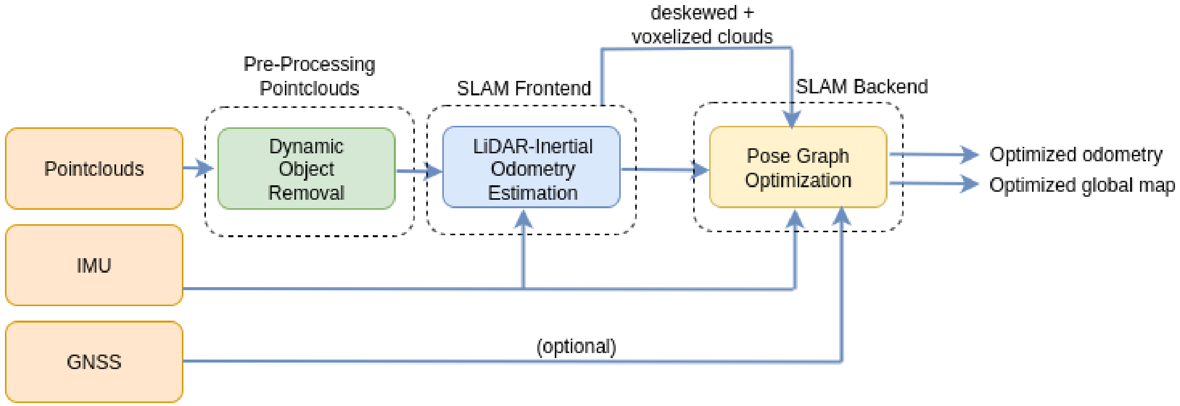
Multitask Deep Neural Network for IMU Calibration, Denoising and Dynamic Noise Adaption

- **MTDNN** architecture that jointly learns IMU calibration, adaptive noise level estimation for NHC, and zero-velocity detection solely **from raw IMU data**.
- Real-time capable on resource-constrained platforms
- No manual tuning required

