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MODEL PREDICTIVE STEERING CONTROL LAW FOR DOUBLE-GIMBAL SCISSORED PAIRS OF CONTROL MOMENT GYROS

Abstract

Since control moment gyro (CMGs) can generate a large torque compared to RW, it is used as an actuator for attitude control of a large spacecraft. However, when the number of SGCMG units is 5 or less, there are "singularities" that cannot generate torque around the desired direction. In order to construct a system in which singularities do not exist within the maximum angular momentum that the CMG system can hold, six or more SGCMGs are required. Since the CMG singularities are in an inconvenient state for attitude control, a great deal of effort has been devoted to overcome the singularity problem of CMGs systems. However, those efforts still have the following problems. (1) The use of six (or more) SGCMGs is not suitable for spacecraft where weight reduction is required. (2) In variable speed CMG (VSCMG), the reaction speed of torque generation resulting from the change in the wheel speed is slow. As the angular momentum decreases, the large torque generating function which is a feature of CMG is impaired. (3) The gimbal control law becomes complicated, and verification for many cases is required. Also, methods of generating perturbation torque make it difficult to realize ground observation that requires highly accurate attitude tracking control due to generated perturbation torque. In order to overcome the above issues, this paper proposes a new configured CMG system that is called "double gimbal scissor-paired control moment gyros (DGSPCMGs). Because the proposed DGSPCMGs system is a hybrid system combining a scissored pairs CMG and double gimbal CMG, this system has no inner-singularities. Moreover, the outer-singularities (saturation singularities) can be escaped by null motion only in this system. Thus, the singularity avoidance steering law that generates a perturbation torque is unnecessary, and precise attitude tracking maneuver can be more easily achieved. In this study, a steering control law for this system is designed by taking singularities into consideration, and cooperating model predictive control to reduce the time required for null motion. Furthermore, the validity of the proposed steering control law is demonstrated through numerical simulations.