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SUPER TWISTING SLIDING MODE SYNCHRONIZATION WITH ON-OFF THRUSTERS FOR RENDEZVOUS IN AN ELLIPTIC ORBIT

Abstract

The rendezvous is one of the most important parts of some current and future space missions. To reduce the risk of collision, the terminal phase of orbital rendezvous is very critical and requires high accuracy for controlling the chaser relative position and velocity. The terminal phase starts with detection of the target spacecraft by the chaser sensors. Due to the safety requirements and availability of the relative position and velocity data, generally the closed loop guidance and control are utilized. In this study, the closed loop guidance and control of the orbital rendezvous of a chaser satellite is studied. The target is assumed to be in an elliptical orbit and the relative dynamics is modeled using the well-known Clohessy-Wiltshire equations. The chaser spacecraft usually maneuvers by the means of on-off thrusters. Although the sliding mode is one of the robust and nonlinear methods, but its control signals are continuous and cannot be applied through on-off thrusters. Generally, the Pulse-Width Pulse-Frequency (PWPF) modulation is utilized to resolve this problem. However, including the PWPF and Schmitt trigger algorithm in control may result in convergence to a limit cycle around the equilibrium point. At the same time, the sliding mode scheme continuously sends command to PWPF to reach the exact desired point. Therefore, the thruster may frequently be on, which in turn results in fuel consumption increase and probability of the thruster failure. Thus, the sliding mode ought to adapt itself with PWPF. To this end, instead of defining an equal point in sliding surface, a stable limit cycle can be defined to reach. In the other words, the surface is considered in such a way that states converge to a desired stable limit cycle when the sliding motion is established. A stable limit cycle radius is determined with respect to the PWPF limit cycle. As a result, the sliding mode is designed with respect to the actuator constraints. On the other hand, the sliding mode may encounter with chattering effect that in many cases make the controller impractical to implement. The high frequency chattering can be attenuated by using higher order sliding mode. The super twisting algorithm as a second order sliding mode method is applied to design the controller. Finally, simulation results show the robustness and effectiveness of proposed scheme in the presence of uncertainties and disturbances.