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STATE ESTIMATION FOR SPACECRAFT FORMATION FLYING BASED ON THE SEPARATION PRINCIPLE

Abstract

Spacecraft formation flying is a promising approach to enhance mission capabilities and reduce the costs associated with it. At the same time, the control of several spacecraft poses a great challenge which becomes more difficult as the number of elements in the formation increases or during proximity operations. Many linear control laws to solve these problems have been proposed; however, most of them present a fundamental limitation: an assumption on perfect knowledge of the spacecraft states. This belief, required to obtain closed-form solutions, is not valid in a realistic scenario and the existence of noise in state measurements requires incorporating a state estimator in the control loop. In this paper, the tracking problem is tackled by a state estimator built on the separation principle, using a parameter-varying dynamical model that incorporates a potential function to perform evasive actions during close manoeuvring. The separation principle states that an observer designed from a known control input can be used to estimate the state of the system and then to generate the next control input. This feature allows the observer and the controller to be designed independently. Two different dynamical models are used in this work: the first is a nonlinear system called *main dynamical system*, which uses the Tschauner Hempel (TH) model for relative dynamics in eccentric reference orbits and an evasive-action potential function; the second is a linear model called *nominal system*, which includes only the TH equation and a control input. The observer is then designed by exploiting the linear form of the nominal system in order to estimate the states of the main system. Test cases comprising multiple spacecraft orbital transfer and on-orbit position switching will be implemented to evaluate the controller performance. The results will show that the proposed control law provides better results in terms of time of convergence, stability and lower delta-v's than a traditional linear quadratic tracking controller. Further, the full nonlinear dynamics of the system comprising the potential function is accounted in the control loop. Finally, in comparison with other similar techniques, such as the Linear Quadratic Gaussian, the proposed control law is easier to design and implement and requires a lower computational load.