Extended Abstract: The attitude control of flexible spacecraft presents significant challenges due to the complex interplay between structural dynamics and control systems, which can degrade performance. This research aims to address these challenges through two main contributions: modeling structural dynamics **and** designing advanced attitude control systems**.** Modeling Structural Dynamics**:** We begin by analyzing the dynamics of flexible components, such as solar panels. A comprehensive model is developed, followed by stability analysis to ensure robustness. This modeling phase is crucial for understanding the intricate behaviors of flexible structures under operational conditions. Advanced Attitude Control Systems: We explore various composite control strategies, including Proportional-Derivative (PD), Improved Proportional-Derivative (IPD), IPD with Disturbance Observer-Based Control (IPD-DOBC), and IPD with Extended State Observer (IPD-ESO). These methods are evaluated through a comparative study focusing on single-axis control of flexible spacecraft. For three-axis stabilized spacecraft, we implement PD-DOBC, Sliding Mode Control with DOBC (SMC-DOBC), and Adaptive Sliding Mode Control with DOBC (ASMC-DOBC). Each method is tailored to enhance maneuvering control and vibration reduction. Optimization Techniques**:** To further refine the control systems, Particle Swarm Optimization (PSO) is employed to optimize controller gains, enhancing both tracking accuracy and robustness against disturbances. Simulation and Results**:** All models and control strategies are validated using MATLAB/SIMULINK simulations. The results demonstrate the effectiveness of the proposed control designs in various operational scenarios, providing a detailed methodology for each control strategy, performance evaluations, and insights into their practical implementation limitations. This structured approach not only advances the theoretical framework for flexible spacecraft attitude control but also offers practical guidelines for selecting appropriate control strategies based on specific mission requirements.

Abstract:

This research addresses the challenges in attitude control of flexible spacecraft, exacerbated by the complex interactions between structural dynamics and control systems. We focus on two main areas: modelling the dynamics of flexible components like solar panels and designing advanced attitude control systems. Our approach starts with developing a comprehensive model followed by stability analysis, which is essential for understanding the behaviors of flexible structures. We then investigate various control strategies, including Proportional-Derivative (PD), Improved Proportional-Derivative (IPD), IPD with Disturbance Observer-Based Control (IPD-DOBC), and IPD with Extended State Observer (IPD-ESO), assessing them in contexts from single-axis to three-axis stabilized spacecraft. Techniques like particle swarm optimization (PSO) are utilized to optimize controller gains and improve tracking accuracy and robustness. Validated through MATLAB/SIMULINK simulations, our simulation results demonstrate the efficacy of these control designs in enhancing maneuverability and vibration reduction, presenting valuable insights for selecting appropriate control strategies in practical spacecraft operations.

Keywords attitude control, flexible spacecraft, disturbance observer, composite control, Structural dynamics.

Master Abstract: This thesis addresses improving attitude control systems for flexible spacecraft, with a focus on fault tolerance and input saturation. Building upon the three-axis flexible spacecraft system model developed in our final project thesis, we incorporate fault modeling and input saturation to design an advanced adaptive Backstepping control method. Particle swarm optimization (PSO) is used to optimize the controller gains, ensuring robust and precise control performance. MATLAB/SIMULINK is employed to simulate and validate our control designs. Additionally, we present the conception, design, and development of a web interface aimed to simplify complex simulation tasks. This interface facilitates the application of our advanced control methods to make the simulation process more accessible and user-friendly. Validated through simulations, our results demonstrate significant maneuverability and fault tolerance improvements. Keywords: fault tolerant control, Backstepping, flexible spacecraft, interface conception and design, User interface (UI).