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SATELLITE SWARM SURVEILLANCE FOR PRECISE ORBIT DETERMINATION AND GUIDANCE DESIGN IN RENDEZVOUS TRAJECTORY WITH UNCOOPERATIVE MANOEUVRING TARGET IN SPACE

Abstract

This paper presents a comprehensive study on utilizing a satellite swarm for precise orbit determination and guidance design in a rendezvous trajectory with an uncooperative manoeuvring target in space. The proposed approach involves fusing observations from multiple satellites within the swarm to obtain a highly accurate and reliable estimate of the target's position.

The methodology employs the Interacting Multiple Model - Extended Kalman Filter (IMM-EKF) method, integrating multiple models to estimate the dynamic position of the uncooperative target. The IMM-EKF method enables the system to adapt to the evolving behaviour of the target during the manoeuvring process.

To enhance measurement accuracy, a combination of LiDAR and cameras mounted on the swarm satellites is utilized. This multi-sensor setup ensures robust and redundant measurements, contributing to the precision of the orbit determination process. Continuous orbit determination is maintained, even in the presence of target manoeuvres, providing real-time updates on the target's position.

The study also focuses on the design of an optimal rendezvous trajectory, taking into account the dynamic nature of the uncooperative target. The trajectory planning is performed in real-time, with continuous updates based on the tracked manoeuvres of the target. This adaptive approach ensures that the satellite swarm can efficiently respond to unexpected changes in the target's behaviour. In the satellite swarm configuration, additional satellites are strategically positioned to fly around the main satellite. The paper explores different scenarios with varying numbers of satellites in the swarm to understand the influence of swarm size on the precision and efficiency of the orbit determination and guidance design process.

The results of this study contribute valuable insights into the practical implementation of satellite swarms for dynamic orbit determination and guidance in scenarios involving uncooperative manoeuvring targets. The proposed methodology demonstrates the capability to achieve high precision, adaptability, and real-time responsiveness, and is further validated through comparison with existing ephemeris data of satellites, considering them as uncooperative entities. This validation reinforces the reliability and accuracy of the presented approach, establishing its applicability for a wide range of space surveillance and tracking (SST) and space exploration applications.