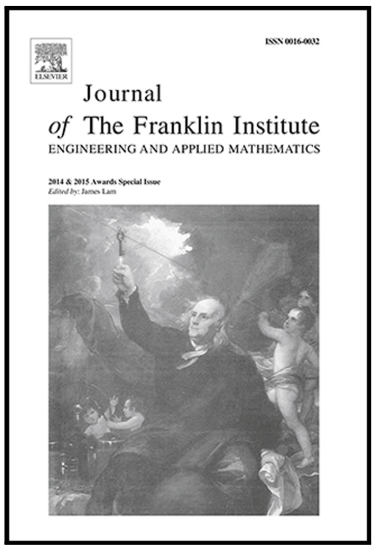

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Adaptive Trajectory Tracking Controller for Quadrotor Systems Subject to Parametric Uncertainties

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Abstract

This paper investigates the trajectory tracking problem of quadrotor systems in the presence of uncertain inertial parameters. The controller is based on the hierarchical control strategy. The main features of this research include: (i) the command control of the position loop is synthesized with a saturation scheme, and a novel immersion & invariance (I&I) adaptation methodology is designed such that the mass estimation converges asymptotically to its real value; (ii) as an intermediate step, the command rotation matrix is extracted from the command control without the singularity; (iii) in terms of the rotation matrix property, the applied torque with appropriate control parameters and initial conditions is exploited for the attitude loop; and (iv) the projection algorithm is used to guarantee the inertial matrix estimation evolving within a prescribed range. It is proven based on the hierarchical system theory that, the developed controller enables the quadrotor system to track the reference trajectory asymptotically. Simulations are provided to support the proposed theoretical results.

Keywords: quadrotor system, trajectory tracking, adaptive control, hierarchical control, immersion and invariance (I&I), rotation matrix

1. Introduction

By virtue of their capabilities of vertical taking-off and landing, hovering and low-speed and low-altitude maneuvers, quadrotors have captured plenty of attention in the past few decades [1, 2]. They can be potentially applied in military and civil areas, such as anti-terrorism, surveillance, agriculture and so forth. Moreover, the quadrotor system is characterized by under-actuation, high nonlinearity and strong coupling [3], and is susceptible to parametric uncertainties, thereby drawing great research interest among the control community.

Due to the cascaded structure of the quadrotor system, the hierarchical control strategy is effective for its controller development, where the outer position

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