# Vision Based Navigation

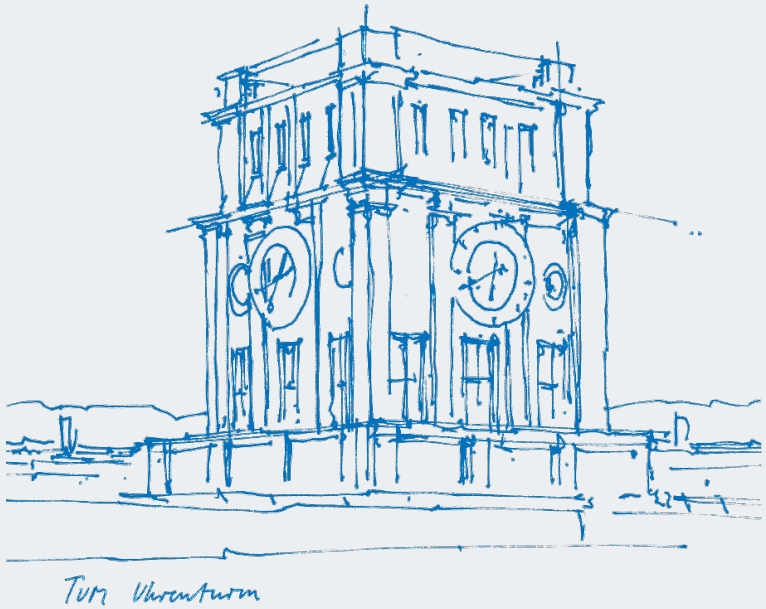
Computer Vision Group - TUM

06.07.2026

# Practical Course: Vision Based Navigation

## Premeeting

Mateo de Mayo, Jonathan Eichhorn
Prof. Dr. Daniel Cremers




Date: 06.07.2026

# Motivations

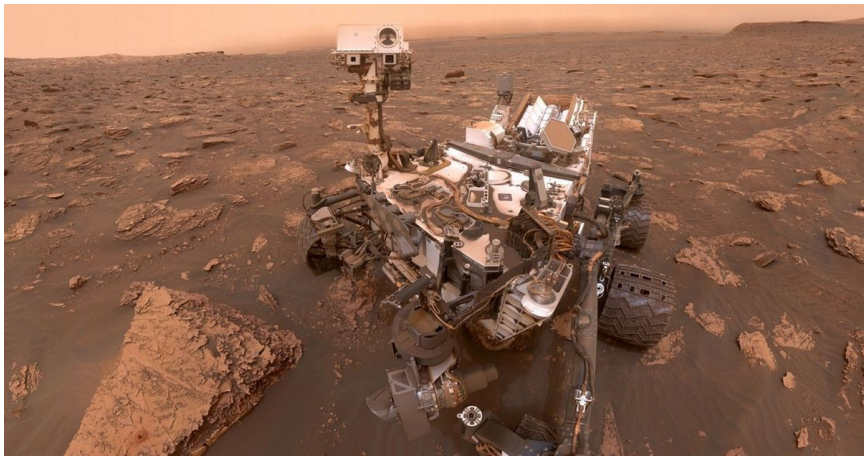


Figure 1: No GPS



Figure 2: Pose estimation

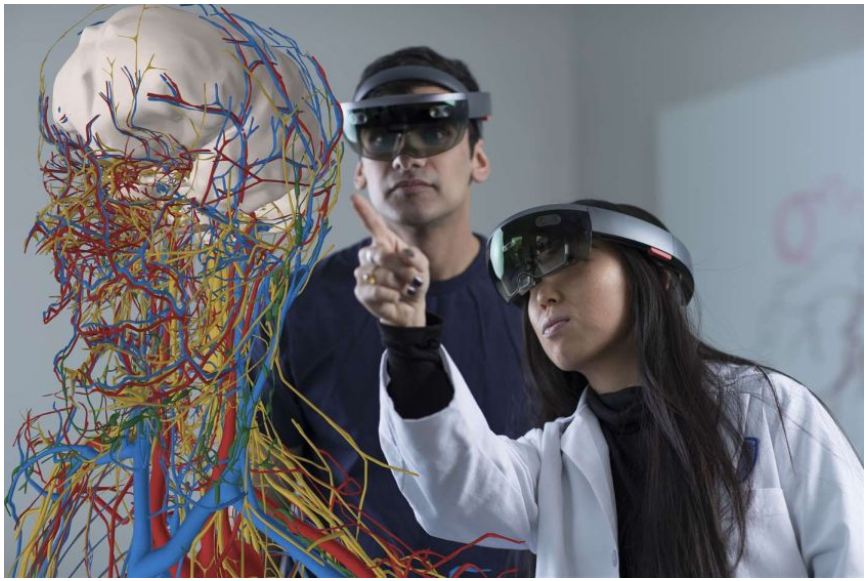


