Practical Course (Fachpraktikum): “3D Perception for Mobile Robotics”

Description
Robots that navigate an environment use exteroceptive sensors such as cameras and LiDARs to understand and build representations of their surroundings. In this practical course we will focus on cameras, and students will learn how to use and deploy these sensors for the purpose of robot navigation. Students will learn the fundamentals of visual perception systems in a robotics context, transitioning between the 3D world and 2D projections, processing image data streams, and understanding common robotics algorithms.

Students will work in teams of four to develop a fully functional visual odometry pipeline in C++. While the course emphasizes core topics, teams are encouraged to enhance their projects further. Example extensions include integrating proprioceptive sensors (such as IMUs), rendering 3D maps using tools like nvBlox or Neural Radiance Fields, adding semantic attributes, or extending the pipeline to full visual SLAM.

The teams will work with datasets and own data collected with real camera systems.

Content
Perspective Camera Model, Camera Calibration, Motion Estimation, Feature Detection-Descriptor-Matching, Multiple-view Geometry, RANSAC, Pose-Graph Optimization, Bundle Adjustment, Visual Odometry, Introduction to PointCloud Analysis, Advanced 3D Perception talks.

Previous Knowledge
A strong foundation in Linear Algebra and C++ is essential for this course, and familiarity with Linux systems is a significant advantage for those who want to extend the final project in ROS.

Objective
The course will enable students to understand the fundamental principles of visual robot navigation, particularly visual odometry. By the end of the course, students will be able to understand, implement and deploy a basic module capable of tracking the pose of a moving camera for mobile robot applications.

Information
- Organizer: Prof. Kai Arras
- Co-Organizers: Dennis Rotondi, Fabio Scaparro, Tim