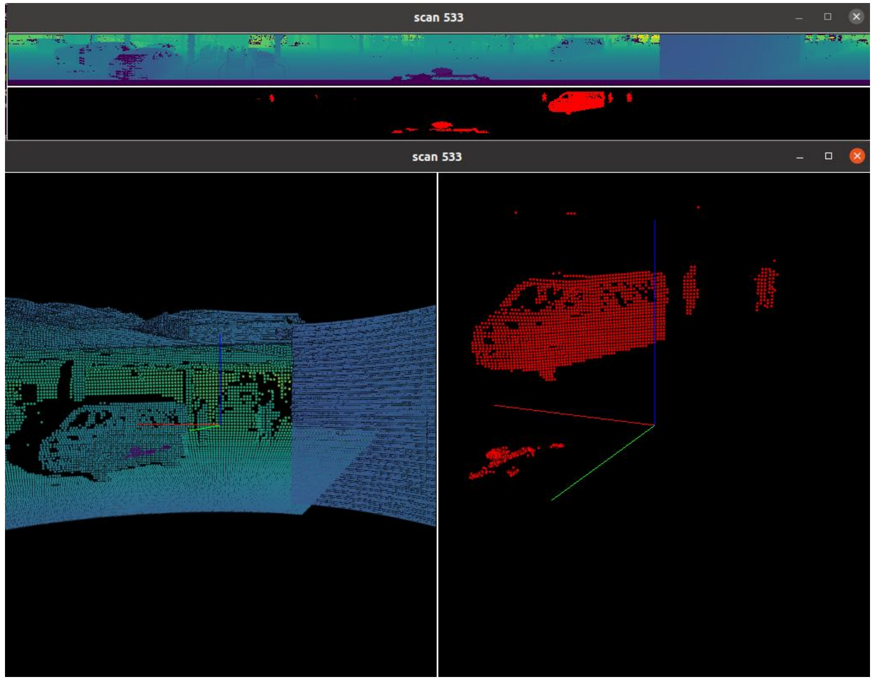




LiDAR SLAM



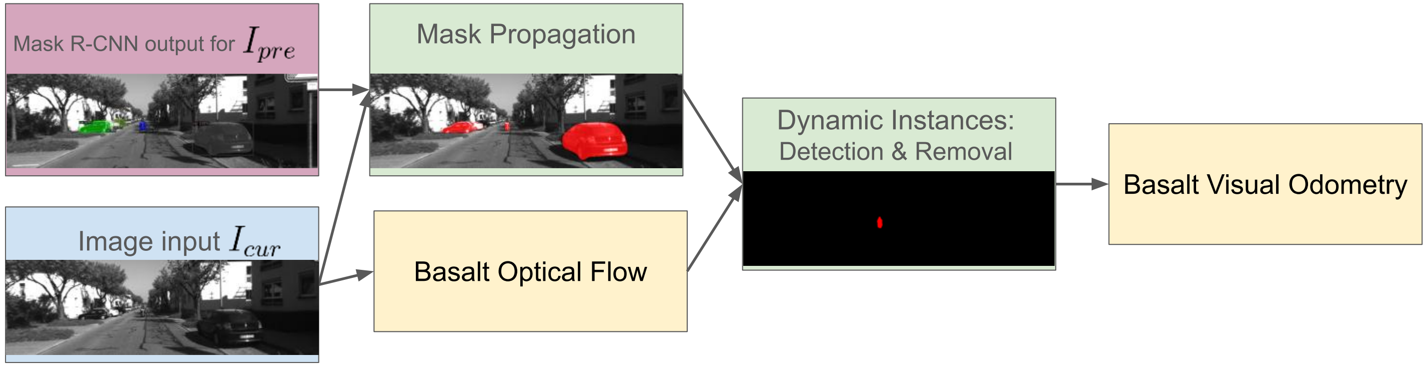
- LiDAR SLAM performs well under **static world conditions** since geometries across frames stay consistent
- Dynamic object removal reduces accumulated odometry drift since **scan registration** across frames improves with **consistent geometries**
- Dynamic object removal is performed by checking the voxel grids for consistency across **semantically aware frames**
- **Real-Time performance @ 20Hz** for an Ouster 128 with a 1024 horizontal resolution

