GALILEO
HIGH ACCURACY SERVICE DAYS
Precise Point Positioning with High Accuracy Service for Autonomous Vehicles

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Autonomous Driving

Strong need for precise and reliable positioning and environment detection.
Positioning System of ANavS

Multi-Sensor RTK/ PPP Module

- 3 integrated Multi-frequency, Multi-GNSS receivers, available in various configurations with chips from different OEMs
- 1 integrated industrial-grade MEMS-IMU, available in various configurations with different IMUs from low to high bias stability
- 1 integrated CAN bus interface for reading wheel and steering measurements
- Integrated processor with ANavS GNSS/ INS/ odometry tightly coupled RTK/ PPP
- Various interfaces: Ethernet, CAN, USB, WiFi, GSM/ LTE
PPP with HAS – main components

**Pre-processing**
- Observation, Navigation and Correction data
- Determination of HAS satellite positions, velocities, clock offsets and clock drifts
- OS PVT
- Outlier detection and cycle slip correction
- Determination of corrected satellite-satellite single differences (SU) of measurements

**Iterative Kalman filter**
- State initialization
  - Determination of normalized sat.-rec. direction vectors and geometry matrix
- State prediction
  - Calculation + application of SD HAS corrections
- State update
  - Last iteration? Yes
  - Initialization of iono and ambiguity states of newly tracked satellites
    - Application of site displacement corrections (Earth tides, polar motion, ocean loading)
  - Last iteration? No
    - Alternating state predictions and updates (one loop per epoch)

**Solution output**

**Iterative state update with Ambiguity Fixing**
- Determination of subset of ambiguities to fix
- (Partial) Integer Ambiguity Fixing
- Tests, state adjustment, and residual check
PPP with HAS and Sensor Fusion

Sensor raw data

- GNSS receivers: carrier phases, pseudoranges, Doppler measurements
- Inertial sensor: accelerations, angular rates
- Vehicle Information (e.g. wheel speed)
- Local position information
- Camera: mono/ stereo images
- Lidar/ radar: 3D point clouds

PPP/ RTK corrections

Kalman filter

- State prediction: position, velocity, attitude, angular rates, ambiguities, IMU biases
- State update: position, velocity, attitude, angular rates, ambiguities, IMU biases

Function monitoring

- Consistency checks based on separate position solutions
- status of sensor data
- position information including accuracy
- Geo-referenced 3D map with semantic information (e.g., localized traffic lights, traffic signs, distance signs, etc.)
Our reference solution for validating PPP: GNSS RTK + INS + Odometry

Test drive in challenging environment in Munich, Germany.

white: ANavS
blue: OXTS
Our reference solution for validating PPP: GNSS RTK + INS + Odometry

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Tunnel Petuelring, Munich (length: ca. 1.5 km)

white: ANavS
blue: OXTS
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PPP Accuracy Analysis
PPP Repeatability Analysis
PPP Convergence Analysis

Position offset of GPS+GAL-PPP solution to RTK reference position on the 10th of March 2022

Horizontal
Vertical
Hor required
Ver required

Position [m]

time [min]
Dynamic Performance
Dynamic Performance
The Reference System of ANavS for Precise Positioning in Challenging Environments

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

Multi-frequency GNSS antenna

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

IMU with 0.8 deg/h bias stability

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

Multi-frequency GNSS antenna

Multi-Sensor Platform for Precise Positioning in Challenging Environments

Customer benefits:

➢ Precise positioning, mapping and object detection in a single device

➢ Very easy and fast installation and de-installation

➢ No need for individual cabling of each sensor

➢ No need for manual and error-prone determination of lever arms
Multi-Sensor Platform for Precise Positioning in Challenging Environments
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Offset of Lidar-only SLAM w.r.t. RTK position solution
Multi-Sensor Platform for Precise Positioning in Challenging Environments
Multi-Sensor Platform for Precise Positioning in Challenging Environments

Comparison Between MSRTK and LiDAR based Positioning Solution

Location: Hornbach Indoor Parking Space, Munich, Germany
Speed: ~20-30 kmph
Driving scenario: Transition between Indoor and Outdoor environment

View 1: First person view captured by FLIR camera
View 2: Bird-Eye-View of VLP-16 LiDAR SLAM
View 3: AMeWS GUI app showing satellite sky plot and real time positioning solution
Multi-Sensor Platform for Precise Positioning in Challenging Environments
¡THANK YOU!

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