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

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January 23rd, 2024.



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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





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ANavS Architecture for Sensor Fusion



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Outdoor Indoor









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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 |



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LiDAR-based positioning in combined indoor/ outdoor environment



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

| View 1 | | | | | | |
|-------------------------|----------------------------|---|---------------------|------------------|---|-----------------|
| Last corrections: 2.6 s | - | ATUTUSE 🧿 | RTK 🥥 LIGH 🌑 | | Thursday, Feb 24, | 2022 3:20:43 pm |
| View 3 | Solution | -III- Filters | M Sensors | Settings | File | 53:34 |
| Absolute Positi | ion | Total in use: | 17 | Select Filter | Last Update: 0.0 s | |
| Latitude | 48.13425699 * | | | | | |
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| neight | 355.255 11 | | | SAL ME COM | AND THE | |
| Relative Position | on | | <u> </u> | Le - Cur | 1112 | |
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| East | -7081.893 m | | × 1 | A Statist | 3.9 5 | |
| Down | -0.217 m | - 20 " | | the site att the | 111620 | |
| Length | 7084.363 m | Signal (dB-Hz) | | A PER | and the | |
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| Heading | 67.92 ° | △Galleo 7 ◇S | BAS 0 | | 11:20 | - Star |
| Pitch | | | | | and the second se | |
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| Roll | -0.43 ° -0.31 ° | CBeidou 3 7 U | o 2 o 3 | | ACIN | 20 |
| Roll | -0.43 ° -0.31 ° | Boldou 3 T U Frequency ID L1CA, L10F, E1, B1 L2C, L20F, E50, B2 | oknown 0 ● 2 ● 3 | | ALL . | S |

View 2

Comparison Between MSRTK and LiDAR based Positioning Solution

| Location: | Hornbach Indoor Parking Space, Munich. Germanv |
|-------------------|---|
| Speed: | ~20-30 kmph |
| Driving scenario: | Transition between Indoor and Outdoo environment |
| View 1: First per | son view captured by FLIR camera |
| View 2. Bird-Eve- | View of VIP-16 LiDAR SLAM |

View 3: ANaVS GUI app showing satellite sky plot and real time positioning solution





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Indoor Localization Accuracy using Laser Scanner-based Ground Truth



Positioning deviations between Lidar and ground truth from laser scanner:

1.064

- 0.537

0.009

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





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ANavS Architecture for Sensor Fusion



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Visual Camera-based Positioning with Al-based Feature Matching



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

[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.



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

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Visual Camera-based Positioning with AI-based Feature Matching



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Al-assisted Localization on Road Maps (Validation)



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