Feature-based target tracking

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Bachelor Thesis
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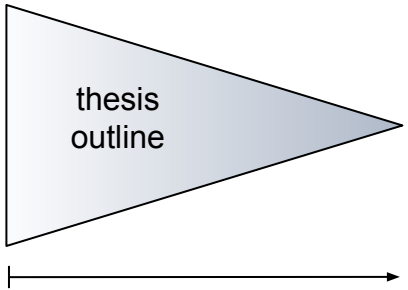
Motivation

High accuracy tracking of feature-based targets

- Tracking: continuous localization
- Set of (noisy) sensor measurements
- Real-time



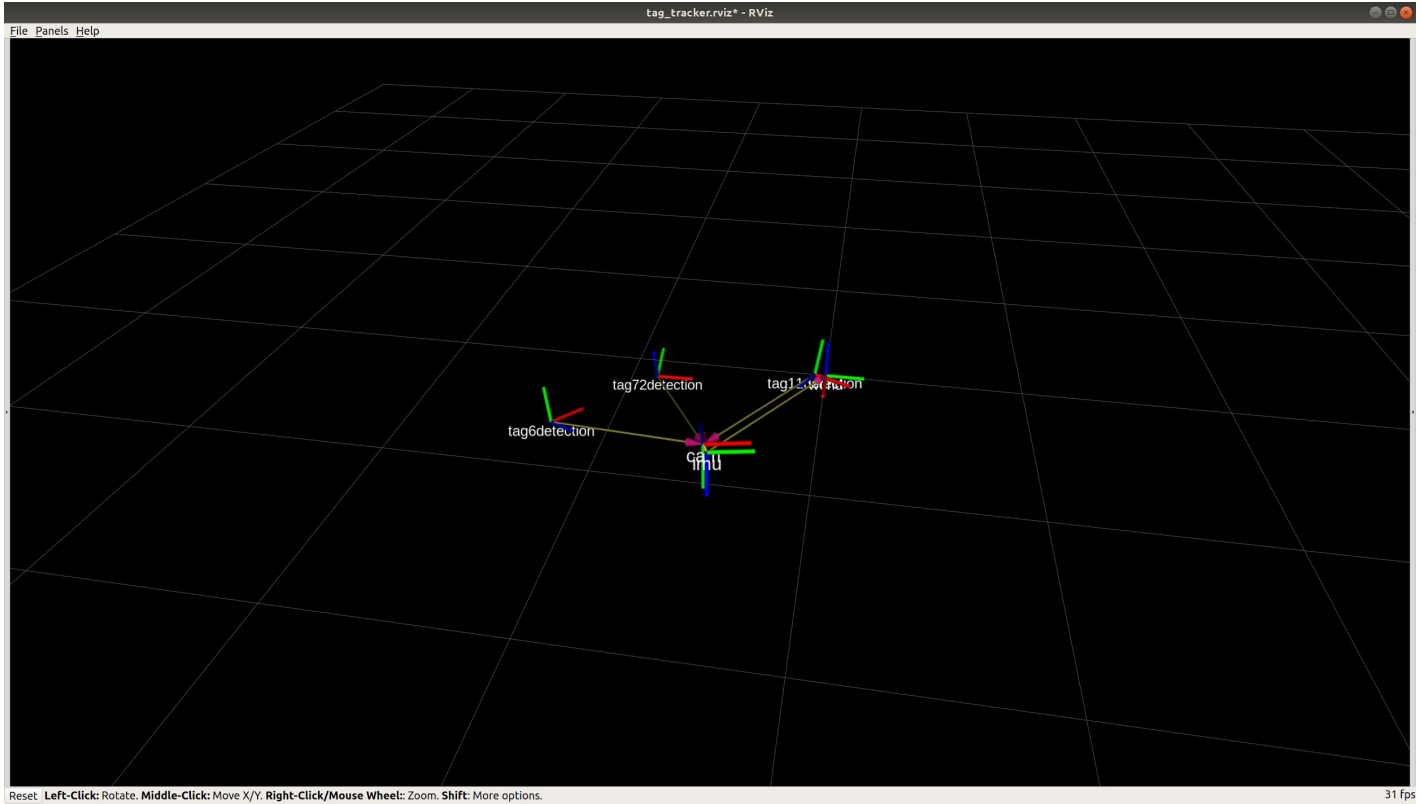
Starting point:

- Camera, IMU, tags
- ConFusion package [1]: estimated camera poses from tags and IMU fusion

