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A NEW RELATIVE NAVIGATION SCHEME USING DOUBLE LINE-OF-SIGHT MEASUREMENTS FOR SPACE AUTONOMOUS RENDEZVOUS

Abstract

The space autonomous rendezvous (SAR) is a necessary element of many current and future space missions, especially asteroid exploration, Moon or Mars sample return exploration, and on-orbit spacecraft servicing. As one of the key technologies for SAR, the relative navigation technology has been being studied and developed all along. In the past, performing space rendezvous operations often required cooperation between spacecrafts and a man-in-the-loop, or complex navigation and guidance instrumentation with addition mass, power, and resource to ensure missions success. However, the notion of performing rendezvous maneuvers autonomously between spacecrafts with incorporating light weight, low power, and compact navigation sensors has become a popular ideal for many space missions. At the same time, the innovatory autonomous relative navigation system should satisfy the demand of rendezvous with a variety of target objects that may be functioning or malfunctioning, passive or active, cooperative or uncooperative.

One significant problem of the relative navigation for SAR is how to estimate the relative motion of the target when the chase spacecraft possessing only the relative angles measuring sensor but not the ranging sensor. To solve this problem, a new relative navigation scheme using only line-of-sight(LOS) angles measurements is presented in this paper. In this scheme, a chief chase spacecraft(CCS), performing rendezvous maneuvers, and a auxiliary chase spacecraft(ACS), assisting CCS in the relative navigation, are flying in space to form a measurement base line relative to the target. CCS and ACS respectively measure LOS angles (azimuth and elevation) of the target with respect to themselves and inertial positions. By the inter-spacecraft communication and relative measurement between two chase spacecrafts, the base line information is obtained synchronously. According to the basic theorem of triangle geometry, using double LOS measurements and the base line information, the relative motion of the target can be estimated for the guidance of rendezvous maneuvers. Actually, some autonomous rendezvous missions, such as on-orbit spacecraft servicing or asteroid exploration, always include a master spacecraft and small sub-spacecrafts which are released by the master to perform rendezvous maneuvers. Therefore, without more system configurations, the master absolutely plays the role of ACS to realize the new relative navigation scheme.

The main works in this paper include: 1) setting up the process noise and measurement model of the relative navigation scheme using double LOS measurements, 2) designing the filtering estimate method for the relative navigation, 3) undertaking numerical imulations to verify the new scheme.