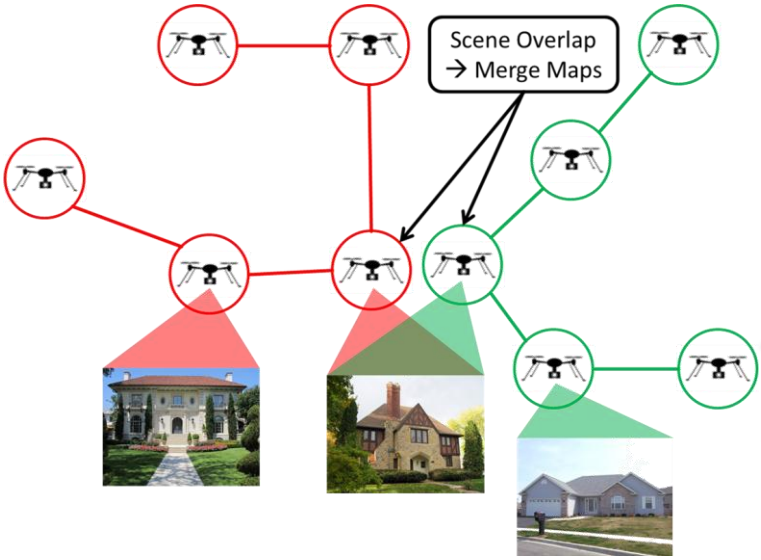
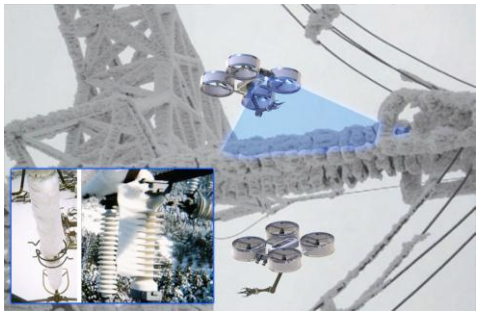
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

V4RL VISION FOR ROBOTICS LAB
Prof. Dr. Margarita Chli

Map Fusion for Collaborative UAV SLAM

Kurzbeschreibung / short description





Above: Application scenario for collaborative aerial SLAM within the AEROWORKS project.

Left: Scheme of two typical SLAM pose graph maps. Discrete positions of the robot are stored ("Keyframes", red and green) and connected by edges.

The goal of this project is to develop a pipeline to merge maps created by different Unmanned Aerial Vehicles (UAVs) operating in the same area.

Simultaneous Localization And Mapping (SLAM) is the task of moving in a previously unknown environment while mapping the robot's workspace and simultaneously estimating its position in this map. This task is one of the most important challenges on the way to full autonomy for a robot, and has been in the focus of research for over the past two decades now. Since state-of-the-art SLAM has become more robust, allowing robots to operate in a large variety of environments as individuals, collaborative SLAM directions using multiple robots is starting to become more popular.

In the AEROWORKS project, the aim is to have a team of UAVs performing inspection tasks on industrial structures together (see image above). To exploit the presence of multiple UAVs, e.g. by combining the collected information about their environment or executing tasks as a team, requires the construction of a common map to be used amongst the team of UAVs. To create this map, a place recognition system detects overlap between maps constructed by different UAVs. If enough overlap is detected between two maps, these maps can be fused into one, which can then be used by multiple UAVs simultaneously. A scheme of typical SLAM map ("Pose Graph") is depicted above.

This work aims to implement a pipeline that, given two SLAM maps with multiple place matches, produces an optimized merged map. This includes finding an optimal alignment of the two maps by a 3D transformation, applying optimization techniques for improved alignment ("Bundle Adjustment") and identifying and fusing the parts of the map that are represent the same part of the world. The speed of the fusion step also has to be taken into account, since the system is meant to run on-line in real-world experiments with UAVs, as is the case in the AEROWORKS project (see image above).

Requirements

- Background knowledge in computer vision and 3D geometry desired
- C++ programming experience
- Experience in Linux, ROS are beneficial

The student will have the opportunity to work on a challenging project on the cutting edge of vision-based perception capabilities for robots with agile and challenging platforms. We offer the occasion to work with a real setup and equipment provided by the Vision for Robotics Lab. This work is part of a large European project and a successful method will directly be used within in the framework developed for this project.

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Typ / Type	Semester thesis / Master's thesis
Zeitdauer / Period	Autumn semester 2016/17

Betreuung / Supervisors Patrik Schmuck, pschmuck@ethz.ch
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Stichworte / Keywords

SLAM, Collaborative SLAM, Bundle Adjustment, Place Recognition, UAV

Umfeld / Context

This Master thesis is a part of AEROWORKS, a large European project on collaborative aerial inspection and maintenance.

Arbeitspakete / Workpackages

The work to be undertaken involves five main work packages (WP):

- WP1: Research into existing works tackling SLAM, collaborative SLAM, place recognition and map optimization
- WP2: Design and implementation of an algorithm that calculates an optimal map alignment from given multiple matches from two maps
- WP3: Extension of the algorithm to a pipeline that outputs a fused and optimized map
- WP4: Design and implementation of a sparsification algorithm that detects and fuses redundant parts in the fused map
- WP5 (optional): Extension of the system to also take into account measurements from an inertial measurement unit (IMU)

Rahmenbedigung / Formal Requirements

A work schedule and a short summary of the project has to be established and presented to the supervisors within Week 3 from the beginning of the project. The student should then submit this in myStudies.

An intermediate presentation (10 minutes presentation and 10 minutes discussion) about your work will take place between Weeks 16-18 (only for Master Theses). Please communicate the specific date with your supervisors in advance. The goal of the presentation is to give a brief summary of the work done, to propose a precise plan for the continuation of the project, and to discuss about the main directions of the project.

A final presentation to all V4RL members to mark the end of the project will be arranged close to the end date of your project with your supervisors. Please communicate the specific date with your supervisors in advance. The final submission of all relevant documents should be handed in 14 days after the presentation at the latest. The final submission should include:

(a) your report with a signed and scanned declaration form,
(b) your final presentation including any associate videos and
(c) your code with a README file detailing how to use the code and the basic functions in it.

These should be handed in electronically to your supervisors, while you also need to submit the original signed declaration form to them. Details on the format of your presentation and report can be found here: https://github.com/ethz-asl/asl-student-templates/wiki

The project is judged according to V4R Lab's evaluation sheet that is handed out by the responsible supervisor.