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ATTITUDE PATH PLANNING TO IMPROVE FULL-MAGNETIC CONTROL PERFORMANCE OF 6S CUBESAT

Abstract

6S is a 1U CubeSat made by PoliSpace students from Politecnico di Milano, with the primary objective of testing the in-orbit functional behavior of a structural battery and a set of experimental perovskite solar cells. In the framework of student-led projects, CubeSats offer the benefits of a short development cycle and low cost. However, their small size strongly limits the achievable performance and the authority of the Attitude Determination and Control System (ADCS). These constraints resulted in the choice of full magnetic control, while an IMU and Sun sensors were selected for attitude determination. Proper testing of the solar cells requires a Sun-pointing profile to be achieved and maintained for a long enough period. The low controllability of the CubeSat due to the magnetic control significantly impairs the feasibility of large slew maneuvers, which are required to reorient the spacecraft. To counteract this effect, an attitude motion planning method is implemented with a novel algorithm based on A* path search, inspired by the recent advancements in attitude path planning algorithms. An optimal continuous path for the slew guidance can be obtained while considering pointing constraints and control limitations. Precisely, the novelty of the developed algorithm consists of the enforcement of the orthogonality between the direction of magnetic field intensity, dependent on the CubeSat orbital position, and the commanded control through the minimization of the integral of the scalar product of the two, along the current sub-optimal path. This keeps a satisfactory level of controllability during the re-orientation maneuver. The discretized sets of attitudes output from the A* is interpolated in the space of the Modified Rodrigues Parameters to obtain a smooth path to be fed into the control law. Additionally, as attitude knowledge is a fundamental piece of information and limited hardware is available, keep-in constraints to maintain the Sun into the Sun sensors' Field Of View (FOV) are also included. The paper presents numerical simulations from the internally developed CubeSat MATLAB simulator highlighting the differences between the classic Lyapunov-based control and the novel algorithm for attitude path planning, critically assessing the benefits and drawbacks of each of them.