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DEVELOPMENT OF A DUAL-MODE ATTITUDE DETERMINATION AND CONTROL SYSTEM (ADCS) FOR SMALL SATELLITES

Abstract

This paper details the development of a robust Attitude Determination and Control System (ADCS) for small satellites. The rapid increase in miniaturized satellite deployment has amplified the demand for high-performance ADCS. Our dual-mode ADCS meets the rigorous requirements of small satellite missions, leveraging an innovative integration of sensor technologies and control strategies.

Our system employs the Adafruit BNO055 sensor for comprehensive orientation and angular rate information through accelerometer, gyroscope, and magnetometer data. This primary setup is complemented by reaction wheels powered by brushless DC (BLDC) motors, controlled via an L298 motor driver, enabling precise orientation adjustments across pitch, yaw, and roll axes.

A novel aspect of our ADCS is the implementation of continuous rotation control based on intensity data, ensuring dynamic and precise adjustments. The Arduino ATmega microcontroller manages system communication, processing sensor input, and executing motor control commands, enhancing reliability and responsiveness.

In the event of primary sensor failure, Light Dependent Resistors (LDRs) act as a redundancy measure, detecting sunlight intensity and direction to approximate the satellite's orientation. This dual-mode approach, combining BNO055 sensor data with LDR-based redundancy, enhances fault tolerance and ensures uninterrupted operational capability.

Simulations performed using Arduino software validated the system's performance, demonstrating stabilization within 20 degrees of desired orientation. Each BLDC motor has a specific target angle, with corrective actions initiated if the satellite's orientation drifts beyond these angles.

Additionally, our design incorporates a processor-in-the-loop (PIL) testing framework, allowing for realistic and cost-effective validation. This framework leverages a quaternion-based dynamic model and employs a simplified control switching strategy to maintain stability with minimal computation and energy resources.

Tailored for CubeSat and small satellite missions, our dual-mode ADCS offers high precision, fault tolerance, ease of implementation, and cost-efficiency. This design ensures future scalability and customization, providing a significant advancement over existing systems.