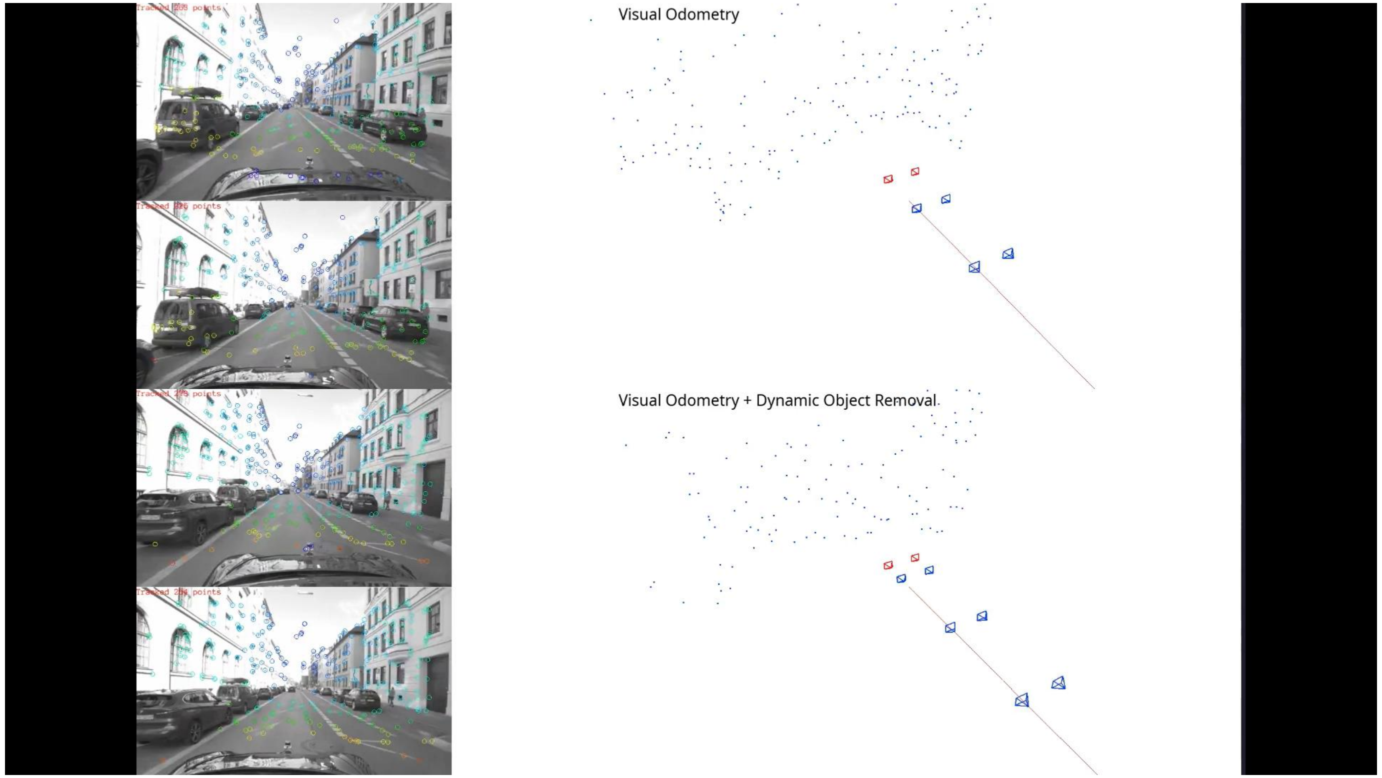


For further information, refer to "Alternative Technologies for GNSS-Denied Environments – Optical Approaches" (Session D6, Friday, Sep. 12, 4:26 p.m.)

Visual Odometry

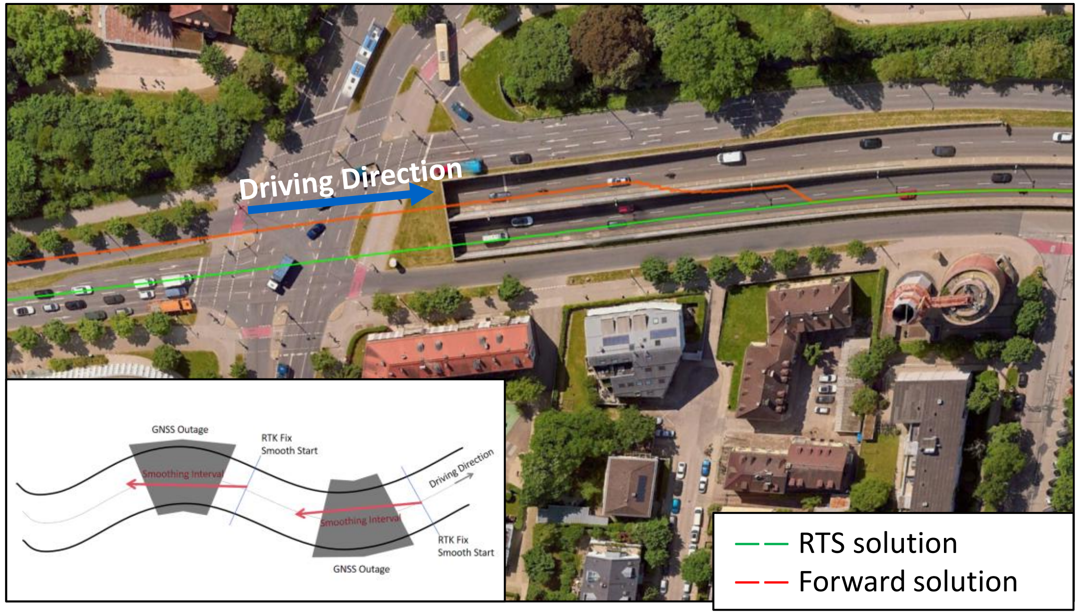
- VSLAM algorithms rely on static world assumption
- Dynamic objects in a scene can lead to 1) trajectory drift, 2) incorrect landmarks in map
- Methodology:
  - **Instance segmentation** using a pre-trained Mask R-CNN model (high computational load)
  - **Mask propagation** mechanism to estimate the segmentation masks for intermediate frames
  - Actual **Dynamic Objects Removal**, using optical flow to evaluate epipolar geometry consistency.



