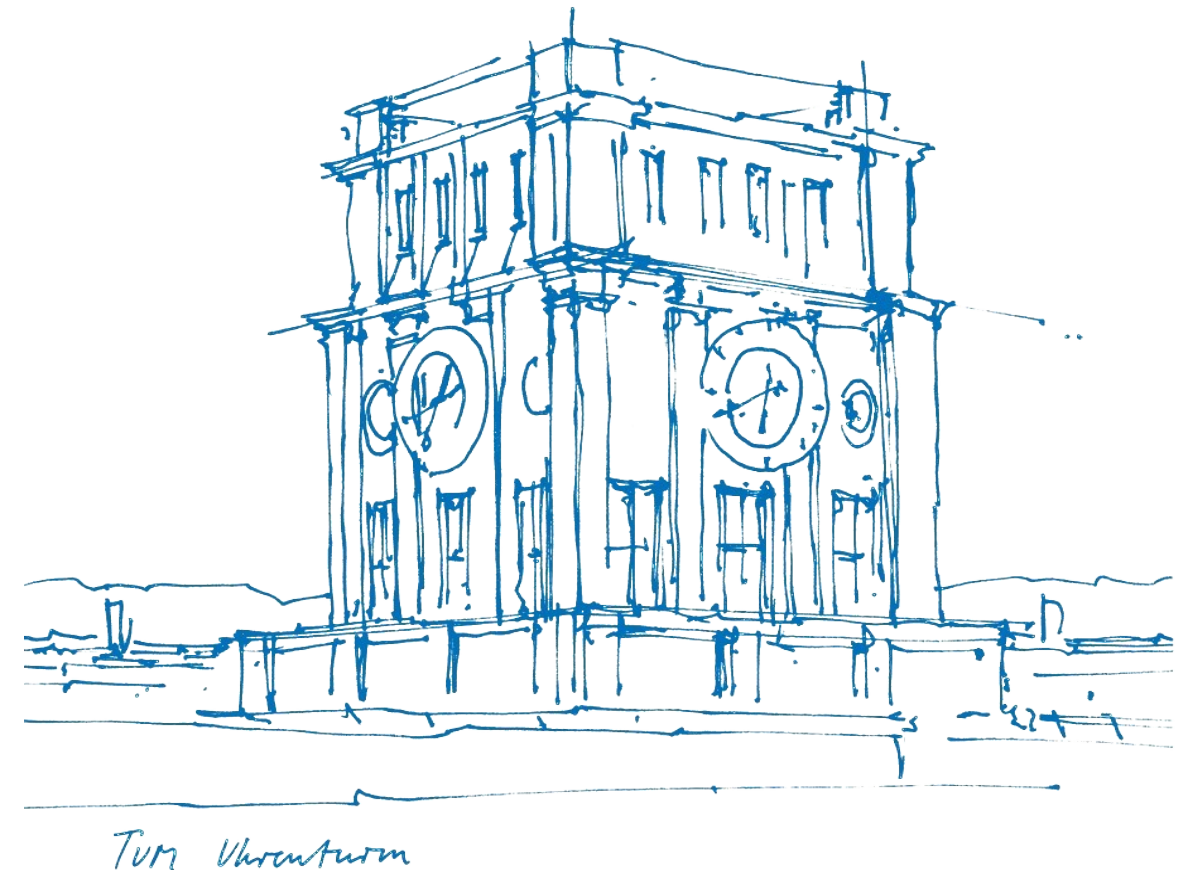


# Practical Course: Vision Based Navigation

## Premeeting

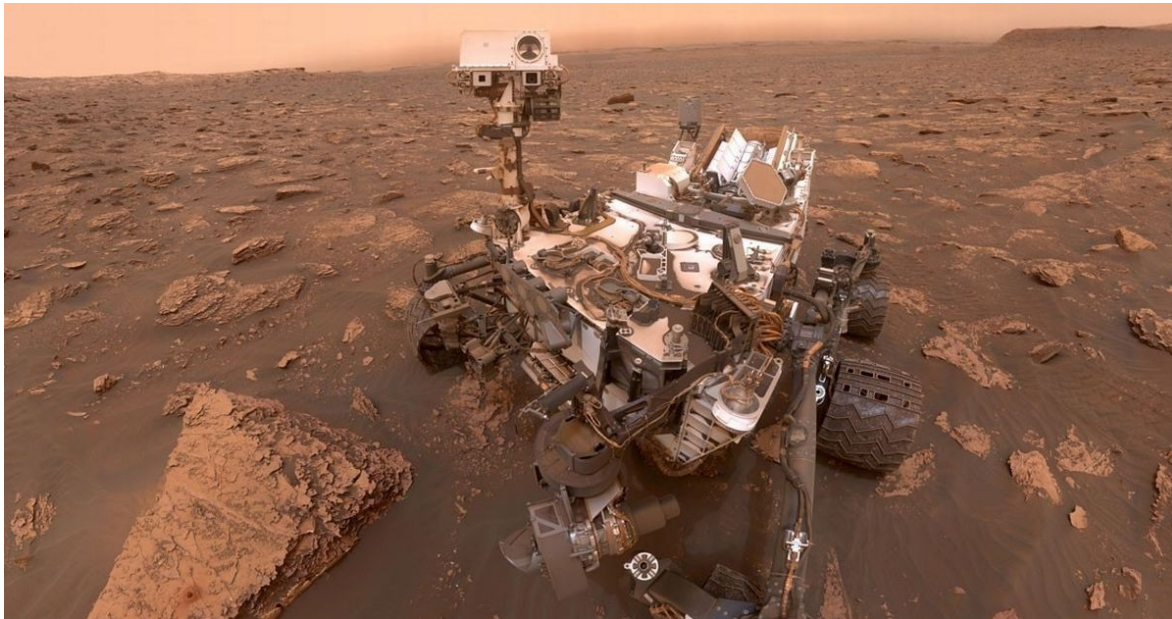
Jason Chui, Mateo de Mayo, Jonathan Eichorn  
