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OPTIMAL-SLIDING-MODE-BASED RELATIVE POSITION AND ATTITUDE COUPLED CONTROL FOR AUTONOMOUS RENDEZVOUS AND DOCKING TO A TUMBLING TARGET

Abstract

With the development of autonomous on-orbit servicing technology, it will be an important field in the future to make small spacecraft perform on-orbit rescue and repair for the tumbling target spacecraft. In such a mission, the servicing spacecraft needs autonomous rendezvous and dock to the tumbling target, and after that, on-orbit servicing operations could be carried out. The coupled control problem of relative position and attitude for the on-orbit servicing spacecraft autonomous rendezvous and docking to a tumbling target is one of the key technologies and urgent issues in the autonomous on-orbit servicing for a tumbling target mission. Focusing on the coupled control problem that the servicing spacecraft, which is small satellite here, performs close-range operations on the tumbling target, this paper will intensively investigate the relative position and attitude coupled control algorithm of the servicing spacecraft with respect to a tumbling target.

The motion of the tumbling target in space is analyzed. Then, a control strategy of autonomous rendezvous and docking between the on-orbit servicing spacecraft and the tumbling target is presented for the most complex motion (which is also the most common motion) of the tumbling target, which is the motion with nutation, whose angular velocity vector is neither parallel nor vertical to the docking port's direction. The proposed control strategy for the most complex motion situation of the tumbling target can effectively avoid the local collision during the approach of the servicing spacecraft to the tumbling target.

Considering the relative position and attitude coupled (also called the control input coupled) which is produced by the propulsion installation, the relative position and attitude coupled dynamic model of the servicing spacecraft with respect to the tumbling target is established. The control objective of the relative position and attitude coupled control system is analyzed, and the relative position tracking coupled (which is also called the control command coupled) is also analyzed according to the relative position tracking command.

In order to add optimality as well as robustness to the coupled control system, an optimal-sliding-mode-based relative position and attitude coupled control algorithm is presented with consideration of the unknown but bounded disturbances, system uncertainties and measurement noise. And, the effectiveness and robustness of the optimal-sliding-mode-based coupled control algorithm is verified via numerical simulations.