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Title

Space-based passive orbital maneuver detection algorithm via a new characterization

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Abstract

Orbital maneuver detection for non-cooperative targets in space is a key task in space situational awareness. In previous studies, active sensors were generally required for accurate and rapid detection of maneuvers. As an alternative, this study develops a passive maneuver detection algorithm using line-of-sight angles measured by a space-based optical sensor. Emphasis is placed on constructing a new characterization for maneuvers as well as the corresponding detection method, especially for targets in high-altitude orbit, the relative distance between the chaser and the target is far less than their geocentric distance for spacecraft on high-altitude orbits and the relative range between chaser and target is far shorter than their geocentric distance. First, the concept of relative angular momentum is introduced to characterize the orbital maneuver of the target quantitatively, and the sensitivity of the proposed characterization is analyzed mathematically. Second, a maneuver detection algorithm based on the new characterization is designed in which sliding windows and correlations are utilized to determine the mutation of the maneuver characterization. Subsequently, a numerical simulation system composed of error models, reference missions and trajectories, and computation models for estimating errors is established. Then, the proposed algorithm is verified through numerical simulations for both long-range and close-range targets. The results indicate that the proposed algorithm is effective. Additionally, the sensitivity of the proposed algorithm to the width of the sliding window, accuracy of the optical sensor, magnitude and number of maneuvers, and different relative orbit types is analyzed, and the sensitivity of the new characterization is verified using simulations.

References

[1] HAKIMA H, BAZZOCCHI M, EMAMI M R. A deorbiter CubeSat for active orbital debris removal, Advances in Space Research, 2018, 61(9): 2377-2392.
[2] SURDI S A. Space situational awareness through blockchain technology, Journal of Space Safety Engineering, 2020, 7(3): 295-301.
[3] Jia, B., Blasch, E., Pham, K.D., Dan, S., & Chen, G. Space object tracking and maneuver detection via interacting multiple model cubature Kalman filters. In IEEE Aerospace Conference Proceedings, 2015.
[4] SPURBECK J, JAH, M K, KUCHARSKI D, et al. Near real time satellite event detection, characterization, and operational assessment via the exploitation of remote photoacoustic signatures[J]. The Journal of the Astronautical Sciences, 2021, 68(1): 197-224
[5] YU S X, WANG X, ZHU T L, Maneuver detection methods for space objects based on dynamical model, Advances in Space Research, 2021, 68(1): 71-84.
[6] FAN L H, TU R, ZHANG R, et al. An orbit maneuver detection method based on orbital elements for BeiDou GEO and IGSO satellites, Advances in Space Research, 2022, 69(10): 3644-3654.