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ASSOCIATING OPTICAL MEASUREMENTS AND ESTIMATING ORBITS OF GEOCENTRIC OBJECTS THROUGH POPULATION-BASED META-HEURISTIC METHODS

Abstract

Currently several thousands of objects are being tracked in the MEO and GEO regions through optical means. The problem faced in this framework is that of Multiple Target Tracking (MTT). In this context both the correct associations among the observations and the orbits of the objects have to be determined. The complexity of the MTT problem is defined by its dimension S. Current research tends to focus on the $S = 2$ MTT problem. The reason for this is that for $S = 2$ the problem has a P-complexity, when $S \geq 3$ the problem becomes NP-hard. However, with $S = 2$ the decision to associate a set of observations is based on the minimum amount of information, in ambiguous situations (e.g. satellite clusters) this will lead to incorrect associations. The $S \geq 3$ MTT problem is an NP-hard combinatorial optimization problem. There are two general ways to solve this. One way is to seek the optimum solution, this can be achieved by applying a branch-and-bound algorithm. When using these algorithms the problem has to be greatly simplified to keep the computational cost at a reasonable level. Another option is to approximate the solution by using meta-heuristic methods. These methods aim to efficiently explore the different possible combinations so that a reasonable result can be obtained with a reasonable computational effort. To this end several population-based meta-heuristic methods are implemented and tested on simulated optical measurements. The algorithms are compared both in their performance and in their time complexity. With the advent of improved sensors and a heightened interest in the problem of space debris, it is expected that the number of tracked objects will grow by an order of magnitude in the near future. This research aims to provide a method that can treat the correlation and orbit determination problems simultaneously, and is able to efficiently process large data sets with minimal manual intervention.