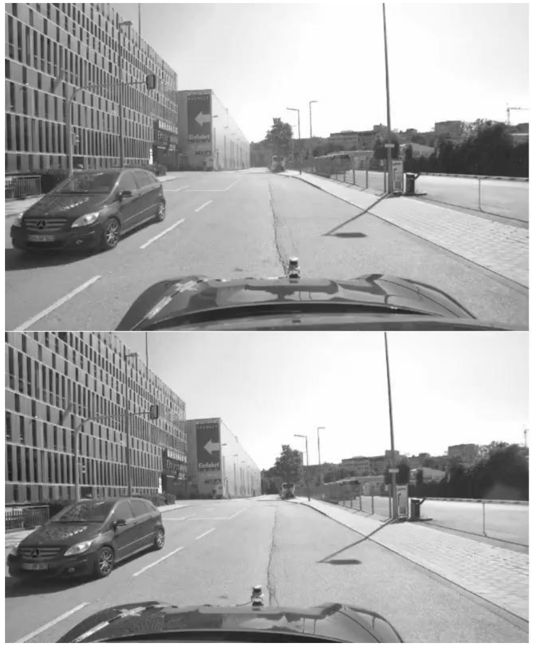


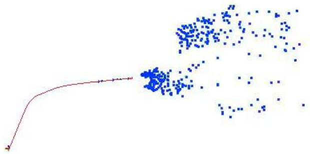
Scenario and Ground Truth Generation

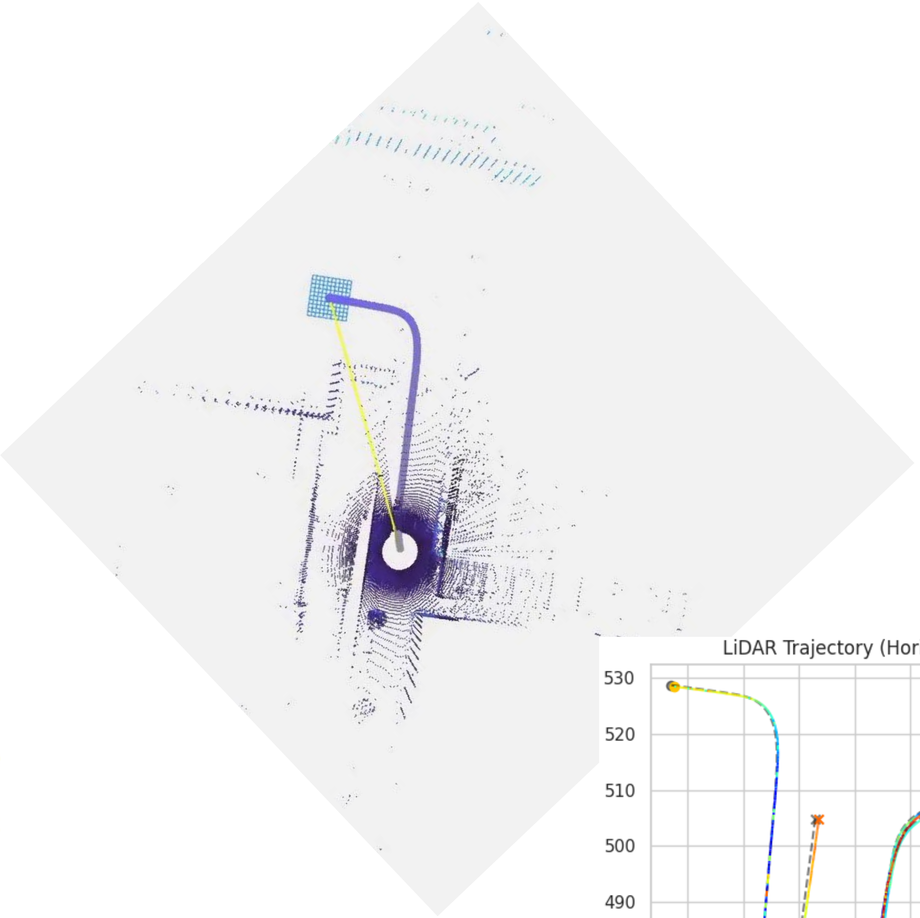
- RTK Reference Station
- Fiber-Optic Gyro (FOG) IMU
- Rauch-Tung-Striebel (RTS) Filter

