Abstract

Dual-Axis Tilting Quadrotor Aircraft

Nicholas Von Klemperer

Thursday 15th February, 2018

This dissertation aims to apply non-zero attitude and position setpoint tracking to a quadrotor aircraft, achieved by solving the problem of a quadrotor's inherent underactuation. The introduction of extra actuation aims to mechanically accommodate for stable tracking of non-zero state trajectories. The requirement of the project is to design, model, simulate and control a novel quadrotor platform which can articulate all six degrees of rotational and translational freedom (6-DOF) by redirecting and vectoring each propeller's individually produced thrust.

Considering the extended articulation, the proposal is to add an additional two axes (degrees) of actuation to each propeller on a traditional quadrotor frame. Each lift propeller can be independently pitched or rolled relative to the body frame. Such an adaptation, to what is an otherwise well understood aircraft, produces an over-actuated control problem. Being first and foremost a control engineering project, the focus of this work is plant model identification and control solution of the proposed aircraft design. A higher level setpoint tracking control loop designs a generalized plant input (net forces and torques) to act on the vehicle. An allocation rule then distributes that *virtual* input in solving for explicit actuator servo positions and rotational propeller speeds.

The dissertation is structured as follows: First a schedule of relevant existing works is reviewed in Ch:1 following an introduction to the project. Thereafter the prototype's design is detailed in Ch:2, however only the final outcome of the design stage is presented. Following that, kinematics associated with generalized rigid body motion are derived in Ch:3 and subsequently expanded to incorporate any aerodynamic and multibody nonlinearities which may arise as a result of the aircraft's configuration (changes). Higher level state tracking control design is applied in Ch:4 whilst lower level control allocation rules are then proposed in Ch:5. Next, a comprehensive simulation is constructed in Ch:6, based on the plant dynamics derived in order to test and compare the proposed controller techniques. Finally a conclusion on the design(s) proposed and results achieved is presented in Ch:7.

Throughout the research, physical tests and simulations are used to corroborate proposed models or theorems. It was decided to omit flight tests of the platform due to time constraints, those aspects of the project remain open to further investigation. The subsequent embedded systems design stemming from the proposed control plant is outlined in the latter of Ch:2, Sec:2.4. Such implementations are not investigated here but design proposals are suggested. The primary outcome of the investigation is ascertaining the practicality and feasibility of such a design, most importantly whether or not the complexity of the mechanical design is an acceptable compromise for the additional degrees of control actuation introduced. Control derivations and the prototype design presented here are by no means optimal nor the most exhaustive solutions, focus is placed on the whole system and not just a single aspect of it.