



## Dense, metric and real-time 3D reconstruction for autonomous drone navigation

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# Dense, metric and real-time 3D reconstruction

## For autonomous drone navigation

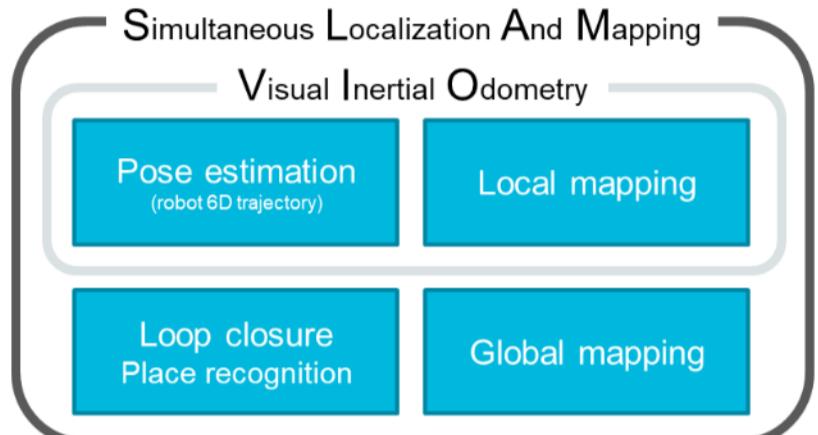
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### 1. Context:

- ▶ Autonomous navigation
  - **Dense** and **metric** mapping
  - **Real-time** application on aerial robots
- ▶ Constraints and challenges
  - Limited computation resources, low energy consumption
  - Use of passive sensors only
  - Restriction to monocular cameras
  - Fast motions
  - Illumination changes

### 2. Approach:

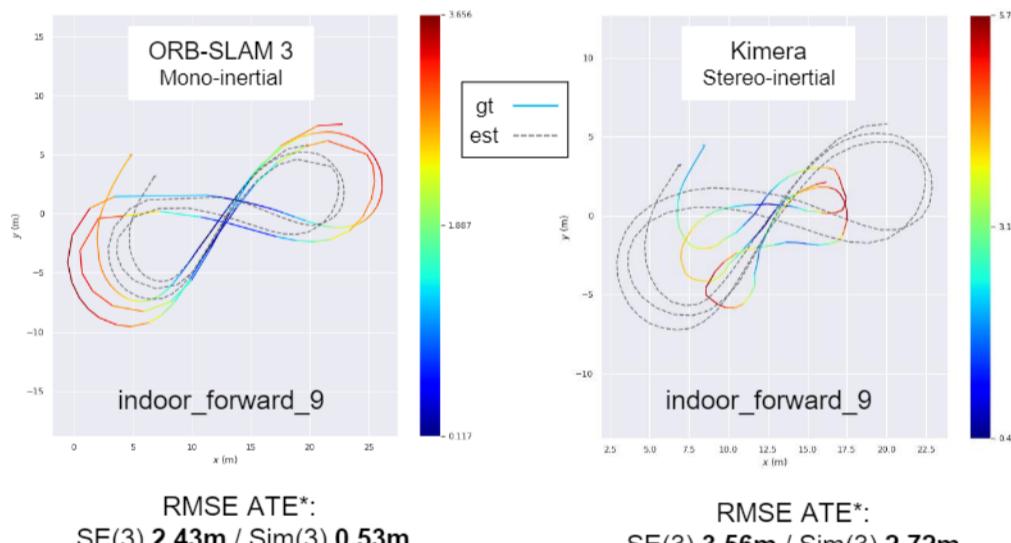


- ▶ State-of-the-art methods:

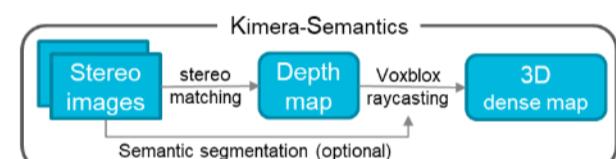
- **ORB-SLAM3** [2] (Mono/Stereo inertial, RGB-D)
- **Kimera** [1] (Stereo inertial)

