Control of Multi-Tethered Satellite Systems Using Lyapunov's Stability Theory

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Three-dimensional librational motion of multi-tethered satellite systems during the retrieval phase is considered. The mass of the tethers is taken into account. A tension control law is devised using the Lyapunov approach. The control law is effective in stabilizing the motion, however, it suffers from poor performance involving slow retrieval and large-amplitude out-of-plane oscillations. A hybrid control law using thrusters as well as modulation of tensions in the tethers is proposed to improve the performance of the controller. It is observed that the hybrid control law has a superior performance and fast retrieval with bounded librational motion is achievable through this control law.

Introduction

Dynamics and control of tethered satellite systems (TSS) have received a lot of attention in recent years [1, 2]. Although the initial interest of the investigators was focused on two-body systems, in the recent years a few studies have been conducted on multi-tethered systems. Most of them are related to three or four-body systems and dealt with their dynamics [3, 4, 5]. Misra and Modi [6] formulated the general three-dimensional dynamics of N-body tethered systems using a multiple-pendulum model with rigid and massless tethers. The lengths of the tethers could vary. Keshmiri and Misra [7] extended this formulation to flexible and massive tethers.

It is known that control of the system in the retrieval phase is much more difficult, since the system is inherently unstable in this phase [8]. Various control methods have been proposed by researchers from the very early stage of tethered satellite system application proposals. Some of them were based on the stability consideration of the nonlinear system, using Lyapunov's stability theory.