Satellite Navigation for Safety—Critical Applications of Automated Driving

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Sensor Fusion

Probabilistic GNSS Raw Data → Probabilistic Integration
Example
Please click here, to start the video from YouTube.
Without NAVENTIK: The reflected multipath signal gives the wrong position.
- With NAVENTIK: The true position is given along with the additional errors from the signal reflections

→ Key technology for sensor fusion and safety-critical applications
GNSS Navigation for Demanding Automotive and Mobile Applications
PATHFINDER Components

FRONTEND PATHFINDER
- Intertial Sensors
- Vehicle Odometry
- HD Maps
- Optional Extensions

CORE PATHFINDER
- GNSS Baseband
- GNSS Observables (and Uncertainty)
- Bayes Filter

State Estimate
Customer Platform
Technology developed during research projects co-funded by the European Commission and the GSA within the 7th Framework Programme and under Horizon 2020

CoVeL
*Cooperative Vehicle Localization*

GAIN
*Galileo for Interactive Driving*

InDrive
*High-Integrity Applications*
NAVENTIK Approach

→ Adapting the philosophy of the safety-concept from aviation applications to the requirements of automotive applications.
Legacy approach: Position error in urban environments. \(\rightarrow\) Integrity is violated

**NAVENTIK:** Signal reflections are statistically tracked in the receiver. The true vehicle position is covered by the multimodal error envelope. \(\rightarrow\) Positioning integrity
NAVENTIK provides the key technology for safe lane-level navigation.

The vehicle can be mapped to the highway or the exit ramp. As the whole system is based on Bayesian statistics, the application can safely start vehicle actuation based on the position information.
PATHFINDER provides the interface for the probabilistic integration of digital High Definition Maps – the last bottleneck of nowadays high performance applications.

- The parametric description of the vehicle’s position on the road, on the lane and the longitudinal offset on the road segment are part of the state space.

- The NAVENTIK approach for map matching: Lane level localization – Reliable and statistically proven.
Advanced Driver Assistance Systems

- Lane keeping assistants can improve the performance and user acceptance by integrating GNSS in order to avoid false alarm decisions under degraded visual conditions or missing lane markings.
Tolling / Insurance Telematics

- Considering the NAVENTIK confidence, you can precisely determine the correct lane according to specified false alarm rates.
High confidence in lateral direction: Position can safely be mapped to the correct lane even with high uncertainty in driving direction.

“Please switch to the left lane and then turn left at the next intersection.”

High confidence in driving direction: Driving instructions can be precise in terms of distance to the next event but should not provide lane level recommendations.

“Please make sure you are on the left lane and then turn left in 30m.”
Indoor/ outdoor Hybrid Navigation

- With reducing signal strength of GNSS signals, the NAVENTIK system enables the seamless transmission to inertial sensors like gyroscope or acceleration sensors.
Adaption to other Time–of–Flight Localization systems

- The Technology of probabilistic signal tracking can be applied to potentially all time–of–flight based, one–way localization systems.
- Wi–Fi or Bluetooth–based indoor navigation suffers strongly from multipath propagation that can be mitigated by PATHFINDER.
- The software–defined approach can be adopted without additional hardware.
Outlook to further Applications

Basically, applications need to utilize the confidence estimate in order to adopt different automation levels and user interaction according to the performance of the system. That enables the compliance to false alarm specifications for automated applications and improved user acceptance for passive systems.

- Automotive (Advanced Driver Assistance Systems and Autonomous Driving)
  - Safe and seamless integration in probabilistic data fusion frameworks (Bayes filter)
  - Initialization of visual perception systems, Trajectory planning

- Unmanned aerial vehicles (UAV)
  - Deep integration to embedded perception systems on drones (24 computing cores for image and signal processing are available on today's consumer drones)

- Mobile Devices
  - Cloud services will be possible, like the correct localization of the user in urban canyons.
  - Providers for On-Demand taxi services suffer from false position information of passengers in urban areas