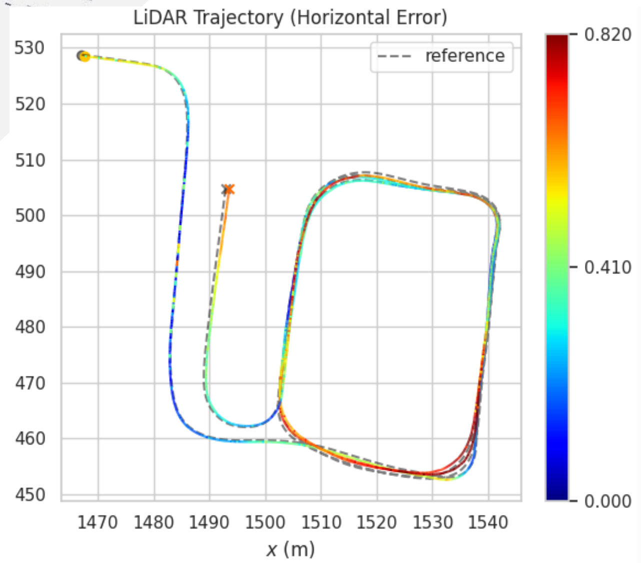


Indoor localization

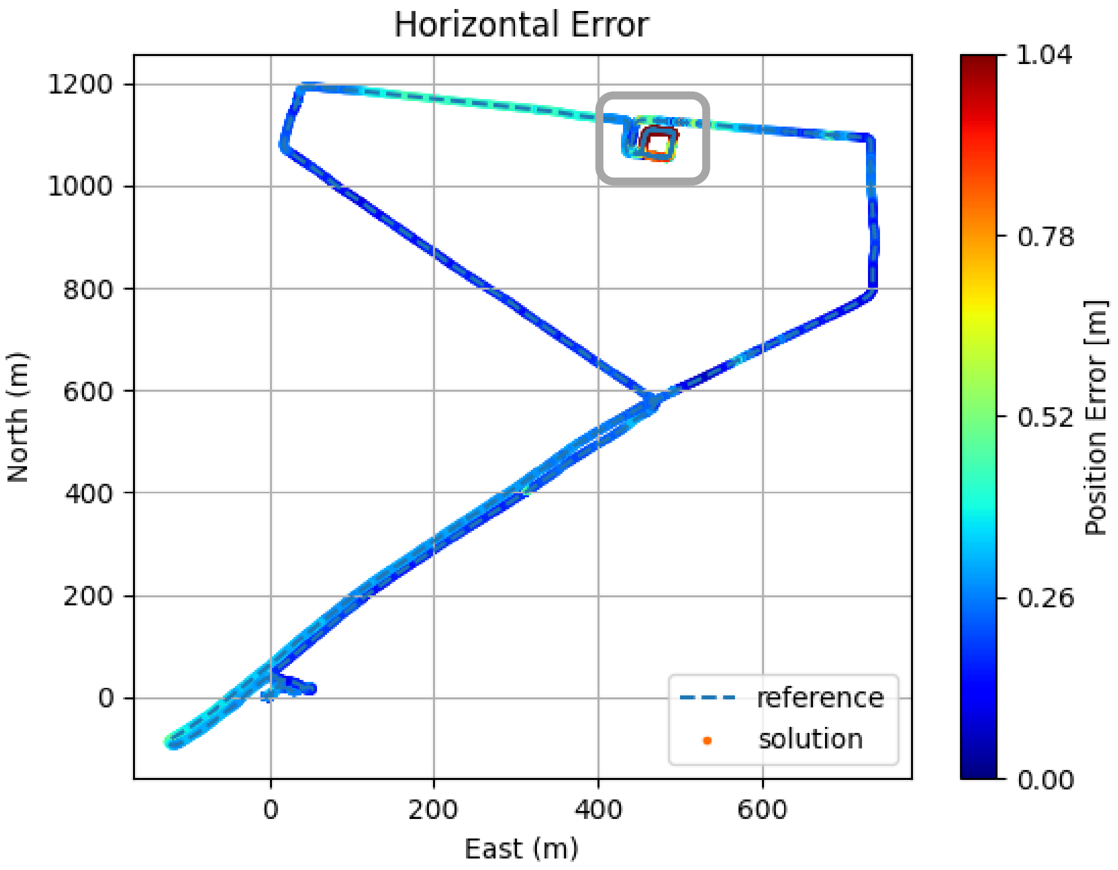


