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NONLINEAR PD CONTROL OF A QUADROTOR AIRCRAFT

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Abstract. *We propose a control strategy to control a quadrotor aircraft. Based on the nonlinear dynamic model, we succeed to command independent references for aircraft position and yaw angle. Our controller is basically composed by six nonlinear Proportional-Derivative loops. This results in a simpler strategy compared with works proposed previously in the literature when they take into account the aircraft nonlinear dynamics during the design stage.*

Keywords: Quadrotor aircraft control, PD control, Nonlinear control, Lyapunov stability

1. **Introduction.** Quadrotors have attracted attention of control community in recent years because they are suitable for dynamic modelling which allows application of linear and nonlinear control techniques. As summarized below, most reported works deal with control of the aircraft attitude and position.

Feedback linerization is used in [1]. This technique is combined with high order sliding modes for partial state estimation. Further, estimation and cancellation of disturbances due to aerodynamical forces are also introduced. An important drawback of this scheme is complexity and a large amount of computations required for controller implementation in any practical application.

In [2], a nonlinear controller is designed for attitude stabilization. First part of that work requires to cancel gyroscopic and Coriolis effects, hence rendering the scheme sensitive to model uncertainties. Although second part of that work avoids such cancellation, however, aircraft position control is not considered.

In a series of works [3]-[5], a controller is proposed which is based on nested saturations ideas introduced in [6]. This control scheme solves both attitude and position regulation control. However, yaw angle cannot be stabilized at a desired value different from zero. This results in a considerable reduction of maneuver capabilities of the quadrotor. Moreover, controller implementation requires lots of computations since the Coriolis terms have to be cancelled.

The recent work [7] proposes a controller which considers the complete quadrotor dynamics and visual data are used to stabilize the aircraft over a given target. However, the yaw angle has to be controlled manually since automatic regulation of this variable increases mathematical complexity. Further, control design is simplified since angular velocity of the camera (instead of velocities of propellers) is considered as control input.

On the other hand, simpler control strategies can be designed when an approximate linear model is used. Such model simplification is achieved by assuming that variations in pith, roll and yaw angles are small [8], [9]. Following these ideas, integral sliding modes and reinforcement learning are used in [8] to compensate disturbances on a quadrotor