Prof. Dr. Daniel Cremers



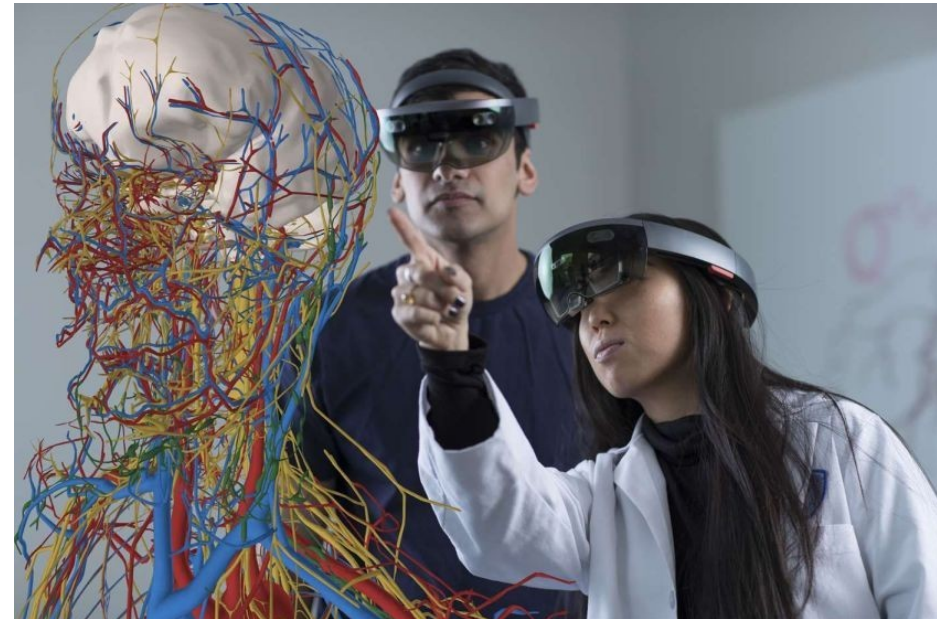


# Motivations

No GPS



Pose estimation



3D reconstruction



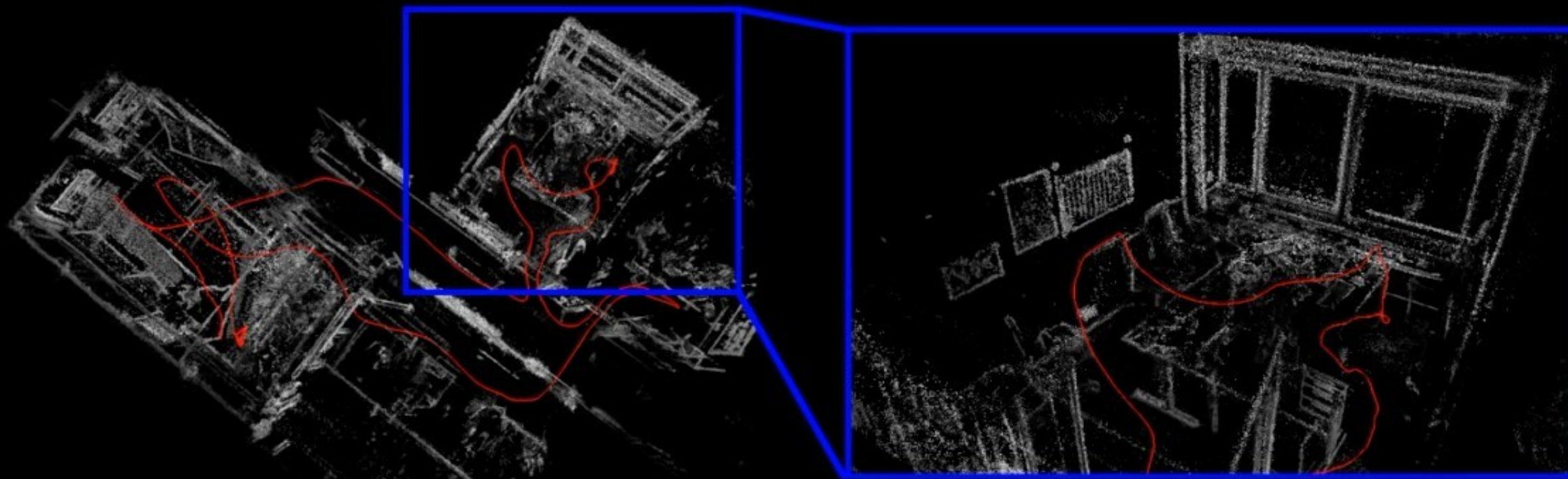
Path planning (when we have a map)





