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MULTI-TARGET TRACKING METHOD BASED ON IMPROVED SORT FOR SPACE-BASED OBSERVATION OF RESIDENT SPACE OBJECTS USING STAR TRACKER

Abstract

In recent years, the number of resident space objects (RSOs), which include space debris and satellites, has been increasing. Additionally, collisions between RSOs have led to further debris generation and satellite failures, causing serious problems. To address these issues, it is necessary to improve space situational awareness (SSA) technology, which observes RSOs and determines their positions and orbits. Currently, space-based observations utilizing satellites for SSA are attracting attention as these methods have the potential to overcome the limitations of conventional ground-based observations. Ground-based SSA methods are limited by weather conditions, atmospheric disturbances and observational time constraints due to the Earth's rotation, making continuous monitoring of RSOs challenging. In contrast, space-based observation enables more frequent and stable monitoring of RSOs. Furthermore, using star trackers (STTs), which are attitude determination sensors, has been proposed as a cost-effective approach for space-based SSA.

When using STTs for RSO observation, it is necessary to simultaneously perform attitude determination and detect and track RSOs in real time. However, most of the currently proposed multiple-RSO tracking methods require significant computational costs because they must process the correspondence of many possible light sources between frames. This increases the processing time per frame, making it difficult to maintain real-time performance. Additionally, integrating RSO tracking and attitude determination further increases the computational burden, as both processes must share limited onboard computational resources. Therefore, achieving both attitude determination and RSO tracking simultaneously remains a major challenge.

This study proposes a method to address these challenges based on Simple Online and Realtime Tracking (SORT), a real-time technique used for Multiple Object Tracking in computer vision. Simply applying conventional SORT may lead to misidentifications when RSOs are close to other light sources such as noise. Additionally, conventional methods struggle in cases where RSOs have low light intensity or become temporarily unobservable due to attitude changes. Therefore, we devise a more robust method based on SORT by adding information on apparent magnitude to evaluate the relationship between RSOs across observation frames and introduce a newly developed process for accurately initializing and terminating RSO tracking. In this study, we demonstrate through simulations that applying the proposed method enables robust and accurate tracking of multiple RSOs. Moreover, this approach does not require additional hardware and can be implemented only through software improvements, making it a highly effective solution for enabling autonomous multi-RSO tracking on orbit.