

ABSTRACT

Quadrotor is a unique rotary wing UAV (Unmanned Aerial Vehicle) with special features such as VTOL (Vertical Take-Off and Landing) and hovering at the desired altitude. Those features, make it a great platform for robotics. Unfortunately, due to its underactuated nature, it can not be stabilized just from its mechanical structure. Furthermore, it is a challenging problem to compensate the inertia perturbation due to the uncertainties of the payload and also input saturation. Hence, such a control algorithm is a must to stabilize its attitude. Despite the adaptive control succeeds to regulate the attitude of quadrotor, the cost of computation is relatively high. Another problem is how to represent the attitude of the quadrotor. There are several representations of its attitude, notably the most popular is the Euler angles representation. Regrettably, it does not offer global representation. It means that the Euler angles representation suffers from the singularity. This report presents design of Proportional-Derivative (PD) controller on SO(3) (Special Orthogonal-3) for transporting quadrotor UAV with payload uncertainties and input saturation. It comes to answer those problems. The PD control algorithm offers ease of design and relatively low cost of computation. Meanwhile, the SO(3) provides global representation.

Before any further, it is necessary to model the quadrotor nonlinear kinematics and dynamics in SO(3). The transported payload is modeled, which perturbs the stability of quadrotor. The proposed PD control algorithm needs to overcome the inertia perturbation due to the payload and input saturation. The input saturation can occur due to physical limits of its actuators. Numerical simulation and analysis are presented to prove the effectiveness of the proposed PD control algorithm. The simulation is conducted for 5 seconds.

The simulation shows that the proposed PD control algorithm prevails to overcome the inertia perturbation and input saturation. It is verified by graphical and data from the simulation. Regardless the initial conditions or uncertainties, it succeeds to regulate the attitude of quadrotor to its desired state. The shortest and longest time to converge are 1.5 and 2 seconds respectively. It implies successful results.

Keywords: Transporting quadrotor, Unmanned Aerial Vehicle (UAV), Proportional-Derivative (PD) control, Special Orthogonal-3.

INTISARI

Quadrotor merupakan jenis rotary wing UAV (Unmanned Aerial Vehicle) yang menarik, karena memiliki kemampuan VTOL (Vertical Take-Off and Landing) dan dapat melayang pada ketinggian yang diinginkan. Hal tersebut menjadikannya platform yang menarik di dunia robotika. Namun sayangnya, quadrotor tidak dapat dibuat stabil hanya dari struktur mekaniknya saja. Terlebih, bila ada inertia perturbation dan input saturation. Oleh sebab itu, diperlukan sebuah kendali untuk mengatur sikapnya. Meski berhasil mengatur sikap dari quadrotor, beban komputasi dari kendali adaptif relatif tinggi. Permasalahan lainnya adalah bagaimana merepresentasikan sikap quadrotor. Ada beberapa representasi sikap, dengan yang paling adalah representasi Euler angles. Namun sayangnya, representasi tersebut tidak bersifat global. Artinya representasi Euler angles mengalami kendala singularitas. Thesis ini memaparkan rancangan kendali Proportional-Derivative (PD) pada $SO(3)$ (Special Orthogonal-3) untuk quadrotor UAV pengangkut dengan uncertainties bebannya dan input saturation. Ini menjawab permasalahan tersebut. Kendali PD menawarkan perancangan yang mudah dan beban komputasi yang relatif rendah. Sementara, $SO(3)$ mampu merepresentasikan sikap secara global.

Sebelum beranjak lebih lanjut, penting untuk merancang model nonlinear kinematika dan dinamika quadrotor di $SO(3)$. Beban yang diangkut dimodelkan, yang mana akan menjadi gangguan bagi kestabilan quadrotor. Kendali PD yang diajukan, harus sanggup mengatasi hal tersebut, ditambah dengan input saturation. Input saturation dapat terjadi karena aktuator bekerja melampaui batasan fisiknya. Simulasi numeris dan analisis disajikan untuk membuktikan efektifitas kendali PD yang diajukan. Simulasi dilakukan selama 5 detik.

Hasil simulasi menunjukkan, kendali PD yang diajukan berhasil mengatasi inertia perturbation dan input saturation. Hal tersebut dibuktikan dari data dan grafik simulasi. Terlepas dari kondisi awal atau faktor uncertainties, kendali tersebut berhasil mengatur sikap quadrotor sesuai yang diharapkan. Waktu tersingkat dan terlama untuk mencapai sikap yang diinginkan adalah 1.5 dan 2 detik. Hal tersebut mengisyaratkan keberhasilan penelitian ini.

Kata kunci: *Quadrotor pengangkut, Unmanned Aerial Vehicle (UAV), kendali Proportional-Derivative (PD), Special Orthogonal-3.*