UNIVERSITI TEKNOLOGI MARA

SLIDING MODE CONTROL DESIGN USING LINEAR MATRIX INEQUALITY FOR UNMANNED AERIAL VEHICLE

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ABSTRACT

Unmanned aerial vehicles (UAVs) have gotten a lot of attention over the last few decades. The use of Unmanned Aerial Vehicles (UAVs) has continued to increase. UAVs are now used for more than just military purposes, with applications ranging from crop surveys and harvesting to tourism. Nonetheless, dealing with the UAVs complex, highly nonlinear dynamics is challenging and difficult. This study focuses on a type of UAV known as a "quadrotor". It has six Degrees of Freedom (DOF) but only four actuators. Due to this, quadrotor is highly nonlinear, multivariable system which is very difficult to control due to the nonlinear coupling between the actuators and the degrees of freedom. Thus, it is crucial to have a suitable and effective control system in order to operate the quadrotor system effectively. The performance of any quadrotor flight experiment is determined primarily by the feedback control scheme used, and the most important components of this feedback system is the controller design. Many control approaches, including proportional-integral-derivative control, backstepping control, and fuzzy control schemes, have been found in the literature. However, these control approaches have a lot of drawbacks, including high computation, a large amount of training data, approximation error, and the presence of uncertainty. These drawbacks affect the quadrotor system performances. To address these issues, a Sliding Mode Control (SMC) with Linear Matrix Inequality (LMI) method is proposed in this study. In the proposed method, LMI will be used to derive sufficient conditions for the existence of a linear sliding surface. The nonlinear differential equations of quadrotor dynamics are first transformed into state-space representations, and the final equation of forces and torques from a single rotor is derived. The presented model is a detailed model, which includes aerodynamic effects and rotor dynamics that are omitted in many literatures. Afterward, three different control approaches to control the altitude, attitude, heading, and position of the quadrotor in space are developed. The first approach is based on the nonlinear Sliding Mode Controller (SMC) with Pole Placement method. The second control approach is based on the Full State Feedback Controller. The third developed controller is a nonlinear Sliding Mode Controller with Linear Matrix Inequality (LMI) method. Simulation based experiments were conducted to evaluate and compare the performance of the three developed control techniques in terms of dynamic performance, stability and the effect of possible disturbances. The simulation works were performed using MATLAB/SIMULINK software. Numerical simulations show the effectiveness of the developed quadrotor solutions. The results demonstrate that the proposed quadrotor control scheme is effective; not only it has good robustness, with almost no chattering and fast-tracking dynamic performance, but it also has the ability to maintain stability in the presence of external disturbances and parameter uncertainties.

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