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Optimal Hybrid Linear and Nonlinear Control for a Quadcopter Drone

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Abstract : A hybrid and optimal multi-loop control structure combining linear and nonlinear control algorithms are introduced in this paper to regulate the position of a quadcopter unmanned aerial vehicle (UAV) driven by four brushless DC motors. To this end, a nonlinear mathematical model of the UAV is derived and then linearized around one of its operating points. Using the nonlinear version of the model, a sliding mode control is used to derive the control laws of the motor thrust forces required to drive the UAV to a certain position. The linear model is used to design two controllers, XG-controller and YG-controller, responsible for calculating the required roll and pitch to maneuver the vehicle to the desired X and Y position. Three attitude controllers are designed to calculate the desired angular rates of rotors, assuming that the Euler angles are minimal. After that, a many-objective optimization problem involving 20 design parameters and ten objective functions is formulated and solved by HypE (Hypervolume estimation algorithm), one of the widely used many-objective optimization algorithms approaches. Both stability and performance constraints are imposed on the optimization problem. The optimization results in terms of Pareto sets and fronts are obtained and show that some of the design objectives are competing. That is, when one objective goes down, the other goes up. Also, Numerical simulations conducted on the nonlinear UAV model show that the proposed optimization method is quite effective.

Keywords : optimal control, many-objective optimization, sliding mode control, linear control, cascade controllers, UAV, drones
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