# Direct Sparse Odometry

Jakob Engel,<sup>1,2</sup> Vladlen Koltun,<sup>2</sup> Daniel Cremers<sup>1</sup>  
July 2016



## ORB-SLAM

Raúl Mur-Artal, J. M. M. Montiel and Juan D. Tardós

{raulmur, josemari, tardos} @unizar.es



Instituto Universitario de Investigación  
**en Ingeniería de Aragón**  
**Universidad** Zaragoza



**Universidad**  
Zaragoza

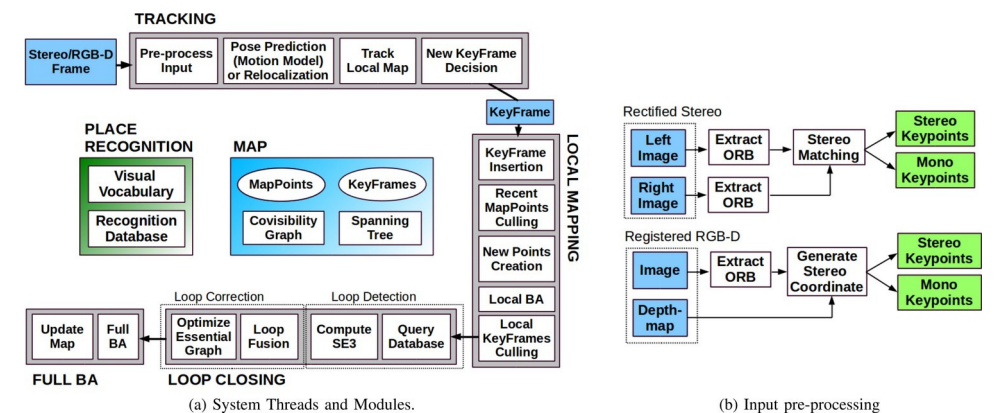
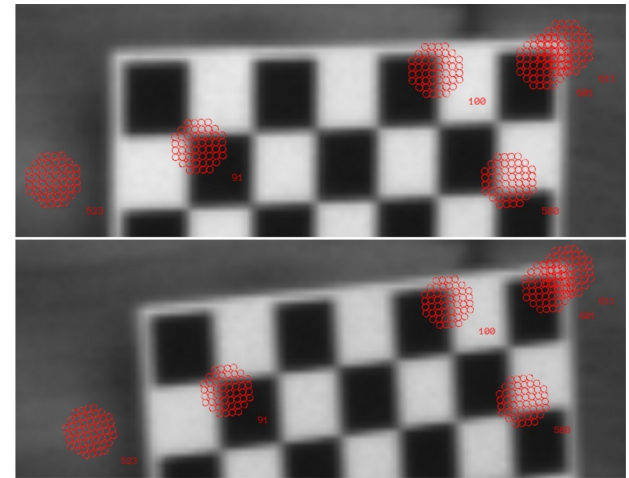
- You can gain practical experience with
  - Visual odometry and localisation / state estimation
  - Vision-based Simultaneous Localization and Mapping (SLAM)
  - Structure from Motion (SfM)
- Implementation of algorithms
- Benefits / drawbacks of specific methods when applied to concrete, relevant problems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

- Course takes place during the lecture period
- The course will be held in person
  - Work on your own Linux desktop / laptop
- 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 (6 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 mins per group + 5 mins Q&A)
  - 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
  - Direct methods (odometry, BA)
  - Dense reconstruction
  - Rotation / Translation averaging (global SfM)
  - ...



