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MODEL PREDICTIVE SPACECRAFT ATTITUDE CONTROL WITH PHYSICS-INSPIRED NEURAL DYNAMICS LEARNING

Abstract

Model-based spacecraft attitude control approaches hinge on the availability of accurate dynamics models, exhibiting limitations especially when the spacecraft is rigid-flexible coupled. Of particular interest in the modeling field is the machine learning schemes by leveraging neural networks to approximate hard-to-model dynamics. In this paper, a learning-based prescribed performance model predictive control structure is designed with physics-inspired neural dynamics learning, and applied to the spacecraft attitude tracking. First, in contrast to the pure data-driven approaches based only on data, physics knowledge is incorporated with neural networks in the paper, yielding a physics-inspired neural dynamics model complied with the underlying physical laws in the training procedure. Then, a learning-based prescribed performance model predictive controller is proposed by taking the learned dynamics as the prediction model of the optimal control problem. Predefined control performance requirements are achieved by resorting to prescribed performance control technique. Finally, numerical case studies of rigid and flexible spacecraft attitude tracking are presented to demonstrate the capabilities of the proposed learning-based control method. Simulation tests for comparison with the control methods using black-box models are conducted. The results show a superiority in both dynamics identification and closed-loop system tracking control.