



Master Thesis

Control and State Estimation for Fully Actuated Aerial Manipulator

Robotics, Aerial Manipulation, Control, State Estimation

Professorship of Autonomous Aerial Systems, Prof. Dr. Ryll

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Description

Fully actuated aerial manipulators extend the capabilities of conventional multirotors by enabling independent control of position, attitude, and interaction forces. This makes them highly promising for tasks such as inspection, contact-based operation, and manipulation in environments that are difficult or unsafe for humans to access. However, the additional actuation and manipulation dynamics introduce strong coupling, model uncertainty, and complex state-estimation challenges that must be addressed to achieve accurate and robust flight performance.

This thesis focuses on transferring an existing indoor control and estimation framework for a fully actuated aerial manipulator to outdoor operation. The main objective is to implement an incremental nonlinear dynamic inversion (INDI) controller and a Kalman-filter-based force and torque estimation method using outdoor-ready onboard sensing. While the current system has been validated indoors with motion capture and IMU measurements, the outdoor setup will rely on IMU, optical flow, and RTK-GPS data from a Pixhawk flight controller. The controller will be implemented in Simulink and deployed through code generation on a Raspberry Pi onboard computer, enabling real-time operation without external motion-capture infrastructure.

Work packages

1. Review the existing indoor INDI controller and Kalman-filter-based force and torque estimator.
2. Adapt the estimation framework from motion-capture-based sensing to IMU, optical-flow, and RTK-GPS measurements.
3. Implement the outdoor controller and estimator in

4. Simulink for Pixhawk and Raspberry Pi integration.
4. Deploy the generated controller code on the Raspberry Pi onboard computer.
5. Validate the complete system in simulation and outdoor flight experiments.



Figure 1: Fully actuated aerial manipulator platform with an end-effector, used for indoor control, state estimation, and interaction-force estimation methods.

Requirements

- Student in a relevant field (e.g., robotics, mechatronics, electrical, or aerospace engineering).
- Knowledge of control theory, state estimation, and multirotor dynamics.
- Experience with MATLAB/Simulink and embedded implementation is highly valued.
- Familiarity with Pixhawk, Raspberry Pi, sensor fusion, or outdoor flight testing is an advantage.

Application

Please submit:

- CV
- Transcript of records.
- A brief description of your experience and research interests.