IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

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KERNEL MANAGEMENT STRATEGY FOR REACTION WHEEL OPTIMAL SPEED CONTROL FOR SPACECRAFTS FOR ENHANCED POINTING ACCURACY AND AGILITY

Abstract

With the demand for improved accuracy and high agility slewing requirements, it is imperative that the simultaneous use of 4-RWs is important for a spacecraft. Now, if the angular momentum capability is enhanced, it increases the spacecraft agility by allowing fast large angle maneuvers thereby catering to spot imaging requirements. Moreover it also leads to enhanced pointing accuracy (significant for Earth observation and interplanetary scientific missions) by maximizing the dumping gaps, that is, by reducing the frequency of attitude disturbing momentum unloading from wheels. The use of fourth wheel provides DOF which allows regulation of the operating point of wheel by choosing a trade of between saturation and margin before zero cross-over. The research brings to light the design of RW momentum management algorithm with mathematical formulation and philosophy for tuning the pertinent parameters of the algorithm towards minimizing the momentum dumping requirements. Wheel speed null-space component based kernel management technique has been studied and the means of achieving the desired targeted speed post acquisition maneuvers have been brought out. The kernel management problem calls for defining a relevant approach to set the torque along the null space in order to manage the RW operation constraint. The research focuses on management of wheel speed error and speed null space component through controller towards achieving explicit constraints of limiting the speeds from undergoing saturation or zero angular velocity (stiction). Thus more margin and hence effective momentum management of the system can be achieved through wheel speed control algorithm. The approach adds additional value in changing the nominal speed of operation dynamically during wheel mode of operation without disturbing the platform. This caters to the requirements of operating the wheels at different nominal commanded speeds even being in zero momentum, torque control mode, without switching actuators. This is required to carry out slews across the entire operational regime of wheels for different attitude and rate profiles, especially for remote sensing and scientific missions. Simulations are carried out in 4RW configuration with typical acquisition maneuvers and extended to rest to rate maneuvers which show the momentum margin and targeted speed achieved during the slews. The potential of the research is highlighted in the wheel speed management and constraint satisfaction for reaction wheels without disturbing the platform performance which can eventually reduce momentum unloading requirements at ease and can be extended for failure scenarios like 3RW configuration.