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STATISTICAL LEARNING OF CONJUNCTION DATA MESSAGES THROUGH A BAYESIAN NON-HOMOGENEOUS POISSON PROCESS

Abstract

Current approaches for collision avoidance and space traffic management face many challenges, mainly due to the continuous increase in the number of objects in orbit and the lack of scalable and automated solutions. To avoid catastrophic incidents, satellite owners/operators must be aware of their assets' collision risk to decide whether a collision avoidance manoeuvre needs to be performed. This process is typically executed through the use of warnings issued in the form of conjunction data messages (CDMs) which contain information about the event, such as the expected time of closest approach (TCA) and the probability of collision. Our previous work presented a statistical learning model that allowed us to answer two important questions: (1) Will any new conjunctions be issued in the next specified time interval? (2) When and with what uncertainty will the next CDM arrive? However, the model was based on an empirical Bayes homogeneous Poisson process, which assumes that the arrival rates of CDMs are constant over time. In fact, the rate at which the CDMs are issued depends on the behaviour of the objects as well as on the screening process performed by third parties. Thus, in this work, we extend the previous study and propose a Bayesian non-homogeneous Poisson process implemented with high precision using a Probabilistic Programming Language to fully describe the underlying phenomena. We compare the proposed solution with a baseline model to demonstrate the added value of our approach. The results show that this problem can be successfully modelled by our Bayesian non-homogeneous Poisson Process with greater accuracy, contributing to the development of automated collision avoidance systems and helping operators react timely but sparingly with satellite manoeuvres.