Figure 3: Path planning



Figure 4: 3D reconstruction

# DSO

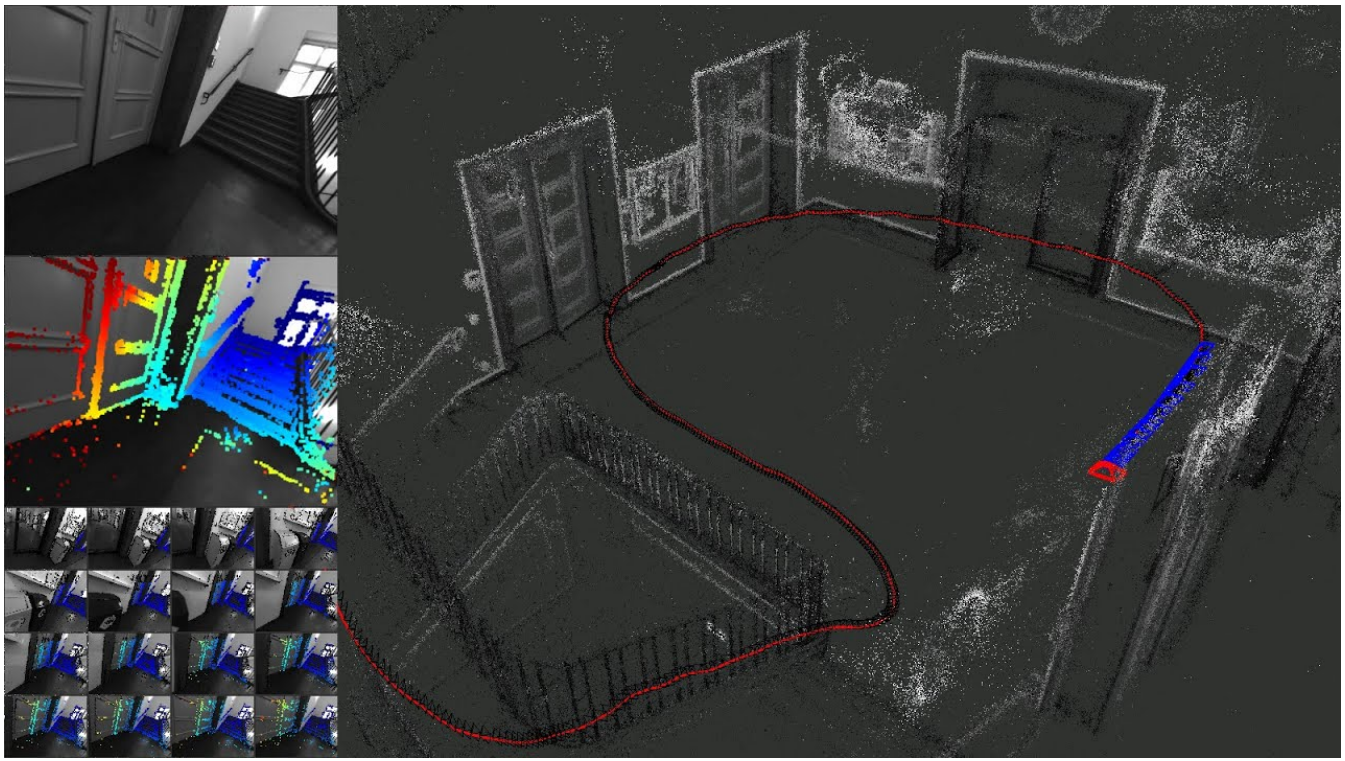


Figure 5: DSO Video

# ORB-SLAM

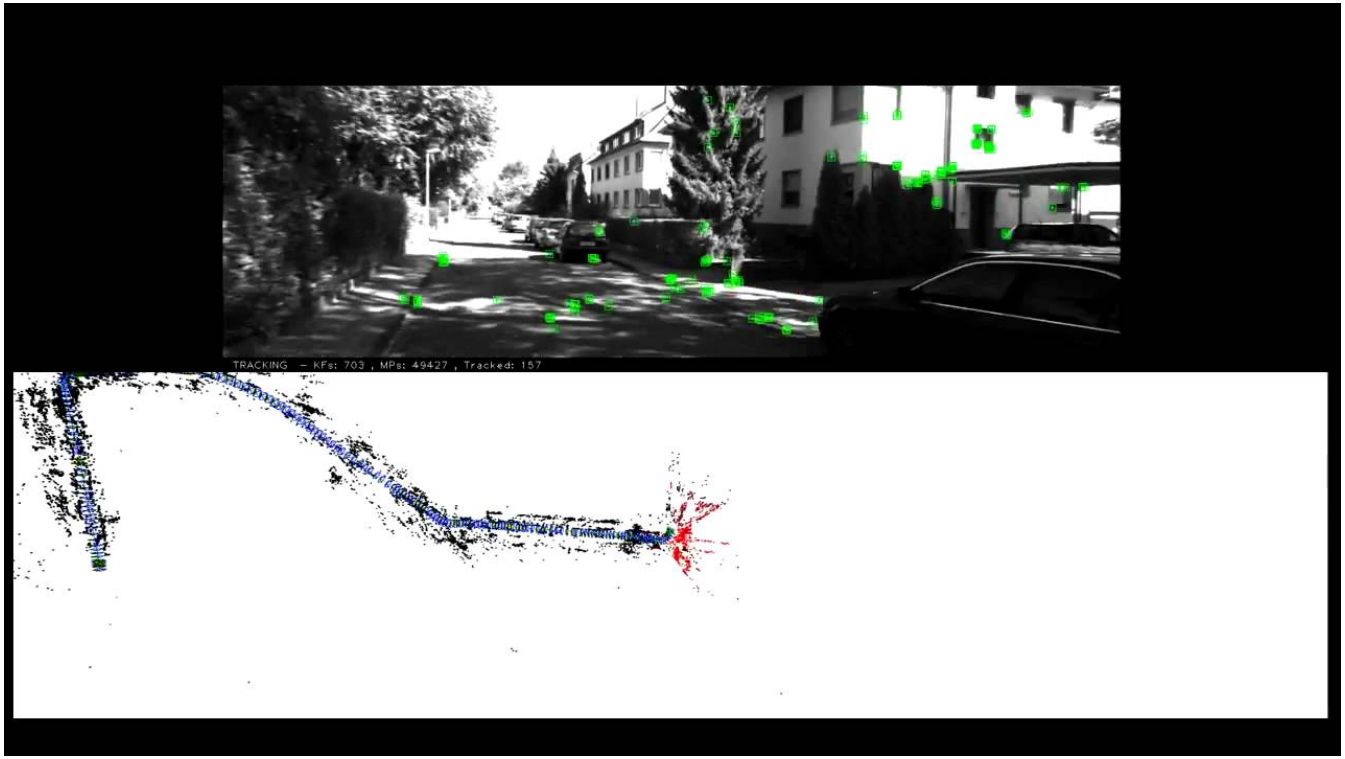



Figure 6: ORB-SLAM Video

# Content of this course

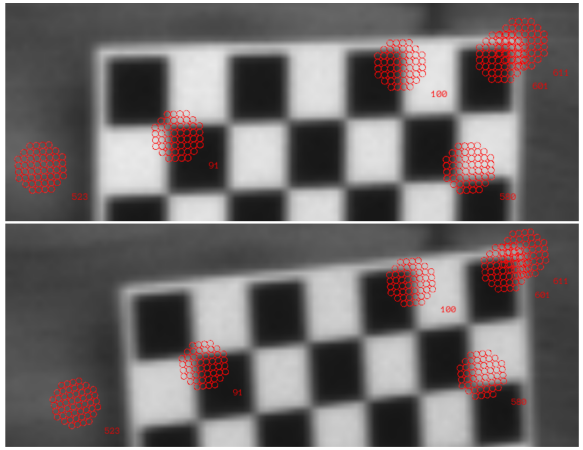
- You can gain practical experience with
  - Visual odometry and localisation / state estimation
  - Vision-based Simultaneous Localization and Mapping (SLAM)
  - Structure from Motion (SfM)
- Implementation of algorithms
- Benefits / drawbacks of specific methods when applied to concrete, relevant problems
- Get familiar with relevant software libraries (Eigen, Ceres, OpenGV, . . . )
- Learn how to work in teams / on projects
- Improve your presentation skills

