IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IPB)

Author: Ms. Taralicin Deka
University of Colorado Boulder, United States, taralicin.deka@colorado.edu

Mr. Jay McMahon
Colorado Center for Astrodynamics Research, University of Colorado, United States, mcmahojw@colorado.edu

EFFICIENT ASTRODYNAMICS-INFORMED SAMPLING-BASED MOTION PLANNING FOR RELATIVE SPACECRAFT MOTION

Abstract

One of the important problems that shows up in designing an autonomous system, in the field of robotics, is the motion planning problem with collision-avoidance. In astrodynamics, traditional guidance algorithms like the Lambert's solution can compute transfer orbit between two given position vectors, but they do not have collision-avoidance capabilities. State of the art methods for spacecraft collision-avoidance such as Model predictive control and Artificial potential functions work well in static uncluttered environments, but they often fall short when optimization and time-varying constraints become key feature of the problem.

Motion planning, in robotics, is a computational problem that seeks its solution as a sequence of actions to safely guide a robot from an initial state to a set of final sets. There exists a vast literature on sampling-based robot motion planning algorithms developed for kinodynamic applications (problems with simultaneous kinematic and dynamic constraints). The framework of these algorithms is sufficiently general that it applies to spacecraft and rovers just as it does to traditional robots. The authors of this paper have previously shown that by augmenting motion planning algorithms like the Stable Sparse RRT (SST) algorithm with knowledge of astrodynamics, fuel-efficient and collision-free motion planning can be achieved in astrodynamics applications. They called this algorithm, the Astrodynamics-informed kinodynamic motion planning (AIKMP) algorithm.

Deka and McMahon, in their work, had used a Lambert's solver to compute the transfer trajectories for building the stochastic tree for the AIKMP algorithm. However, solving the Lambert's problem requires an iterative root-finding method which makes the solution computationally very expensive. As a solution to this problem, McMahon and Scheeres had proposed the Linearized Lambert Solution (LLS) using 2-body dynamics that gives roughly 99.9% computational savings as compared to the Lambert solution at the cost of less than 1% errors in accuracy. Deka et. al. later leveraged the properties of the LLS and showed that stringent targeting accuracy can be achieved with LLS even in perturbed environments.

In this work, the authors propose to extend the application of the AIKMP algorithm to a perturbed environment. To achieve this, they will utilize the LLS (instead of a Lambert's solution) along with the AIKMP algorithm. This will significantly improve the computation efficiency of the AIKMP algorithm and will make it suitable for collision-free and fuel-efficient motion planning for relative spacecraft motion. The resulting algorithm will have widespread applications ranging from collision-free spacecraft formation flying to spacecraft proximity operations.