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A NEW METHOD OF NAVIGATION AND GUIDANCE USING DOUBLE LINE-OF-SIGHT MEASUREMENTS FOR AUTONOMOUS RENDEZVOUS

Abstract

The space autonomous rendezvous (SAR) is an essential element of many current and future space missions, such as asteroid or Mars sample return exploration, on-orbit spacecraft servicing, space military defense. Different from the past space rendezvous operations which often required cooperation between spacecraft and a man-in-the-loop, the notion of performing autonomous rendezvous should satisfy the demand of a variety of rendezvous targets which may be cooperative or uncooperative, functioning or malfunctioning, passive or active. And then, the relative navigation and guidance method has become the key technology for SAR missions. Therefore, the purpose of this paper is to present a new method of relative navigation and guidance using only line-of-sight (LOS) angles measurements for autonomous rendezvous.

The angles-only navigation and guidance is not a new technology and has been exploited in other applications areas. But it is a new challenge to utilize this technology in autonomous rendezvous missions because of the different relative dynamics and the different measuring instruments. We have presented a new angles-only relative navigation method for autonomous rendezvous in the past. It is supposed that a chief chase spacecraft(CCS), performing rendezvous maneuvers, and a auxiliary chase spacecraft(ACS), assisting CCS in the relative navigation, form a measurement base line relative to the target in space and respectively measure LOS angles (azimuth and elevation) of the target. 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. However, the previous research results indicate that the configuration of measurement triangle influences the estimation accuracy and the degree of observability of navigation system. Therefore, the purpose of maneuvers guidance of the chase spacecraft is not only to rendezvous with the target but also to guarantee the advantage configuration for triangle navigation. On the base of the previous research work, this paper is focused on the rendezvous guidance law with navigation constrain. Actually, the presented method of angles-only navigation and guidance could be adopted in some asteroid exploration or space military autonomous rendezvous missions including a master plat spacecraft (corresponding to ACS) and some small sub-spacecraft (corresponding to CCS).

The main works in this paper include: 1) introducing the relative navigation method using double LOS measurements, 2) designing the rendezvous guidance law with navigation constrain via potential function method, 3) undertaking numerical simulations to verify the presented method of navigation and guidance.