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PROCEEDINGS

Koopman-Operator-Based Optimal Predictive Control for Libration Point Orbit Rendezvous

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ABSTRACT

An optimal predictive control method for spacecraft rendezvous based on Koopman operator is proposed for the the libration point rendezvous problem of Earth-moon system. Firstly, the relative motion dynamics model between the chaser and the target spacecraft in the Earth-moon system is established. Secondly, considering the influence of nonlinearity on spacecraft rendezvous control, a global linearization method of nonlinear rendezvous system driven by Koopman operator is proposed. In this method, the Koopman linearization operator is approximated by the extended dynamic mode decomposition (EDMD) method on the finite dimension. Subsequently, based on the linearization model of spacecraft rendezvous, the iterative sequential action control (ISAC) algorithm is used to calculate the optimal action of the rendezvous process, including the optimal control value, application time and duration. Meanwhile, the asymptotic stability of the closed-loop spacecraft rendezvous control system is proved. Compared with the traditional ISAC algorithm, the analytical optimal predictive control algorithm combined with Koopman operator can obtain the global approximate linear model without relying on the exact relative motion dynamics model. At the same time, compared with local linearization based on Taylor expansion, it avoids the shortcoming of updating linear model in real time calculation, and greatly improves the calculation accuracy and tracking accuracy. Finally, numerical simulations and analyses are employed to verify the effectiveness and robustness of the proposed method. Simulation results show that the method has higher computational efficiency and tracking accuracy, and significantly reduces the energy consumption in the rendezvous process.

KEYWORDS

Optimal predictive control; Koopman operator; spacecraft rendezvous; iterative sequential action control

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