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# RAPID CONVEX GUIDANCE FOR LONG-RANGE SPACECRAFT RENDEZVOUS

**Abstract**

Increased access to space and miniaturization and modernization of spacecraft technology herald a near future where low-cost spacecraft will be abundant throughout the inner solar system. In the current state-of-the-art, spacecraft in deep space are operated primarily from the Earth by large dedicated teams of engineers. The spacecraft position and velocity must be determined, its trajectory must be planned, and its motion must be controlled to follow those plans. This involves labor-intensive and time-consuming analysis that must be automated and adapted for the computationally constrained reality of onboard guidance, navigation, and control. Among the many details to consider, this work is focused on the task of onboard guidance.

There are many obstacles to onboard guidance which are well-known within the spaceflight community. For example, there is a need to incorporate uncertainty quantification and stochasticity into the guidance design. Beyond this, nonlinearity itself presents another perennial and ubiquitous challenge. Nonlinear systems are harder to optimize and analyze than their linearized counterparts, and a great deal of effort in astrodynamics has been dedicated to overcoming these difficulties. In an onboard guidance architecture, problem nonlinearities manifest in prohibitively long compute times and robustness limitations.

In this work we present a new idea that has strong implications for the problem of onboard spacecraft guidance for nonlinear systems. We present a framework by which the trajectory optimization problem is posed as a path-planning problem in a space liberated of dynamics, leveraging transcription via pre-computed nonlinear basis functions directly related to the dynamics in the vicinity of a reference. The path planning problem is then solved via a successive convexification scheme which exhibits an excellent radius of convergence. Via this framework, the real-time computational load of computing optimal trajectories is kept to a minimum, and satisfactory performance of the guidance scheme is easy to assure. We apply this new approach to long-range spacecraft rendezvous and station-keeping. This is a nonlinear problem in spaceflight for which such an approach is particularly well-suited.