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APPLYING FICTITIOUS REFERENCE ITERATIVE TUNING TO QUATERNION FEEDBACK AND QUANTITATIVE EVALUATION

Abstract

The authors consider the fictitious reference iterative tuning (FRIT), which can obtain desired controller parameters with experimental data, applying to quaternion feedback. FRIT is one of the data-driven controller parameters tuning methods, which enables the tuning of desired control parameters with only one-shot experimental data in a closed-loop system. Quaternion feedback is a feedback controller for a three-axis attitude stabilized spacecraft, and control torque is calculated by multiplying each of the three vector parts of error quaternion and angular velocity by the gain and summing them. Two gain values decide the characteristics of the controller so gain tuning is essential. The application of FRIT to quaternion feedback is promising but has been rarely investigated.

Applying FRIT to quaternion feedback is expected to obtain new gain values that improve attitude controller characteristics by only using the on-orbit experimental data with the robustly tuned controller. FRIT does not need open-loop experiments or experiments using identification input signals, such as random inputs. These kinds of experiments would disturb the attitude of spacecraft, which can lead to a loss of satellite integrity, so deep considerations are essential for these operations. In addition, most on-orbit spacecraft already use pre-set robust but medium performance gain values for nominal operations. FRIT can obtain new gain values that make the attitude controller performance close to the desired attitude controller performance without any high-risk operations, and only using the operation data with these kinds of robust gain values.

The method of applying FRIT to quaternion feedback is derived. The authors assume a specific satellite model that uses three reaction wheels and conduct a numerical simulation to obtain close-loop experimental data. Then, the authors quantitatively compare a couple of tuning methods. First, the authors calculate gain values by existing tuning methods. Next, the authors obtain new gain values by FRIT using the close-loop experimental data. Numerical simulations are conducted again to evaluate quantitatively the characteristics of the attitude controller with new gain values tuned by different methods. The authors consider reference models for FRIT and quantitatively compare different reference models by numerical simulations.