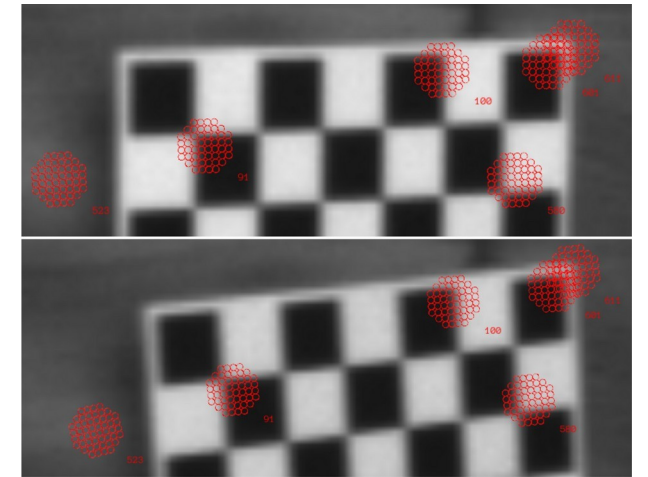
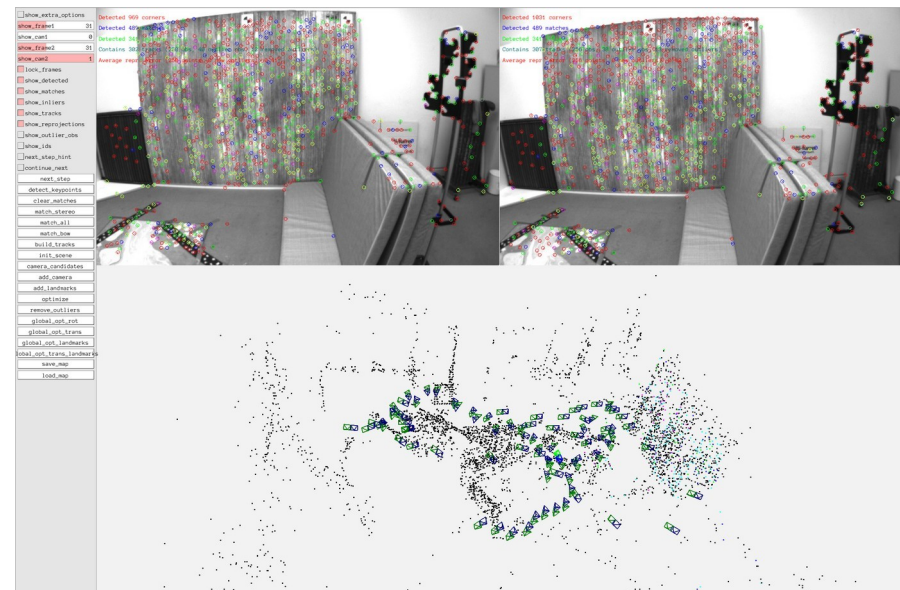
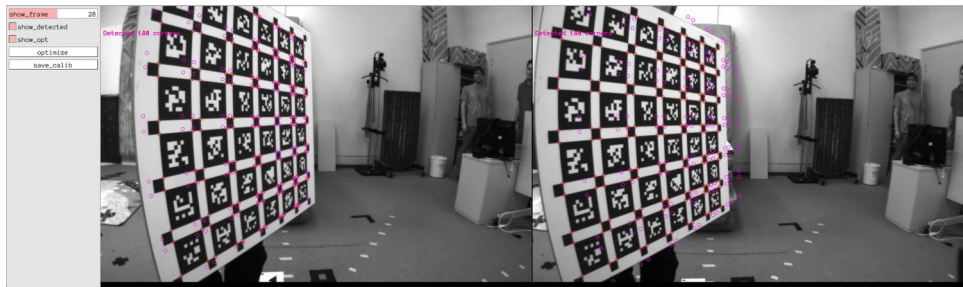
- **Good knowledge of the C/C++ language is essential**
- Good knowledge of basic mathematics such as linear algebra, calculus, probability theory, and numerics is required
- Prior practical knowledge in robotics and computer vision topics is a plus
- Participation in at least one of the following lectures of the TUM Computer Vision Group
  - Computer Vision I: Variational Methods
  - Computer Vision II: Multiple View Geometry
  - Similar lectures can also be accepted



# 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++!** List concrete examples of projects you have worked on.
  - Send all your grade transcripts, in particular showing any lectures on pre-requisite topics (computer vision / robotics / maths) that you have attended to the email shown in the course website: [https://cvg.cit.tum.de/teaching/ws2025/visnav\\_ws2025](https://cvg.cit.tum.de/teaching/ws2025/visnav_ws2025)
- The deadline for the matching system and prerequisite email is 22.07.2025.
- 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/ws2025/visnav\\_ws2025](https://cvg.cit.tum.de/teaching/ws2025/visnav_ws2025)
- The course starts on Monday, 13.10.2025

Demo



Questions?