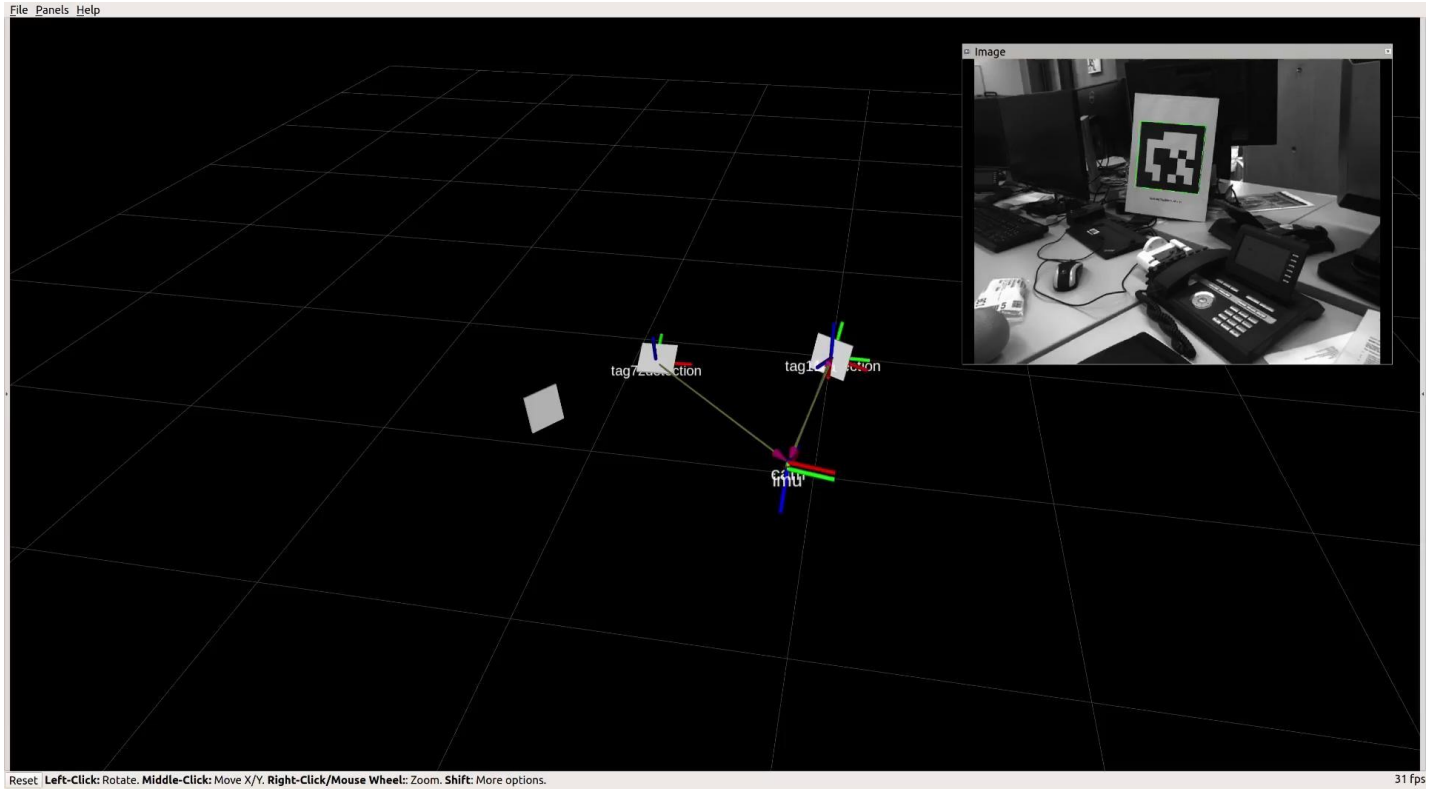
Aim:

- Using tracked features for sensor fusion → remove tags

Setup


tag_tracker.rviz* - RViz
File Panels Help
tag72detection
tag6detection
imu
Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
31 fps

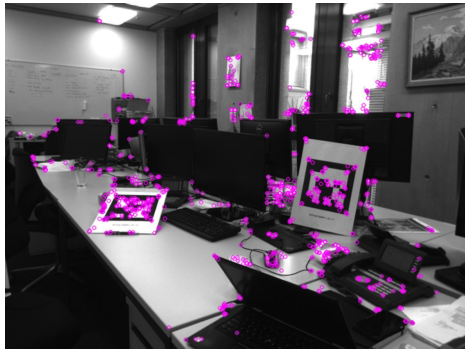
Bag file

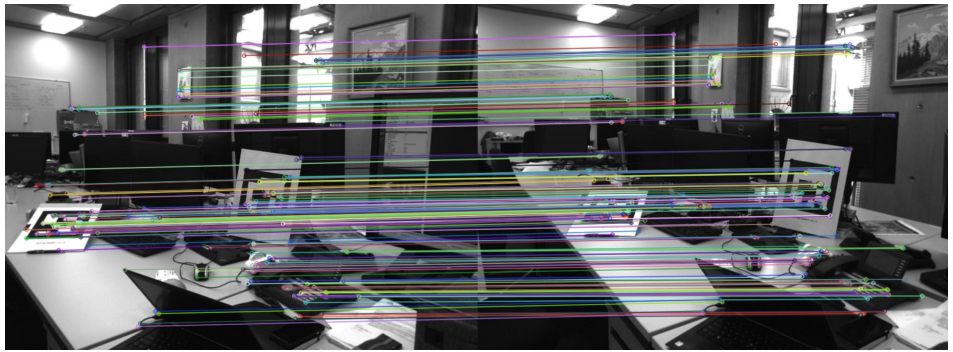

File Panels Help
Image
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
31 fps

