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PRACTICAL APPROACH FOR QUICK ATTITUDE MANEUVER OF SPACECRAFT WITH ACTUATOR SATURATION

Abstract

In this study, a practical method for quick attitude maneuver of spacecraft is proposed. As the satellite has been used for commercial service, the agility of a satellite has become a crucial performance. The method has been developed in order to improve the agility of SpaceEye-1 bus system which is an earth observation satellite of Satrec Initiative. In space industries, one of the most conservative fields, the heritage of an attitude control algorithm is as important as its theoretical optimality for applications. Also, the simplicity is a critical factor because of the limited resource of its application environment. For these reasons, the traditional quaternion feedback control, which can be approximated to proportional-derivative control, is recommendable due to its heritage and efficiency. The quaternion feedback has been studied, verified and widely used in orbit for last decades. The proposed method in this study deals with actuator saturations by using the quaternion feedback control. The actuator saturation has been a bothering problem for quick attitude maneuver due to its nonlinearity. In order to achieve fast maneuver with actuator saturation, the spacecraft attitude maneuver is approximated to single axis rotation in one dimensional space with bang-bang control which is fit for actuator saturation conditions. By the approximation, the proper proportional and derivative gains are derived. The gain values are calculated by a simple and closed form of formula, so it could be instantly applied to the traditional quaternion feedback control loop with minimal changes. Although the proposed method is not the ideal time-optimal solution of three axis attitude control problems, the simulation study shows that it works as sub-optimal solution similar to bang-bang control, which is a good sub-optimal control for three axis attitude control especially if the moment of inertia of the satellite is nearly symmetric. Compared to the ideal bang-bang control, it gives optimality gaps of 7% for 180 degree maneuver and less than that for smaller maneuver angles while maintaining the advantages of the quaternion feedback closed loop control.