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GUIDANCE AND CONTROL STRATEGIES FOR A SPACECRAFT TO RENDEZVOUS WITH A NON-COOPERATIVE SPACECRAFT

Abstract

Non-cooperative spacecrafts are those current or future assets in orbit which have lost their control authority in one or more degrees of freedom and cannot convey any information concerning their states to facilitate RVD/B process. A growing field of study in space research is to develop On-Orbit Servicing (OOS) technology capable of dealing with these spacecrafts called targets which are designed without any intention to be serviced. To render services such as repair, refuel or removal of the target from orbit, the chaser spacecraft should exhibit sophisticated RVD/B technology for formation fly and terminal phases of the mission. Assuming that the final stage proximity operations and eventual capture can be achieved by suitable robotic technology on board chaser, this study relies upon proven technology and outlines GNC methodologies to achieve rendezvous with the non-cooperative target. The entry gate of chaser after phasing is defined at a distance of 50 km in +/- V bar in the target's orbit. To account for errors in modeling, navigation or actuation, two hold points are defined along the path of the chaser before a final capture of the target from the second hold point. Possible scenarios pertaining to the behavior of the target in a circular orbit are considered and guidance schemes for different phases of the mission are presented using a combination of Hill equations and Glideslope algorithm. Guidance maneuvers are separated between different points and include trajectories to realize a closer approach to the first hold point from the entry gate, inspection or fly around, a closer approach again to the second hold point from where the chaser can initiate the final phase of capture by the manipulator. The chaser performs a station keeping maneuver at the second hold point until initial conditions for the capture are met. Relative controllers both for position and attitude of the chaser are also presented. A LQR controller for relative position and PID controller for relative attitude are chosen to track down the error and enable rendezvous with the target. The methods presented here are general and provide a simulator to the chaser to perform rendezvous analysis with non-cooperative targets. By presenting a comparison between time and fuel efficiency of CW solution of Hill equations and Glideslope, the study proposes a coordinated selection and execution of these algorithms for different phases by the chaser to achieve rendezvous.