A parallel distributed compensation approach to fuzzy control of spacecraft combined attitude and sun tracking

ABSTRACT

A spacecraft combined attitude and sun tracking system (CASTS) is a synergized system in which solar array drive assemblies are used as sun trackers and simultaneously as attitude control actuators. This paper, a continuous research on CASTS, addresses its attitude control problem. The kinematics and dynamics equations of a rigid spacecraft attitude motion is inherently nonlinear. In the attitude regulation problem, the attitude motion can be treated as a simple linear system for a constrained range of operating conditions, but it has impacts on the accuracy of the linear model when a model-based controller is implemented. Naturally, this is a compromise between simplicity and accuracy that all design engineers have to face. In this paper, we present a systematic approach to improve the accuracy while preserving the model as linear as possible, by deriving a quasi-linear approximation of a nonlinear spacecraft attitude motion. The quasi-linear approximation is based on the framework of the Takagi–Sugeno (T–S) fuzzy model. If a spacecraft can be modeled in the form of a rule-based T-S fuzzy system that acts as an interpolator between linear state-space systems, an approach called parallel distributed control (PDC) can be used to stabilize the attitude motion. The design philosophy of PDC is to create a simple fuzzy controller,where each rule's consequent is a control law designed to stabilize the linear system in the corresponding consequent of the spacecraft T-S fuzzy system. Numerical results validate that the attitude and sun-tracking performances are achievable using the proposed PDC strategy.

Keyword: Attitude control; Fuzzy control; Parallel distributed compensation; Spacecraft; Takagi–Sugeno fuzzy model