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A NEW METHOD FOR TIME OF CRITICAL APPROACH CALCULATION

Abstract

Satellite clusters constitute one of the future trends in space systems. However, thus far, there has not been an efficient method for guaranteeing a safe operation of clusters in debris-rich environments. This paper suggests a method for a fast and accurate calculation of the Time of Critical Approach (TCA) between each member of a cluster of satellites and cataloged space debris. A cluster is a group of satellites flying under minimum and maximum distance constraints. All members of a cluster are in danger of collisions among themselves, as well as with other orbiting objects, such as other spacecraft and debris. The TCA is crucial in situational awareness; it is at that point in time in which the maximum probability of collision and the evasive maneuver are calculated. There are numerous methods today for finding the TCA between two orbiting objects; these methods vary in accuracy and speed. However, the problem of quickly calculating the TCA's of N satellites belonging to a cluster with M exterior objects has not been addressed. In this paper, we first suggest a method which is an effective compromise between speed and accuracy for finding the TCA between two space objects. The proposed method is a Surrogate Based Optimization algorithm (SBO), using the Alfano/Negron Close Approach Software (ANCAS) as the surrogate function. ANCAS fits a cubic polynomial to the relative speed, searching for the minimum distance in the critical points where the speed is null. As in SBO, the true position and speed are calculated at the TCA estimated by ANCAS; if the error is too large, the information of the new calculated point is used to fit a cubic polynomial and repeat the process. The described method is compared with exiting methods and the advantages are shown. Then, a generalization of the search to large groups of objects is suggested based on the known characteristics of the clusters members. The method is compared with an all-on-all search that is currently in common use.