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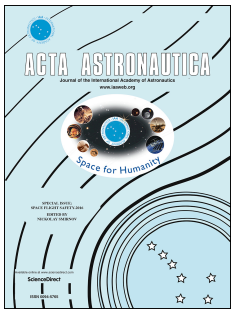

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Fuzzy Attitude Control of Solar Sail via Linear Matrix Inequalities

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Abstract

This study presents a fuzzy tracking controller based on the Takagi-Sugeno (T-S) fuzzy model of the solar sail. First, the T-S fuzzy model is constructed by linearizing the existing nonlinear equations of motion of the solar sail. Then, the T-S fuzzy model is used to derive the state feedback controller gains for the Twin Parallel Distributed Compensation (TPDC) technique. The TPDC tracks and stabilizes the attitude of the solar sail to any desired state in the presence of parameter uncertainties and external disturbances while satisfying actuator constraints. The performance of the TPDC is compared to a PID controller that is tuned using the Ziegler-Nichols method. Numerical simulation shows the TPDC outperforms the PID controller when stabilizing the solar sail to a desired state.

Keywords: solar sail, Takagi-Sugeno fuzzy model, twin parallel distributed compensation, linear matrix inequalities

1. Introduction

The appeal of solar sails lies in their propellantless means of thrust. Solar 'sails utilize the solar radiation pressure (SRP) from the Sun in a similar manner to how kites use wind to keep them aloft. Photons from the Sun transfer some of their momentum to the sail when they hit and reflect off the sail membrane. This provides an infinite means of thrust that eliminates the need for fueling stations for long trips [1]. In addition to thrust, the SRP can also be utilized for attitude control of the sail. This is done by creating an offset between the sail's center of mass (cm) and center of pressure (cp). This offset can be manipulated to create various torques for attitude control.

Wie discusses several attitude control systems (ACS) for a square configuartion solar sail [2, 3]. These control methods include control vanes, gimbaled control boom, shifting and tilting panels, reflectivity modulation, and translating masses. To change the location of its cp, IKAROS uses reflectivity modulation to change the reflectivity coefficient of various areas of its membranes. Fu and Eke [4] developed a novel method to change the location of the cp by pulling the