Dense, metric and real-time 3D reconstruction

For autonomous drone navigation

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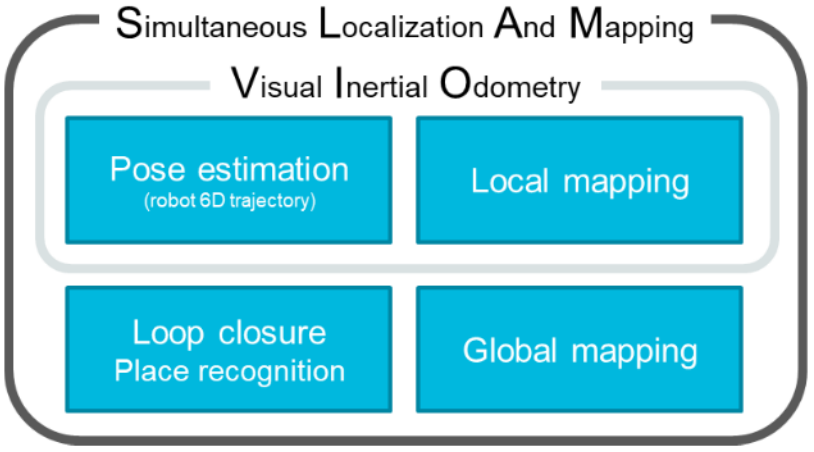
1. Context:

- 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

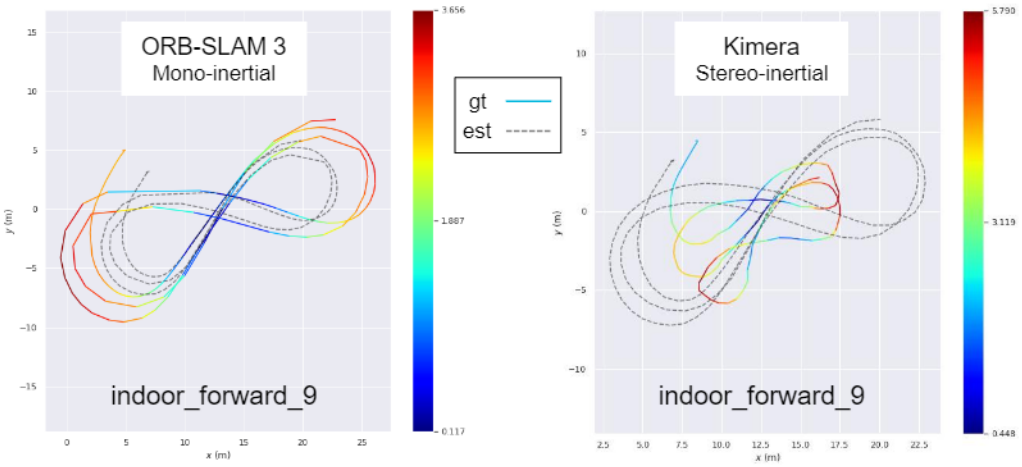
2. Approach:



- State-of-the-art methods:
  - **ORB-SLAM3** [2] (Mono/Stereo inertial, RGB-D)
  - **Kimera** [1] (Stereo inertial)

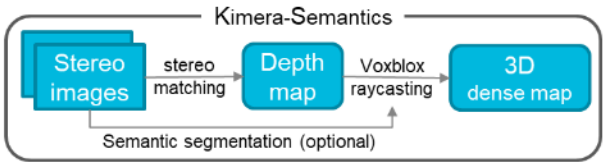
3. Indicative performance of state-of-the-art

VIO evaluation on UZH FPV Drone Racing dataset [3]

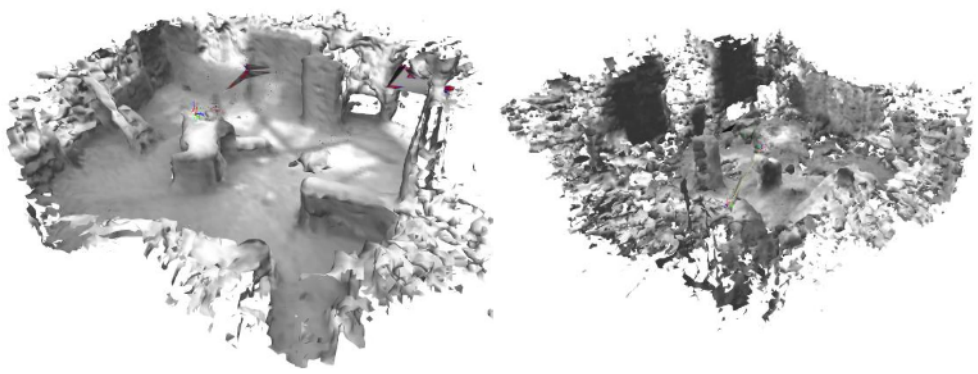


RMSE ATE*:
SE(3) **2.43m** / Sim(3) **0.53m**

RMSE ATE*:
SE(3) **3.56m** / Sim(3) **2.72m**



Kimera 3D reconstruction on EuRoC [4] dataset



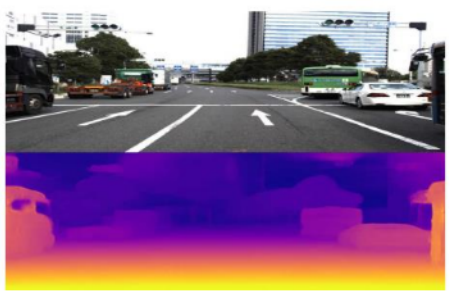
V1_01_easy

V1_02_medium

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

4. Monocular depth estimation

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

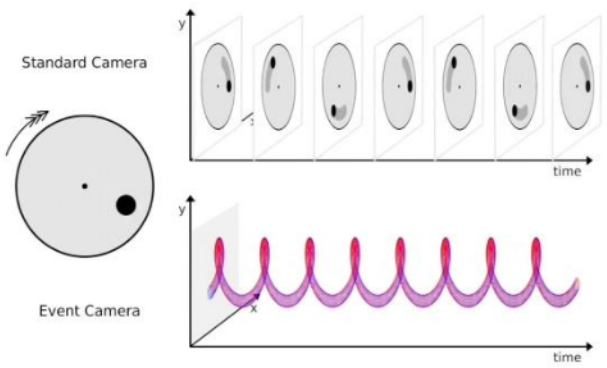


PackNet [5] monocular depth map prediction

Training	**Supervised, Unsupervised, Semi-supervised**
Architectures	**CNN, Auto-encoder, RNN, GAN**
Task	**Single task: Depth map** **Multi-tasks: 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 **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)

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