Reaserch Project 1 - Linear Quadratic Optimal Low-Thrust Spacecraft Rendezvous Guidance Laws

Student: Yahli Drucker*, Advisor: Vitaly Shaferman†
Technion, Israel Institute of Technology, Haifa, Israel, 3200003

In this project, the problem of spacecraft rendezvous is considered. This project addresses the terminal phase of the rendezvous for two relatively close spacecraft near a circular orbit, such that the problem can be described by the Clohessy-Wiltshire equations. Two different problem formulations are used to derive two guidance laws, each optimal for a different target strategy. One guidance law is based on optimal control, and the other on differential games. The two problems are formulated as optimization problems with linear dynamics and quadratic cost functions, with either soft constraints or hard constraints on the miss distance and velocity miss at the end of the scenario. Two analytical, closed-loop minimum fuel consumption optimal guidance laws are then derived. The performances of the two guidance laws are investigated and compared in simulations, and the guidance law based on optimal control is also compared to a numeric direct optimization solution. It is shown that the target can be reached with a negligible miss distance and velocity miss and that the numeric solution fits the solution of the proposed guidance law. In addition, it is evident that the guidance law based on optimal control performs better against a non-maneuvering target, and the guidance law based on differential games performs better against an optimally-evading target. Therefore, choosing which guidance law to use depends on the scenario.

*Undergraduate Student, Faculty of Aerospace Engineering, Technion, yahlidrucker@campus.technion.ac.il.
†Associate Professor, Faculty of Aerospace Engineering, Technion, vitalysh@technion.ac.il.