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MOTION PLANNING OF A ROBOTIC FREE-FLYER FOR ON-ORBIT ASSEMBLY USING RRT*-PANOC

Abstract

1 Abstract

Deploying large, complex space structures is of great interest to the modern scientific world as it can provide greater capabilities in obtaining scientific, communicative, and observational information than current missions. However, many mission conceptual designs contain complexities that must be constrained within launch vehicle lifting constraints including size and mass. To mitigate such constraints, the use of on-orbit additive manufacturing and robotic assembly allows for the flexibility of building large complex structures including telescopes, space stations, and communication satellites. The contribution of this work is to develop motion planning algorithms using rapidly-exploring randomized trees and proximal averaged Newton-type method for optimal control (RRT*-PANOC) to plan trajectories for an Astrobee free-flyer that acts as a robotic assembler. By obtaining trajectories that consider obstacle avoidance, dynamics, and contact constraints, Astrobee will rapidly consider and plan the construction of space structures as new components are made from a 3D printer. The approach is a natural generalization to repairing, refueling, and re-provisioning space structure components while providing optimal collision-free trajectories during operation.

2 Background

The concept of robotic assembly of space structures is becoming closer to reality with various works proposed by NASA, industry, and at the Massachusetts Institute of Technology (MIT) Space Systems Laboratory (SSL). The Restore-L servicing mission is an upcoming mission that will refuel the Lansat 7 spacecraft on-orbit through the use of autonomous rendezvous and grasping technology. This servicing mission ships components (i.e. fuel) from the ground and performs autonomous navigation to the spacecraft of interest. Tethers Unlimited, Inc. is currently enabling new technologies for on-orbit fabrication including antennas, solar panels, and truss structures using SpiderFab. These servicers and assemblers are defined by capturing the structure with a robotic arm for servicing or assembly. Alternatively, space structures can be assembled using proximity operations. At MIT's SSL, Astrobee a six degree of freedom (DOF) free-flyer with a 3 DOF robotic arm, is being enabled for capabilities in microgravity manipulation, multi-agent coordination, and higher-level autonomy. With Astrobee as the testbed, trajectories will be rapidly considered for planning the assembly of space structures (from 3D printed components) using rapidly-exploring randomized trees and proximal averaged Newton-type method for optimal control (RRT*-PANOC) allowing for optimal collision-free trajectories during operation.