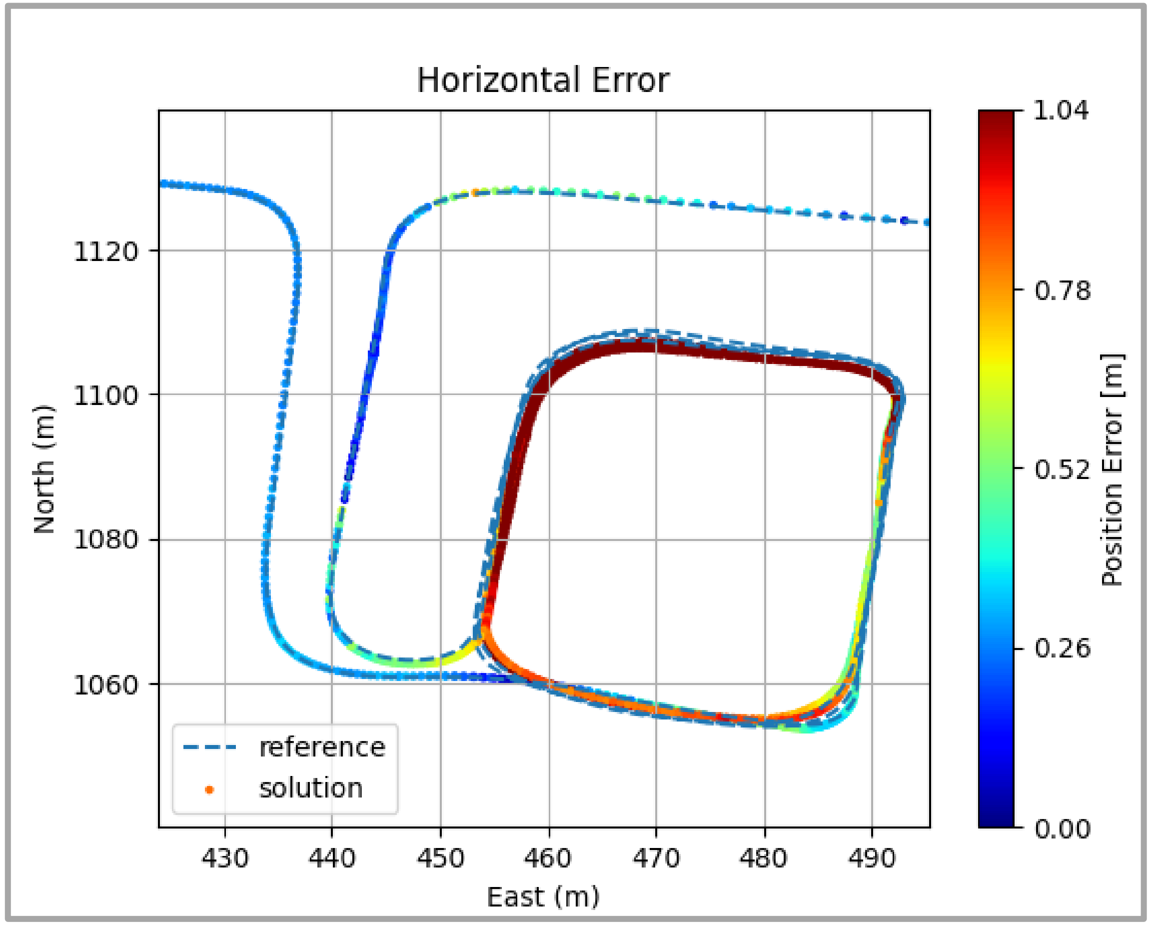






Multi-sensor Fusion Results (PPP/INS/LiDAR/Vision)





