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CONSTRAINED OPTIMAL COLLISION AVOIDANCE MANOEUVRE ALLOCATION UNDER UNCERTAINTY FOR SUBSEQUENT CONJUNCTION EVENTS

Abstract

With the increase of the traffic in orbit there is the need to re-consider the optimisation of Collision Avoidance Manoeuvres (CAM) to account for the occurrence of multiple subsequent conjunction events. This paper proposes a method to compute the optimal CAM for a multiple encounter scenario accounting for operational constrains. The proposed method builds on previous works from the authors where a single CAM was optimised to achieve the required reduction in the Probability of Collision (Pc) under epistemic uncertainty in miss distance and covariance matrices, at the time of closest approach. The uncertainty in the probability of collision derived from the epistemic uncertainty in miss distance and covariance was quantified with Dempster-Shafer theory of evidence (DSt). Within the framework of DSt we defined families of uncertain ellipsoids, with associated probability assignment, that represent all possible relative positions of two objects. CAMs are then optimised to minimise the Probability of Collision for the uncertain ellipse that would yield the highest Pc. This paper extends this technique by computing the optimal strategy when more than one event is possible within a given time window. Later events can involve the same secondary object or new ones. We will consider both single and multi-CAM strategies. In both cases there is a trade-off between the risk of the subsequent encounters, the complexity of the strategy (one or more manoeuvres), the cost and the inherent risk of the manoeuvre. Thus, the computation of an optimal CAM under several encounters requires the solution of a multi-objective min-max optimisation problem. In addition, actual missions may present constraint on the execution of the CAM. First we will show how to derive the families of ellipsoid with their associated probability assignment. We will then formulate the above-mentioned multi-objective min-max to incorporate operational constraints. In particular, we will consider constraints on execution time or on the magnitude and direction of the manoeuvre. Finally, we will incorporate the new multi-CAM optimisation in the framework of CASSANDRA (Computer Agent for Space Situational Awareness aNd Debris Remediation Actions) to automatically allocate CAM and provide operation support to operators. Some representative examples will illustrate the applicability of our approach.