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A MAGNETIC CONTROL LAW FOR FAST DETUMBLING OF SPACECRAFT

Abstract

A novel control law for detumbling a spacecraft using magnetic actuators is proposed. The time required to stabilize a spacecraft is minimized by applying the maximum control effort possible during the whole stabilization process. Moreover, the direction of the control torque is such that a situation where the angular velocity is parallel to the magnetic field is avoided. Most controllers, in order to maximise rotational energy dissipation, apply a torque parallel to the projection of the angular velocity on the plane defined by the magnetic field vector. If the control effort is relatively high, angular velocity is steadily dissipated until it becomes parallel to the magnetic field, where no torque can be applied—and the controller itself maintains this undesired stable situation, even if the field vector changes due to orbital motion. The proposed control strategy addresses this issue, caused by the very nature of magnetic control, applying optimal control theory. The resulting torque may appear instantaneously inefficient in the sense that it does not reduce the velocity at the maximum rate, but it contributes to keep the angular velocity vector as separated as possible from the magnetic field vector, where actual energy dissipation can occur. A stability proof based on the Lyapunov method is derived. For validation of the theoretical analysis numerical simulations are realised, modelling orbit disturbances, sensors and magnetorquers. In order to assess the performance and suitability of this controller in a variety of scenarios, different parameters such as inertia, power, orbit and initial conditions are tested. A comparison with other detumbling control laws, including the widely used B-dot, is conducted.