Aerospace Engineering Thesis Defense

Fabrication, Modeling and Control of a Spherical Tail-Sitter UAV

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abstract

In the past decade, real-world applications of Vertical Take-Off and Landing (VTOL) Unmanned Aerial Vehicles (UAV) have increased significantly. There has been growing interest in one of these types of UAVs, called a tail-sitter UAV, due to its VTOL and cruise capabilities. This thesis presents the fabrication of a spherical tail-sitter UAV, and derives a nonlinear mathematical model of its dynamics. The singularity in the attitude kinematics of the vehicle is avoided using Modified Rodrigues Parameters (MRP). The model parameters of the fabricated vehicle are calculated using the bifilar pendulum method, a motor stand, and ANSYS simulation software. Then the trim conditions at hover are calculated for the nonlinear model, and the rotational dynamics of the model are linearized around the equilibrium state with the calculated trim conditions. Robust controllers are designed to stabilize the UAV in hover using the H-2 control and H-infinity control methodologies. For H-2 control design, Linear Quadratic Gaussian (LQG) control is used. For the H-infinity control design, Linear Matrix Inequalities (LMI) with frequency-dependent weights are derived and solved using the MATLAB toolbox YALMIP. In addition, a nonlinear controller is designed using the Sum-of-Squares (SOS) method to implement large-angle maneuvers for transitions between horizontal flight and vertical flight. Finally, the linear controllers are implemented in the fabricated spherical tail-sitter UAV. The performance trade-offs and the response of the UAV with the linear and nonlinear controllers are discussed in detail.

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