ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

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PID CONTROLLER OPTIMIZATION FOR ANDROID-POWERED NANOSATELLITES USING JACOBIAN-BASED SCALING

Abstract

Smartphone-based nanosatellites have recently seen an increase in popularity due to their low cost and well-suited set of onboard sensors, often including accelerometers, gyroscopes, GPS receivers, and magnetometers. However, because Android is not a real-time operating system, many traditional control techniques fail for such satellites due to the latencies and asynchronous measurements that occur in smartphone-based control systems. On the other hand, PID controllers tend to only require a few minor modifications in order to stabilize such systems. Hence in this paper, we design a PID controller suitable for Android-based nanosatellite attitude control systems.

Although a satellite's attitude dynamics are well-known, their inherent nonlinearity makes optimizing a PID controller difficult, even around a linearization point. Hence in this paper, we take a three-step approach for PID controller design in which we:

1)Estimate a high-order linear model about a linearization point of interest.
2) Design a linear quadratic integral (LQI) reference-tracking controller for the estimated model.
3) Optimize a PID controller for the estimated model, using the PID-like state feedback gain matrix of the LQI controller as the initial guess for the PID controller values.

Furthermore, we show that off-the-shelf optimization routines typically have trouble with PID controller tuning, and hence we introduce scaling techniques to resolve the sensitivity.

Finally, we demonstrate the effectiveness of the proposed approach by designing a reference-tracking PID controller for an Android-based quadcopter attitude control system, which we verify through flight testing. Since the attitude dynamics of the quadcopter are not known precisely, are subject to highly nonlinear aerodynamic forces, and operate at a significantly higher frequency than a satellite's attitude dynamics, we feel that such flight testing verifies the validity of the proposed method for Android-based nanosatellite attitude control system design.