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Comparison of different optimization methods to construct an acquisition plan finding the best compromise between calculation time and algorithm performance

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The observation of celestial bodies other than Earth can without any doubt benefit from Earth observation satellites. This study, conducted for the latter, can easily be applied to Phobos for example, as part of the MMX (Martian Moons Explorer) project.

Earth observation satellites realize several acquisitions, which are linked together through an acquisition plan. The calculation time needed to construct such a plan is limited; therefore the method usually employed is the greedy algorithm which gives a solution quickly but not optimal. The temporal and kinematical constraints are numerous, making this a high combinatorial problem. The biggest time cost is the management of kinematics, especially checking if the acquisitions can be linked to each other, that is, calculating the minimum duration of the rallying sequence “attitude maneuver + acquisition”. In order to reduce the calculation time, the duration of each attitude maneuver and each acquisition can be calculated approximately, by adding an error margin to the result in order to ensure the feasibility of the acquisition plan. Therefore, a balance must be found between the calculation time an optimization method leaves to the kinematics and the margin associated to the needed approximation. Typically, an exact resolution method which leaves less calculation time for kinematics computation needs a rough approximation, and thus a big margin, which deoptimizes the calculated acquisition plan.

A simplified simulation model is used in order to quickly evaluate the quality of a plan constructed with a method (for example: greedy algorithm, branch and bound, stochastic greedy algorithm, genetic algorithm, simulated annealing, taboo search), as well as the needed calculation time and therefore the time left for kinematics computation. This model is based on a time windows representation.

The originality is to determine these elements according to different margins then determine which model for the calculation of kinematics, with the associated margin, gives the best results.

The results are different depending on the studied context; the goal is to find the method that offers the best compromise between quality of the plan and calculation time left to kinematics.

Summary

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