AI-controlled Space Traffic. An overview of AI applications for Space Traffic Management

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The space debris population and the number of active satellites has increased dramatically over the past years. This large amount of space objects poses a threat to operational satellites because of the risk of collision. This is reflected in the collision avoidance operations performed by satellite operators, where the risk of collision is continuously monitored and, when above thresholds, mitigation actions are executed. These mitigation actions are normally implemented through Collision Avoidance Manoeuvre (CAM) that reduce the risk below acceptable thresholds.

Collision Avoidance is one of the key operations in the scope of Space Traffic Management (STM), that promotes a common set of rules and techniques to guarantee the safe use of outer space. The Collision Avoidance process is very demanding in terms of manpower and relies on expert knowledge to identify critical events and the corresponding avoidance actions.

The applicability of Artificial Intelligence techniques has been largely studied in the last years to estimate the Collision Risk and to automate the Collision Avoidance decisions. Among other initiatives, the European activity CREAM[1] under the ESA's Safety Space Program is a clear example of that.

Machine Learning techniques have been proposed in the literature to automate the collision risk prediction and mitigation, mainly focusing on predicting the probability of collision risk to judge the criticality of the close approach.

The assessment and compensation of covariance realism is also of interest in the STM, and the automatic covariance realism has been proposed in the literature since it is one of the main components, and at the same time maybe the main source of uncertainty, to calculate the probability of collision. Machine Learning techniques are being applied by GMV to this problem in the scope of two ESA activities AUTOCA[2] and CREAM[1].

The detection of potential collision events is largely automated, however, the coordination between two manoeuvrable objects is left to the owner/operators, and this is still nowadays a non-automated process that requires manual intervention by satellite operators. Encounters between two active satellites have been seldom in the past, but due to the increasing number of objects in orbits, mostly due to large constellations, the number of in orbit encounters between two active satellites will increase more and more. Finding a mechanism that allows a simple and robust way to coordinate between both parties is a challenge in which Artificial Intelligence can help. Multi-agent systems

are definitively a possibility to model this communication scenario and to come up with an agreement on the CAM to be implemented. Rule-based and even DLT technologies are also alternatives to this problem that are being already considered in some activities carried out by the industry.

During the presentation Space Traffic Management (STM) and Collision Avoidance will be briefly introduced. Then, a general overview will be given of how the Artificial Intelligence techniques can be applied to solve this problem, paying special attention to the activities developed by the industry.

References

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