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IMPROVING THE CONTROL DESIGN OF THE KNATTE PLATFORM WITH FLEXIBLE PANELS

Abstract

The effect of flexible structures such as solar panels or long booms on the dynamics of a spacecraft of any size can become a problem for the stability of its control subsystem. That said, proper control algorithms can be designed to reduce the vibrations of such appendages. The Kinesthetic Node and Autonomous Table-Top Emulator (KNATTE), developed at Luleå University of Technology in collaboration with the University of Rome "La Sapienza", is a frictionless vehicle that has been conceived as a multipurpose platform to perform hardware-in-the-loop simulation experiments with real and analogous small-satellite components. The platform can emulate spacecraft behavior in orbit for validating various guidance, navigation and control algorithms.

The object of this study is the KNATTE platform carrying a pair of flexible mock-up solar panels. In such circumstances, the steering system of the vehicle is not able to maneuver by applying a conventional Proportional-Integral-Derivative control algorithm. However, a Linear-Quadratic-Gaussian (LQG) algorithm has been proven effective to control the vehicle with the appendages in former simulations. The purpose of this work is to validate the performance of the previously developed LQG algorithm in a hardware-in-the-loop simulation experiment and compare its results to those of applying a Sliding Mode Control (SMC) algorithm to the same scenario.

This article presents a comparative study of the LQG and SMC algorithms. For that, both algorithms have been developed in Simulink and tested in equivalent modeled environments. Next, the algorithms have been adapted to the operation of KNATTE for their validation on hardware, including additional modifications to the experiment setup when necessary. The tracking data coming from a computer vision system has been filtered to improve the accuracy of the navigation block. The signal conditioning circuit has also been upgraded to improve the reliability of panel deflection measurements given by piezoelectric sensors.

Both the LQG and SMC algorithms proved to be effective to reduce the destabilizing vibrations of the flexible panels and their suitability for controlling the KNATTE platform with such panels despite their dependency on an accurate model of the plant. The SMC algorithm showed less error than the LQG algorithm in the tested scenario. Additionally, the implementations in this work can be used for future educational and research experiments with frictionless platforms.