Abstract

In recent years, the usage of the Unmanned Aerial Vehicles (UAV) has been increased noticeably. Quadrotor is one type of aerial vehicle that has some unique abilities such as high maneuverability (hovering and $VTOL$) and maneuver in tight spaces. Commonly, the position of quadrotor's center-of-gravity (CoG) is assumed coincide with the geometric center of quadrotor. But in many cases, the quadrotor's CoG position may not be located at its geometric center and cannot be easily measured. For example, the placement of the on-board electronic component, the battery and the payloads, may not be fixed symmetrically to the geometric center of a quadrotor. This condition affects the attitude of quadrotor , which cause the unbalance thrust on an axis.

Attitude is the most basic and important in controlling a quadrotor. This yields the need of a robust attitude control algorithm which can compensate the uncertain parameter such as the unmeasurable effect of the deviated CoG position. Some previous works use an adaptive algorithm to compensate the effect of the deviated CoG, while a Proportional-Derivative control failed. The adaptive control algorithm has a non-fixed structure of the control law. In this work, a new robust control algorithm with a fixed control law structure is developed. This proposed control algorithm is more simple in terms of its control law structure. It requires no observers, function approximators, or online adaptation laws, but only requires the minimal information about the system, such as the bounding function of the uncertain parameter of the deviated CoG position. The proposed control strategy is to combine a linear controller such as Proportional-Derivative (PD) algorithm with a robust compensator. This proposed robust compensator algorithm can improve the performance of the Proportional-Derivative control to compensate the uncertain CoG position of quadrotor. By using a bounding function and control lyapunov function in nominal condition, a robust compensator can be obtained. To avoid complexities and ambiguities associated with other attitude representations such as Euler angles or quaternions, both of the attitude dynamics and the proposed control system are globally expressed on the special orthogonal-3 (*SO(3)*) group.

The robustness of the proposed robust compensator is demonstrated by some simulations. It is tested in several cases, i.e., in nominal condition, under a disturbance, and under deviated CoG position. The simulation results show that the performance of a Proportional-Derivative control is improved by the robust compensator. The asymptotic stability of the quadrotor attitude is achieved in stabilization and tracking control of attitude. This proposed controller gives a better performance compared to the nominal proportional derivative controller, where the response of the system is faster. The settling time is reached in 0.06 sec, while the nominal controller can reach in 1.8 sec.

Keywords: Quadrotor, CoG, Bounding Function, Proportional-Derivative, Compensator, Special Orthogonal-3