Self Tuning Sliding Mode Control for Quadrotor Waypoint Tracking

Swadexi Istiqphara[1], Trihastuti Agustinah[1], and Ali Fatoni[1]

Abstract–In this paper, self-tuning sliding mode control is proposed to control quadrotor with mass parameter uncertainty on waypoint trajectory tracking. Parameter uncertainty is one of the factor that cause instability of quadrotor. Self-tuning sliding mode control is used to maintain the stability of quadrotor in this parametric uncertainties condition. The simulation results show that the quadrotor can track the waypoint trajectory in the presence of parameter uncertainty.

Index Terms - quadrotor, UAV, waypoint tracking control, Sliding mode control.

INTRODUCTION

Currently, unmanned aerial vehicle (UAV) has been widely used for various purposes such as search and rescue mission, mapping and surveillance. Generally, UAV can be divided in two categories, fixed wing and rotary wing. Quadrotor is one type of UAV rotary-wing that fly by using four propellers. The difference between quadrotor and fixed-wing vehicle is that quadrotor can take off and land vertically (VTOL) in small spaces, and hover and fly with high maneuverability.

There are various control methods used to solve stabilization and tracking problem of quadrotor, such as sliding mode control, optimal PID, nonlinear backstepping, etc. Sliding mode control has been proposed in [1] to track waypoint trajectory. The control system can track the trajectory fast. However, the actual position is displaced from the trajectory in the presence of disturbance on x-y translation. The developments of a PID control method to obtain stability in flying the Quad-rotor flying object is explained in [2]. LQ and PID controller are compared to control the attitude of quadrotor [3]. The simulation results show that both control methods provide average results, due to modelling imperfections. Nonlinear backstepping control is used to track a waypoint trajectory of quadrotor [4]. The simulation results show that the proposed control system provides good performance.

In this paper, self-tuning sliding mode control is used to track waypoint trajectory with mass parameter uncertainty of quadrotor. Quadrotor is simulated to track to desired waypoint, then landing to take the object with unknown mass and drop the object to another waypoint. Parameter gain K of sliding mode control is tuned based on least square method to handle the unknown added mass, and the conventional sliding mode control is used to control rotation motion (see Figure 1).

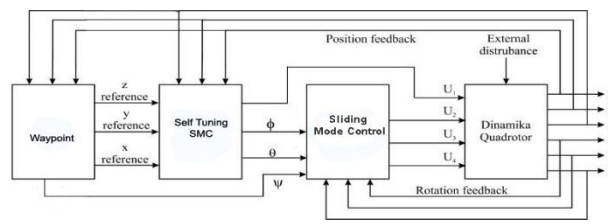

Figure 1. Control System Diagram block.

RESULTS

To measure the effectiveness of proposed method, the simulation is done by using Matlab/Simulink. Object is taken at waypoint #2 to simulate the parametric uncertainty of quadrotor. Quadrotor must track the waypoint trajectories that listed on Table 1.

TABLE 1. WAYPOINT COORDINAT

Waypoint	*X*	*Y*	*Z*	Mission
#1	0	0	10	0
#2	10	10	10	0
	10	10	0.5	Take Object
	10	10	10	0
#3	10	-10	10	0
#4	0	-10	10	0
	0	-10	0.5	Drop Object
	0	-10	10	0
#5	0	0	10	0

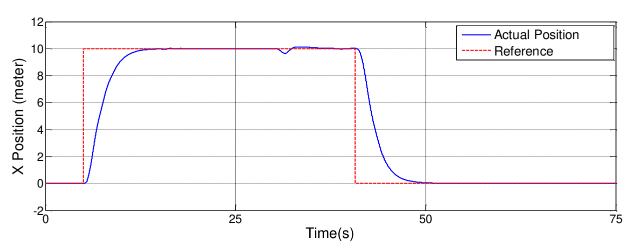

Figure 2. X-axis Translational Motion.

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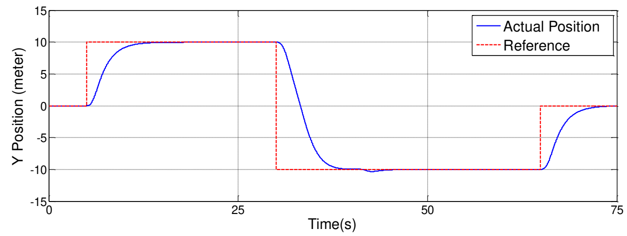

Figure 3. Y-axis Translational Motion.

