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Getting Started: Model Reference Adaptive Control of Satellite Orientation

This GUI displays a visualization of adaptive control in stabilizing a satellite’s orientation.

Controlling the attitude of a satellite is an important part of ensuring that it can receive signals from the ground and transmit effectively.

The GUI utilizes a simple model for the motion of a satellite:

where : θ represents the satellite attitude angle,is the control input (a net torque on the satellite), and *J* is the satellite’s moment of inertia about its center of mass. The interesting part of this model is that *J* is an unknown quantity – the controller isn’t armed with explicit knowledge of the satellite’s moment of inertia. Therefore, an adaptive PD controller is used to adjust the satellite’s response to input signals. The controller includes a “reference model,” which simulates the ideal response of the satellite to the reference input. The controller then adjusts its proportional gain, P, and derivative gain, D, to attempt to track this reference model output.

To understand how this adaptive controller functions and how its response is affected by the addition of dither, the provided GUI plots time plots of satellite motion and controller coefficients with selectable initial conditions and parameter values.

**Parameter Inputs**

The input parameters are split into four categories. **System parameters** affect the nature of the satellite itself, including its initial angle, its angular velocity, and its actual moment of inertia about its center of mass. **Controller parameters** influence how the controller responds to measurements of the system and its response. The guessed moment of inertia affects the initial values of P and D, while the two adaption rates influence how quickly the controller adjusts P and D to respond to discrepancies between the model and the actual system. **Dither parameters** let the user set the variance of the awgn dither. Finally, **reference signal parameters** let the user choose between several reference signals for the satellite to track and adjust the magnitude and frequency of that reference.

All of these inputs can be set by directly entering them into the text boxes and are automatically limited to reasonable ranges. The dithering parameters can also be adjusted using the corresponding scroll bars. The scroll bar for the dithering amplitude operates on a logarithmic scale. Each parameter can be reset to its default setting by pressing its corresponding *Default* button.

**Outputs**

All outputs will update when the “Run” button is pressed.

The **Reference Signal** plot shows the reference signal that the satellite will attempt to track, which is the sum of the main reference signal and the dither. The **Theta over Time** plot shows the actual attitude of the satellite over time, along with the ideal attitude of the satellite as specified by the model reference. The **P over Time** and **D over Time** plots show the time evolution of the controller parameters. The **Lyapunov over Time** and **Derivative of Lyapunov over Time** plots show the value of the Lyapunov function

and its derivative. With properly chosen   and , this function should demonstrate the system’s global stability by being positive definite and monotonically decreasing.