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REACHABLE RELATIVE MOTION DESIGN AND NONLINEAR CONTROL OF SPACE ROBOTIC ARM ACTUATED MICROGRAVITY PLATFORM

Abstract

A novel concept of space-based microgravity platform is presented in this paper. This paper presents the idea of using the space manipulator to create a microgravity platform. The whole system is composed of a spacecraft, a manipulator installed on the outer surface of the spacecraft, an isolation shield installed at the end of the manipulator and a microgravity platform floating inside the shield. The purpose of the shield is to isolate disturbances such as the atmospheric drag and the solar wind pressure. The floating platform is not physically contacting the shield during working mode. In this way the platform exerts only the gravitational force, thus retains a very high level of microgravity. This type of the microgravity platform has following advantages: 1. it ensures high level of the microgravity environment. 2. it costs much less than a satellite. 3. it has a larger range of relative motion than in a module of a space station. 4. it has little influence upon other missions performed on the spacecraft.

The dynamics of the system are modeled using the Lagrange's equation. A Lyapunov based nonlinear controller is developed to fulfill the tracking mission. In order to achieve a rather long period of the microgravity status, the initial parameters of the manipulator should be carefully designed. For an extremely close proximity formation, which is within 10 meters, existing analytical solutions of the relative motion such as solutions to the Clohessy-Wiltshire equations may not be accurate enough to design a long period, bounded trajectory. Two cases are studied: zero-velocity releasing and nonzero-velocity releasing. Bounded motion conditions in meter level proximity formation and reachable region requirements are investigated.

A high accuracy analytical solution (CP solution) to the close-proximity relative motion is formulated to describe the relative motion. This solution remains stable around the accurate trajectory while the CW equation and TH solution diverges. The CP solution is utilized to design the bounded relative motion. In order to achieve longer period of the microgravity status, the relative motion of the platform should be bounded w.r.t. the spacecraft, and the relative motion should stay within the reachable region of the space manipulator. The conditions for the boundary requirement are formulated for two cases: zero velocity releasing and nonzero velocity releasing.