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OBSERVER-BASED FAULT-TOLERANT INTEGRATED ORBIT-ATTITUDE CONTROL OF SOLAR SAIL

Abstract

In recent years, solar sails have been widely used in spacecraft propulsion systems due to their unique advantages, such as high efficiency, long-term operation, and sustainability. However, the complexity and uncertainty of the space environment pose significant challenges to the control of solar sails. In particular, the malfunctioning of the reflectivity control devices (RCDs) used in solar sails can cause severe attitude and orbital dynamics instability. To address this challenge, a fault-tolerant control system based on observer technology is proposed to stabilize the attitude and orbit dynamics of a malfunctioning solar sail with only one RCD facing failure. The observer is used to observe the attitude and orbit dynamics of the solar sail, including the position, velocity, and angular velocity. The proposed fault-tolerant control system includes two main components: the fault detection and isolation (FDI) module and the controller. The FDI module monitors the output of the observer and detects any abnormal behavior of the RCDs. Once a fault is detected, the FDI module isolates the malfunctioning RCD and sends a signal to the controller. The controller then generates a fault-tolerant control signal based on the observer's observed state and the isolated fault signal. The controller's objective is to stabilize the solar sail's attitude and orbital dynamics while ensuring the system's safety and performance. To evaluate the performance of the proposed observer-based fault-tolerant control system, simulation experiments are conducted under various scenarios, such as different RCD failure rates and different disturbance levels. The simulation results demonstrate that the proposed system can effectively stabilize the attitude and orbit dynamics of the malfunctioned solar sail with only one RCD facing failure. In conclusion, the proposed observer-based fault-tolerant control system provides a viable solution for stabilizing the attitude and orbit dynamics of a malfunctioning solar sail with malfunctioned RCDs. The system can effectively detect and isolate the RCD fault and generate a fault-tolerant control signal to stabilize the system's dynamics. The simulation results confirm the system's effectiveness, demonstrating its potential for real-world applications in future space missions.