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Author: Mr. Nicholas D'Amore
University of Maryland, College Park, United States

Dr. David Akin
University of Maryland, College Park, United States

SPACE MANIPULATOR CONTROL FOR THE DYMAFLEX FLIGHT EXPERIMENT

Abstract

Unlike traditional fixed-base manipulators, manipulators used in space are mounted to a spacecraft which may move freely in response to any forces or torques. This results in a highly coupled dynamical system. In the past, robotic arms have often been slow and lightweight in comparison to their host spacecraft; but as economic incentives drive the development of smaller, faster, lighter vehicles, this coupling will present an increasing challenge in the development of suitable control systems. To improve understanding of the dynamics of this coupled system and to demonstrate and validate proposed controllers in the space environment, the University of Maryland Space Systems Lab is constructing the DYnamic MAnipulation FLight EXperiment (DYMAFLEX) microsatellite, the development of which is partially funded by the United States Air Force University Nanosat Program. Equipped with a high-performance manipulator representing approximately 14% of the mass of the combined system and having greater rotational inertia at full extension than the spacecraft itself, the DYMAFLEX vehicle represents the ideal test bed for space manipulator dynamics and control.

This paper presents an overview of the DYMAFLEX science mission, with simulation results exploring the intended maneuvers. These maneuvers are designed to provide empirical validation of existing models for the behavior of a space manipulator as well as to provide a basis for comparison between proposed control strategies to assess their strengths and weaknesses in the actual application environment. A simple PD controller is compared to more sophisticated inverse dynamics (computed torque) and passivity-based approaches. These strategies are applied in both free-floating (in which the spacecraft itself is not actuated) and free-flying (in which thrusters are used in addition to the arm itself) contexts. An adaptive controller is considered as a further means of improving performance. Preliminary conclusions are drawn, to be verified on the DYMAFLEX platform.