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GAME OF CAT AND MOUSE IN SPACE THROUGH MULTI-OBJECTIVE OPTIMIZATION

Abstract

Space situational awareness is a key to protect space assets for both civilian and military applications. Today, threat in space is a reality and spacecraft are design to do offensive approaches in space. From spying communication or disrupting its mission, sensitive operator must have mobility capacity to avoid offensive approach. The method proposed here is an efficient way to detect offensive approaches and design evasive manoeuvre while minimizing the service loss duration.

Through chaser and target spacecraft orbit, our approach, first, determines the relative dynamics of theses objects in order to correctly assess the evasive manoeuvre strategy. In case of conjunction avoidance the algorithm determines when an where there is a conjunction with the offensive spacecraft and plan a conjunction avoidance manoeuvre while taking in account many constraints detailed later. If the offensive spacecraft is already close to our spacecraft and try to do some approaches, the algorithms can be tuned to compute an escape manoeuvre avoiding the chaser spacecraft and ended the offensive approach.

Once the type of problem is characterized a multi objective optimization problem is set in order to find a bench of solution. For the conjunction avoidance problem, first objective is to find an evasive manoeuvre which maximize the closest approach distance between the chaser spacecraft and the target. Second objective is minimizing the velocity increment needed for this manoeuvre. Then these objectives are filled under constraint of maximum allowed velocity increment and time (forbidden interval in which the target spacecraft can't manoeuvre). If necessary other objective can be added to the problem like minimizing the service loss duration, it is assume here that once the target spacecraft is manoeuvring the spacecraft service is no longer available. For the proximity operations escape case instead of minimizing the service loss duration we search to minimize the duration where chaser and target relative distance are under a certain threshold.

Once the evasive manoeuvre for our spacecraft is design a reaction manoeuvre of the chaser can be computed in order to modelized its reactivity. All these optimization are made through a NSGA-II (Non-dominated Sorting Genetic Algorithm) extended algorithm which search the Pareto optimality of the define problem.

Future works are now planned to take in account other objective in the optimization problem as maximizing the cost of pursuit for the chaser spacecraft or spacecraft system constraint and taking in account low thrust manoeuvre as well.