A fractional-order sliding mode control for nominal and underactuated satellite attitude controls

ABSTRACT

Sliding mode control (SMC) is widely used in many existing nonlinear control solutions due to its capability against external disturbances and uncertainties, while the fractional order control (FOC) is employed as it can further enhance the control performance due to its robustness. This paper attempts to implement a fractional-order sliding mode control (FOSMC) for a small satellite with reaction wheels (RWs). In this work, a conventional SMC was initially designed to cope with the uncertainties of satellite attitude dynamics. In order to improve the attitude control performance, the FOSMC was designed accordingly and the classical chattering problem was alleviated by using the hyperbolic tangent function. This current work is the maiden work on FOSMC especially for small satellites using RWs. The FOSMC was also tested for a satellite with only two functional RWs, in which the control allocation technique is proposed to solve the underactuated satellite attitude control problem. Since the angular momentum of the reaction wheel will become saturated over time, it will be managed using the momentum unloading technique with the unique fuzzy proportional-integral (FPI) control. All control algorithms were numerically treated and analysed. The results show that the FOSMC is effective in achieving the overall desired attitude control performance for nominal and underactuated satellites.

Keyword: Attitude control; Reaction wheels; Sliding mode control; Fractional-order; Underactuated satellite