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Finite-time formation control for a group of quadrotor aircraft ⋆

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Abstract

In this paper, the problem of finite-time formation control for a group of quadrotor aircraft with a leader-follower structure is investigated. Based on backstepping design, finite-time formation control algorithms including finite-time position controller and attitude controller are designed respectively. By skillfully using homogenous system theory and Lyapunov theory, the finite-time stability of the closed-loop systems is given and it is shown that the desired formation pattern and the desired trajectory can be achieved in a finite time under the proposed controllers. Finally, a simulation example is given to show that the efficiency of the proposed method.

Key words: Attitude control, Finite-time control, Formation control.

1 Introduction

Recently, the formation control problem for a group of quadrotor aircraft has attracted a great deal of attention. The interest is motivated by its various applications including civilian field and military field, such as aerial photography, express delivery, regional investigation, and disaster relief, etc [1–4]. In the case of executing complicated missions, multiple quadrotor aircraft has a significant advantage over a single quadrotor aircraft. For example, which means that replaced a single quadrotor with a group of quadrotor, the efficiency and robustness of the multiple quadrotor aircraft can be improved. Moreover, since more sensors or equipments can be installed on quadrotor aircraft, more difficult tasks can be achieved. However, from the control viewpoint, the control problem of multiple aircraft will be more challenging and difficult since not only the single quadrotor aircraft but also the cooperative control among multiple aircraft are considered [4–7]. Actually, even for single quadrotor aircraft, the control problem is still challenging due to the strong nonlinear coupling [8–12].

By introducing the coordination architecture, the formation control problem was investigated in [13] for multiple spacecraft. By employing leader-following formation structure, a formation control algorithm including inner and outer loop were given in [14]. Based on behavioural decentralized approach, the work [15] designed the formation control algorithm to carry out a waypoint-passing mission. By considering obstacle/collision avoidance, an integrated optimal control method was given in [16] to achieve formation flying and trajectory tracking. By utilizing the tools of graph rigidity and persistence, the problem of decentralized cohesive motion control of a multiple aircraft was studied in [17].

Up to now, most results for formation control of a group of quadrotor aircraft are about asymptotically stable. That is to say that, the desired formation cannot be achieved in a finite time. From the viewpoint of convergence time, the convergence rate of quadrotor aircraft is hoped to be as fast as possible. In this case, the technique of finite-time control introduced in [18] can guarantee that the closed-loop system is finite-time convergent. Moreover, the finite-time control technique can also provide better disturbance rejection performance as shown [19,20]. It is noted that, there are some results about finite-time control for a single quadrotor aircraft [21] or attitude control system [22–28]. However, to the best of authors' knowledge, there is no available result on finite time formation control for multiple quadrotor aircraft. The reasons are due to the high dimension and nonlinear coupling of multiple quadrotor aircraft systems, which

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