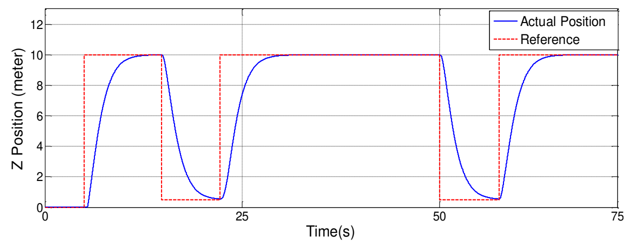

Figure 4. Z-axis Translational Motion.

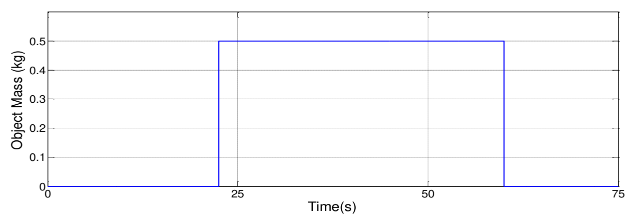

Figure 5. The Mass Parameter Changes Scenario.

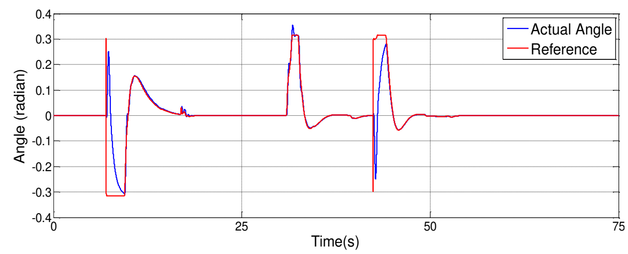

Figure 6. Pitch Angle.

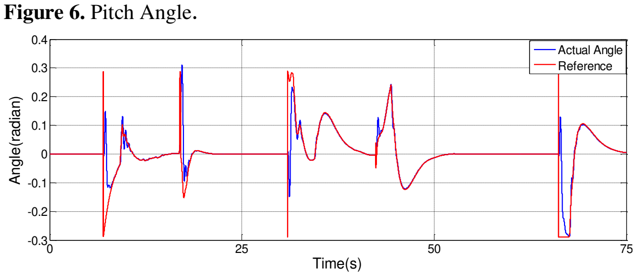

Figure 7. Roll Angle.

Figures 2-4 show the translational motion of X, Y and Z axis. From these figures, it can be seen that quadrotor performance did not affected by the mass parameter changes. The parameter change scenario is as shown in Figure 5. The output of self-tuning sliding mode controller (i.e. pitch angle and roll angle) is as shown on Figure 6-7. It can be seen that the angles change when quadrotor track from one waypoint to the next waypoint. These angles do not change when parameter changes occur. Figure 8 shows the vertical motion (Z axis) of quadrotor.

The gain changes that occur in simulation is as shown in Figure 9. From this figure, it can be seen that the controller must raise the control signals to handle the additional mass and lower the control signals in case of the mass of the object reduced.

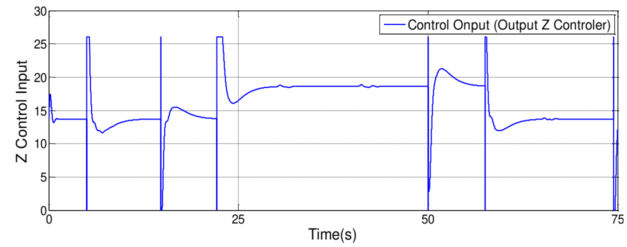

Figure 8. Z-axis control input.

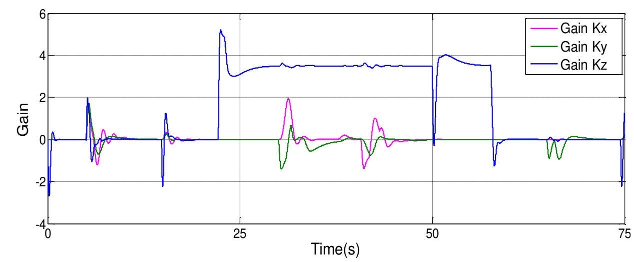

Figure 9. Gain Changes that Occur in The Simulation.

CONCLUSION

In this paper, self-tuning sliding control strategy is presented. The simulation results show that the proposed control system is able to stabilize the quadrotor and track the given waypoint trajectory. There is no chattering phenomenon on the control input of the system. The control system still give good performance in the presence of the parameter change.

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