Progress so far

3D reconstruction

- Pinhole camera model
- Detect keypoints, compute descriptors, check keyframe criteria → match features
- Obtain depth information via triangulation
- Match extracted features from new images to triangulated points





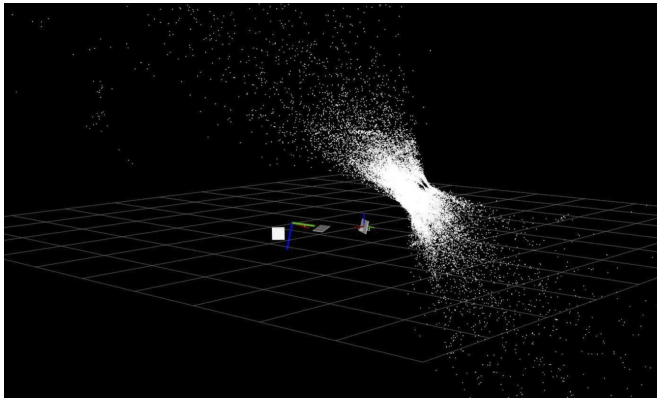
Triangulation

Linear approximation → 3D point initialization

$$\underbrace{\lambda \cdot p_i}_{\text{parallel}} = \underbrace{M_i \cdot P}_{\text{parallel}} \quad \rightarrow \quad p_i \times M_i \cdot P = 0 \quad \rightarrow \quad [p_i]_\times \cdot M_i \cdot P = 0$$

↳ $M_i = \underbrace{K}_{\text{camera to image}} \cdot \underbrace{[R|t]}_{\text{world to camera}}$!

p	*projected point on image plane*
M	*projection matrix*
K	*camera matrix (intrinsic)*
R	*rotation matrix*
t	*translation vector*
P	*3D point coordinates*
i	*keyframe*



[2]

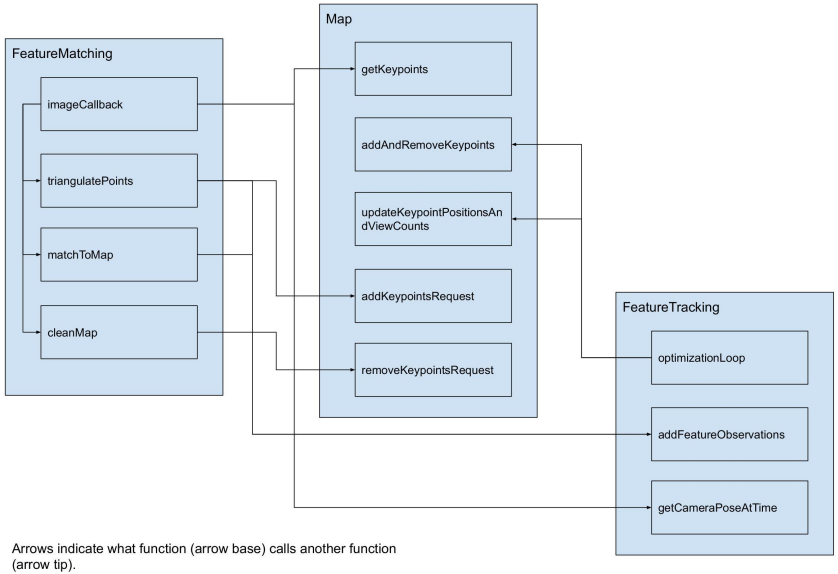
Point cloud

Features detected in frames

Triangulated points from keyframes

Current challenges and next steps

- Timing, retrieving transformation info (include message filter?)
- Fuse point observations over time



Arrows indicate what function (arrow base) calls another function (arrow tip).

⟹ Today's meeting

Schedule

- **24.02.** **Kickoff**

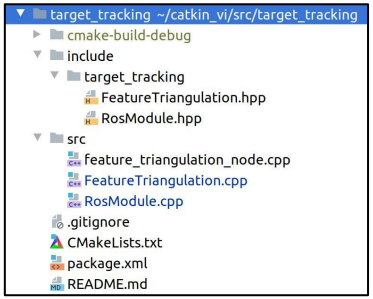
  Package *target_tracking*: feature detection & matching → triangulation
  matching to initial set of 3D points

- **20.04.** **Midterm presentation**
- 27.04. Fuse observations of matched points (3D-2D) over time
- 04.05. ...
- 11.05. ...
- 18.05. ...
- 25.05. ...

  Discuss and fix in today's meeting

- 01.06.. Finish work, preparations for final presentation & test run?
- **08.06.** **Final presentation + Studies on Mechatronics**

→ Two weeks of writing, hand in: 22.06.2020



References

[1] T. Sandy, L. Stadelmann, S. Kerscher and J. Buchli, "ConFusion: Sensor Fusion for Complex Robotic Systems Using Nonlinear Optimization," in IEEE Robotics and Automation Letters, vol. 4, no. 2, pp. 1093-1100, April 2019.

[2] D. Scaramuzza. (2019). Multiple View Geometry 1 [PowerPoint slides]. Available: *http://rpg.ifi.uzh.ch/docs/teaching/2019/07_multiple_view_geometry_1.pdf*