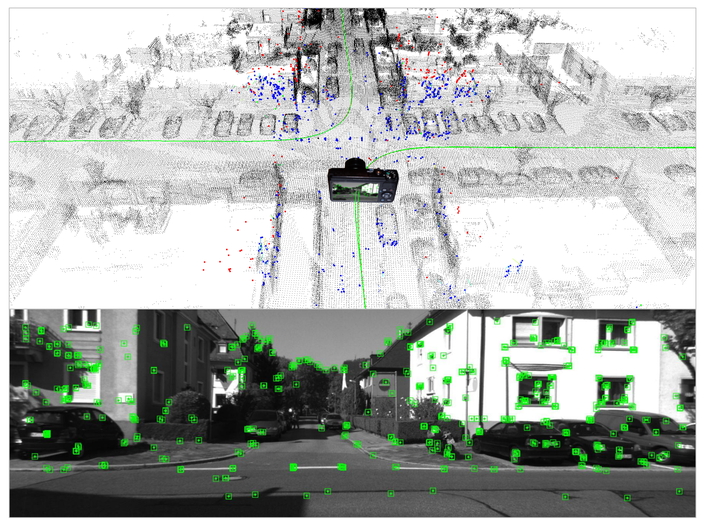
# Matching Geometry for Long-term Monocular Camera Localization

Tim Caselitz, Bastian Steder, Michael Ruhnke, Wolfram Burgard

UNI FREIBURG

AiS Autonomous Intelligent Systems



- **Localization of a monocular camera in a given geometric map**
- **Long-term localization: recordings of maps often date back considerably compared to the time of localization**
- **Geometry of the environment remains reasonably stable over time**
- **Our approach: matching geometry instead of photometric appearance**

## Proposed Method

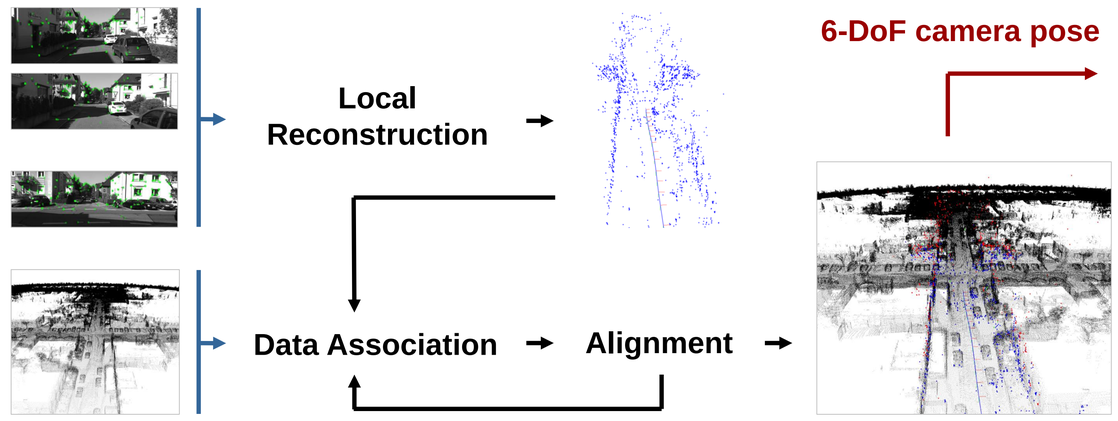
- Objective: estimate the 6-DoF camera pose
- Input: Image stream, geometric map

### Local Reconstruction

- Visual odometry with local bundle adjustment based on ORB-SLAM by Mur-Artal *et al.*
- Reconstruct a set of points $\mathbf{d}_i \in \mathbb{R}^3$ observed as features in images captured from keyframe poses

### Data Association

- Iterative Closest Point (ICP) algorithm
- Match geometry: point-to-point correspondences $\mathcal{C}_k$ between local reconstruction and map points $\mathbf{m}_j \in \mathbb{R}^3$
- Handle partial overlap by analyzing the local point distribution of the geometric map




### Alignment

- Align local reconstruction with geometric map to indirectly obtain the 6-DoF camera pose
- Visual odometry accumulates drift in 7-DoF
- Estimate a similarity transformation:

$$\mathbf{S}_k^* = \underset{\mathbf{S} \in Sim(3)}{\operatorname{argmin}} \; F_{Data}(\mathbf{S}, \mathcal{C}_k)$$

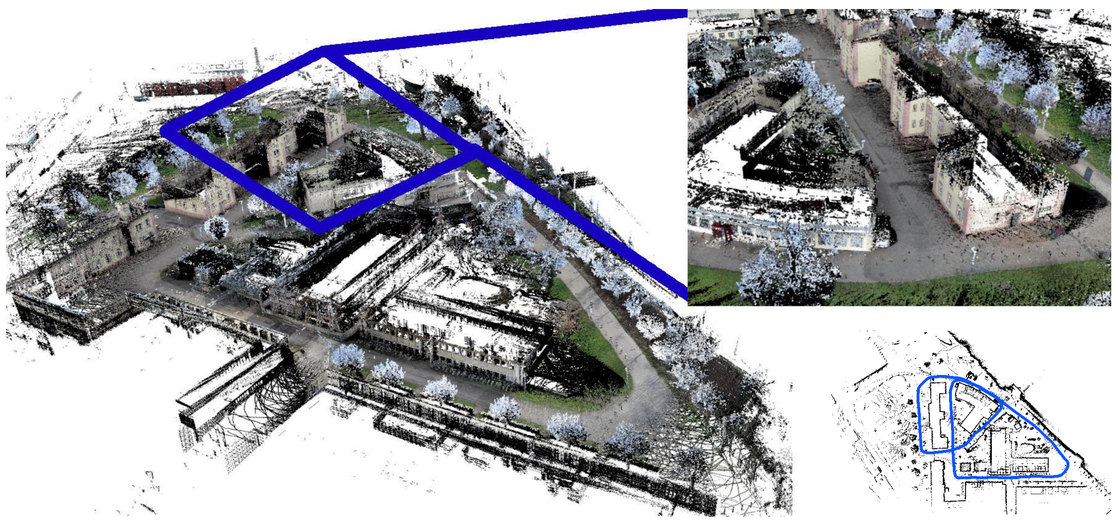
$$F_{Data}(\mathbf{S}, \mathcal{C}_k) = \sum_{\mathcal{C}_k} \rho \left( \mathbf{e}_{Data}^\top \mathbf{e}_{Data} \right)$$

$$\mathbf{e}_{Data}(\mathbf{S}, \mathbf{d}_i, \mathbf{m}_j) = s\mathbf{R}\mathbf{d}_i + \mathbf{t} - \mathbf{m}_j$$

## Experimental Evaluation

### Evaluation of Accuracy

- KITTI odometry dataset, sequence 00, camera 0
- LiDAR-based SLAM to build consistent geometric map
- 6-DoF localization error averaged over 10 runs: translational: 0.30±0.11m / rotational: 1.65±0.91°
- Online tracking at a frame-rate of 10fps



### Evaluation under Varying Conditions

- Freiburg campus dataset (self-recorded)
- Geometric map: Velodyne HDL-32E LiDAR, SLAM
- Localization with Canon S100 / iPhone 5s camera on different days with varying weather conditions in opposite direction compared to map acquisition
- Post-colorization of geometric map visualizes quality of camera pose estimates