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AI TO SUPPORT DECISION MAKING IN COLLISION RISK ASSESSMENT

Abstract

This paper introduces an Artificial Intelligence-based system to support operators to manage the risk of collisions. The system implements a Machine Learning (ML) techniques to predict the risk of collision between two space objects, where one of the two is an operational satellite and the other is a piece of debris. The ML technique will provide a prediction of the Probability of Collision (Pc) and associated confidence interval. The AI system will then incorporate other factors, such as the time to the expected collision and the consequences of a possible collision avoidance manoeuvre, to advise on what action to implement. A novel ML technique based on a combination of Deep Neural Networks (DNN) and High Dimensional Model-Representation (HDMR) is proposed to build a global surrogate representation of the Probability of Collision starting from a database of states of pairs of synthetic space objects. High Dimensional Model-Representation allows for both the assessment of high dimensional input-output system behaviour and the prediction of the output, taking into account only the most important inputs and the most relevant interaction between them. This will allow for an effective description of the most influential parameters for each pair. A revised calculation of the Pc is proposed to mitigate the Dilution of Probability that affects the usual definition of this quantity. This phenomenon gives the counterintuitive idea that the lower the quality of the data (or amount of information available to the operators), the smaller the probability of collision, which can lead to a false confidence in the likelihood of a collision or forces operators to accept very large margins. The method presented here will account for epistemic uncertainty in the prediction model which lead to the definition of confidence intervals on the probability of a collision. Confidence interval incorporate the dependency of the probability of collision on the amount and quality of the available information. The result of this revised calculation of the Pc is a more informed decision that. At the same time a lack of information can lead to a higher uncertainty on the decision to be made. Thus the paper will propose a possible approach to make optimal decisions under epistemic uncertainty where the cost of the decision is the risk associated to the decision are concurrently taken into account.