# Course organisation

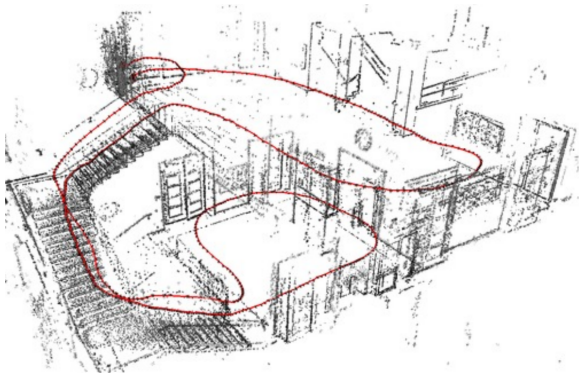
- Course takes place during the lecture period
- In Garching CIT in a seminar room TBD
  - Work on your own machine
  - We support Ubuntu 24.04, and 26.04 (MacOS and Windows may work with some cmake tweaking)
- Initial phase (first 5 weeks): Lectures & Exercises
  - Mondays 2-4 pm lecture
  - Mondays 4-6 pm exercise session
  - Programming assignments will be handed out every week and checked / graded by the tutors
  - Assignments are worked on individually by every student; each participant should be able to explain their solution
  - Attendance to lecture and exercise sessions voluntary (but **highly** encouraged)
- Second phase (5-7 weeks): project
  - Work in small groups (1-2 people) on a project
  - Mandatory weekly meeting with tutors to discuss progress and next steps (Mondays 2-6 pm)
  - Implement a specific algorithm / extension / paper, which one tbd
  - Present project outcome in talk and Q&A session (15+5 min per group)
  - Written report on project outcome (10-12 pages, single column, single-spaced lines, 11pt)

# Topics covered

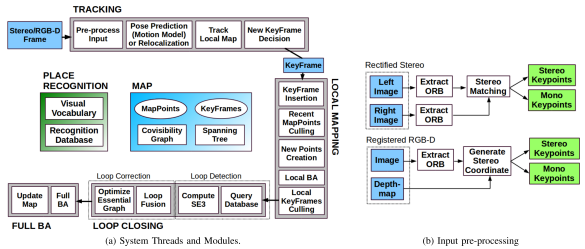
- 3D geometry and camera models
- Non-linear optimisation and camera calibration
- Feature detectors and descriptors, feature matching, RANSAC
- Offline Structure from Motion, Bundle Adjustment, Schur complement
- Visual odometry and SLAM (online BA)
- Possible topics for projects:
  - Large-scale consistency for SLAM
  - Visual place recognition
  - Optical flow for visual odometry
  - Gaussian Splatting SLAM
  - Direct methods (odometry, BA)
  - Dense reconstruction
  - Rotation / Translation averaging (global SfM)
  - ...



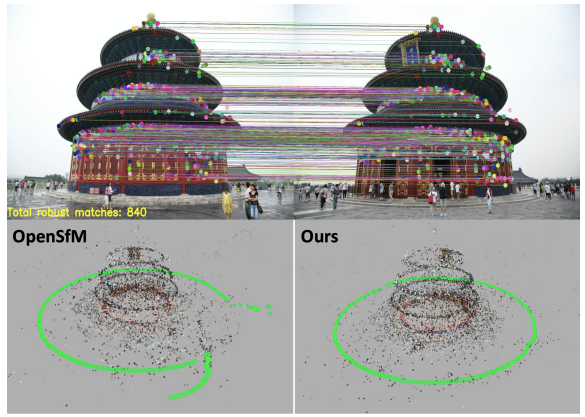


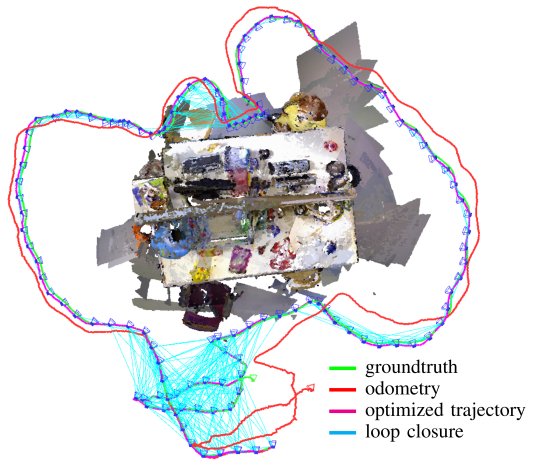






(a) System Threads and Modules. (b) Input pre-processing



# Course requirements

- **Knowledge of C++ is essential** (C/Zig/Rust experience may be accepted)
- Good knowledge of basic mathematics such as linear algebra, calculus, probability theory, and numerics is required
- Prior practical knowledge in robotics and computer vision topics is a plus
- Participation in at least one of the following lectures of the TUM Computer Vision Group
  - Computer Vision I: Variational Methods
  - Computer Vision II: Multiple View Geometry
  - Similar lectures can also be accepted
- Note: If you don't satisfy the requirements but are still interested in the course, please contact us and we can discuss your case individually