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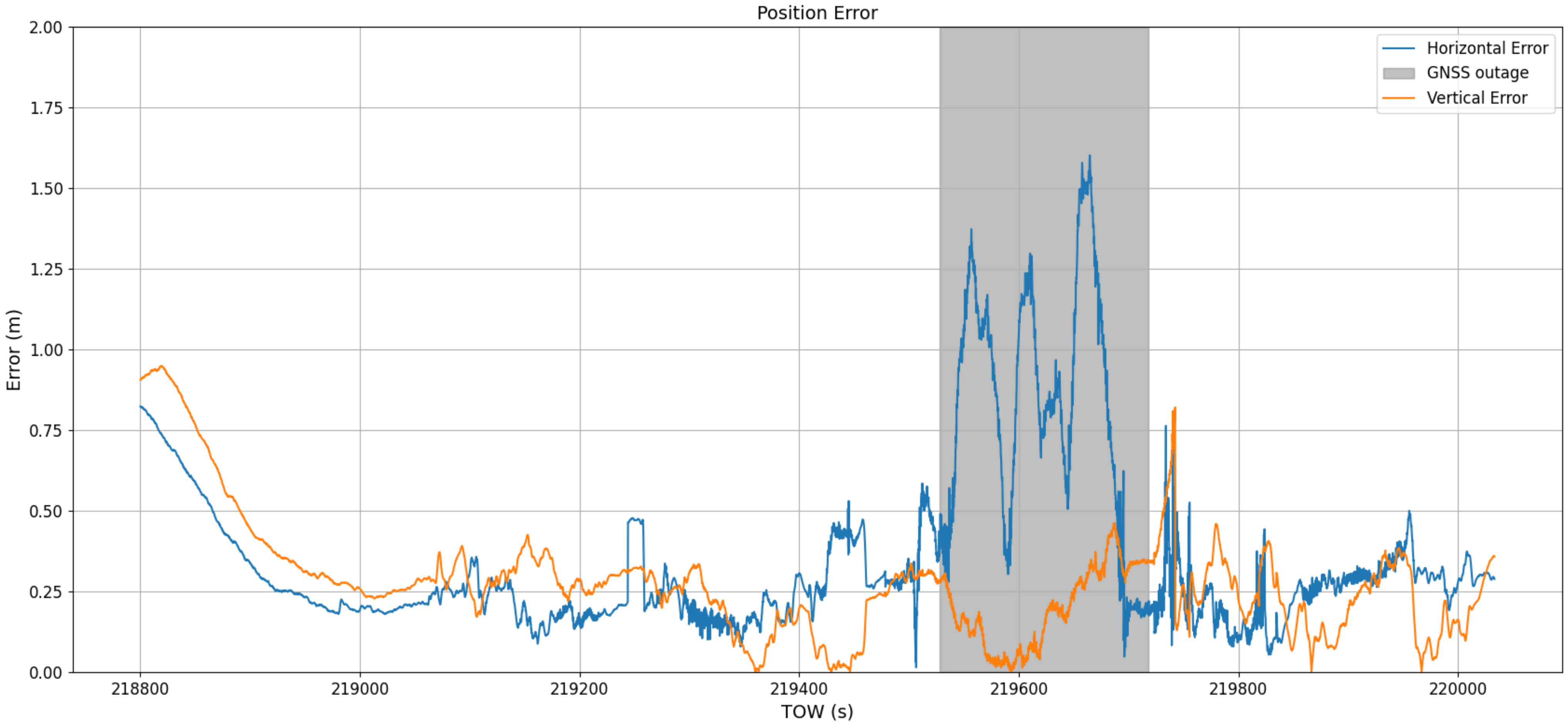

Conclusion and Next Steps

- Presented a subset of **AI techniques** developed by our company, with examples **across different sensors and localization approaches** to strengthen our multisensor positioning system.

- AI networks successfully deployed and validated in our test vehicle, proving **real-time performance on embedded platforms**.

- The AI-supported multisensor framework **enhances localization accuracy and robustness**, achieving meter-level precision even in **challenging indoor environments.**

- Planned **integration** of these localization **enhancements into our product portfolio**, alongside additional AI-enabled features such as **3D object detection & tracking and HD map generation**.

Contact & Project Information

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DREAM Project

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- contract number: EUSPA/GRANT/03/2022.
- https://dream-project-eu.com/

DRIVING AIDS POWERED BY E-GNSS AI AND MACHINE LEARNING