### 3. Indicative performance of state-of-the-art

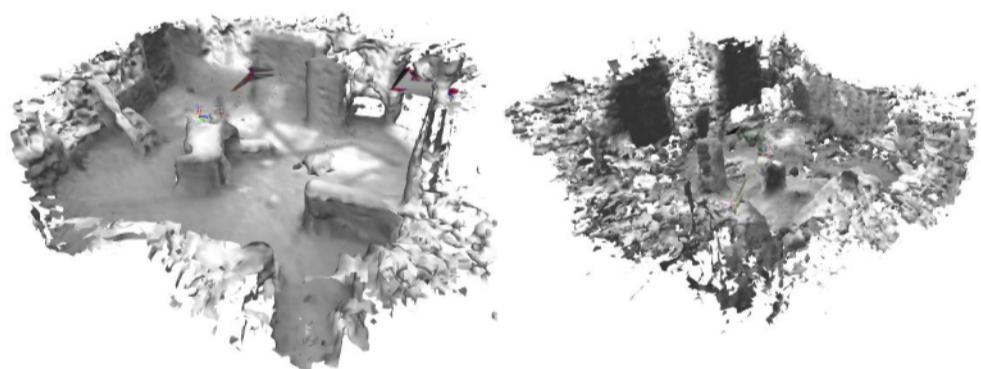
VIO evaluation on UZH FPV Drone Racing dataset [3]



\* Root Mean Square Error (RMSE) of the Absolute Trajectory Error (ATE)



Kimera 3D reconstruction on EuRoC [4] dataset



### 4. Monocular depth estimation

- ▶ As we restrain our study to monocular cameras, stereo-matching is replaced by Deep Learning-based depth estimation.

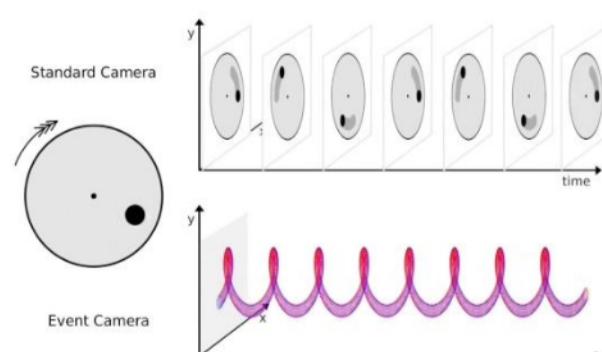


PackNet [5] monocular depth map prediction

|               |  |
|---------------|--|
| Training      | Supervised, Unsupervised, Semi-supervised  |
| Architectures | CNN, Auto-encoder, RNN, GAN  |
| Task          | <b>Single task:</b> Depth map<br><b>Multi-tasks:</b> Depth map, visual odometry, optical flow, semantic segmentation |

### 5. Event cameras

- ▶ The characteristics of the sensor are particularly suitable for our context. It is robust to fast motions and high illumination changes.



|  |                                |
|--|--------------------------------|
| High Dynamic Range: 120 dB             | No direct intensity value      |
| Asynchronous<br>High update rate: 1MHz | No data in static scenes       |
| Low Energy consumption: 20 mW          | Few computer vision algorithms |

[1] Rosinol, Antoni et al. "Kimera: an Open-Source Library for Real-Time Metric-Semantic Localization and Mapping." 2020 IEEE International Conference on Robotics and Automation (ICRA).

[2] Campos, Carlos et al. "ORB-SLAM3: An Accurate Open-Source Library for Visual, Visual-Inertial, and Multimap SLAM". IEEE Transactions on Robotics. (2021): 1-17.

[3] Delmerico, Jeffrey et al. "Are We Ready for Autonomous Drone Racing? The UZH-FPV Drone Racing Dataset." 2019 International Conference on Robotics and Automation (ICRA).

[4] Burri, Michael et al. "The EuRoC micro aerial vehicle datasets". The International Journal of Robotics Research. (2016).

[5] Guizilini, Vitor et al. "3D Packing for Self-Supervised Monocular Depth Estimation." 2020 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)