# Course registration

- You apply for this course through the matching system: https://matching.in.tum.de/
- Additionally, you have to send us an email:
  - Please specify how you meet the course requirements / if you have attended any related computer vision courses before!
  - **Comment on your programming experience in C++ or otherwise**! List concrete examples of projects you have worked on or send us your github/gitlab/etc profile.
  - Send all your grade transcripts, in particular showing any lectures on pre-requisite topics (computer vision / robotics / maths) that you have attended to: visnav-ws26@vision.in.tum.de
  - A CV is also nice if you have it

The deadline for the matching system and prerequisite email is 15.07.2026.

We can only guarantee places to students assigned through the matching process (and fitting the course requirements)!

Watch announcements on the course website:
https://cvg.cit.tum.de/teaching/ws2026/visnav_ws2026

The course starts on Monday, 19.10.2026 at 14:00 in Seminar Room 02.09.023.

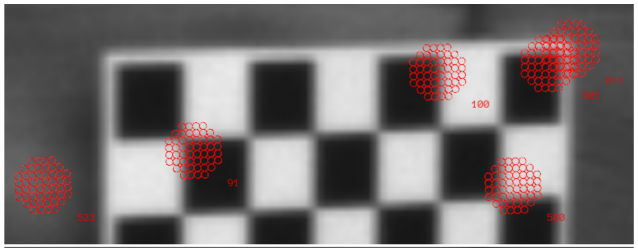
# Demo

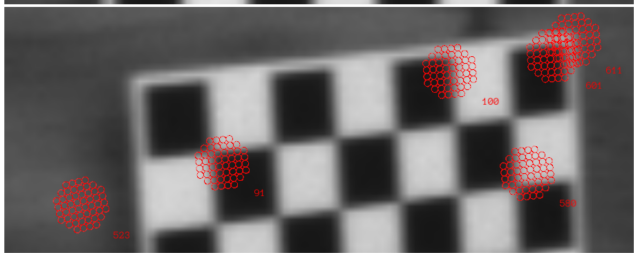
# Questions?

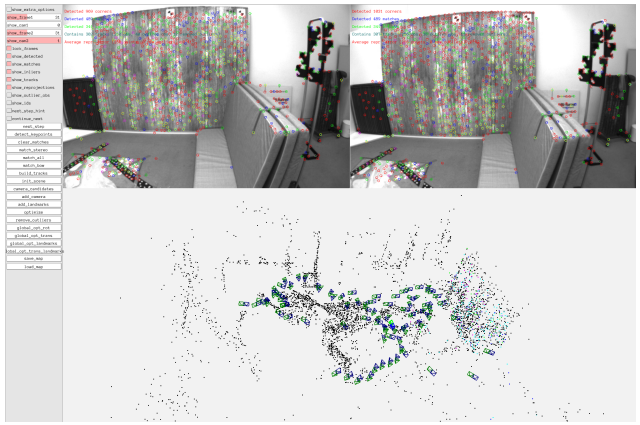


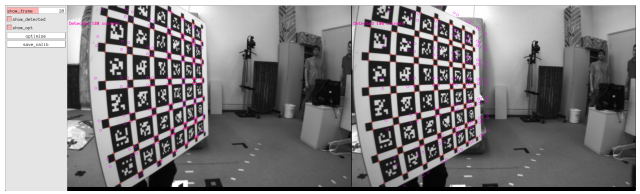


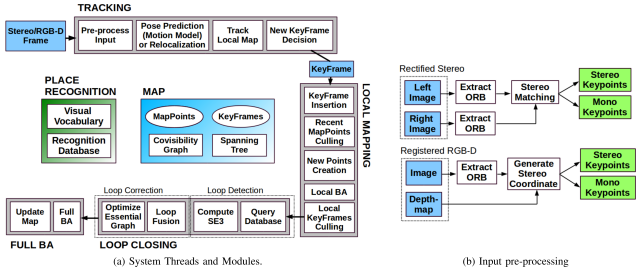













(a) System Threads and Modules. (b) Input pre-processing

