Autonomous Vehicle Simulation (AVS) Laboratory, University of Colorado

Basilisk Technical Memorandum

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PROPORTIONAL-DERIVATIVE (PD) MRP ATTITUDE FEEDBACK CONTROL

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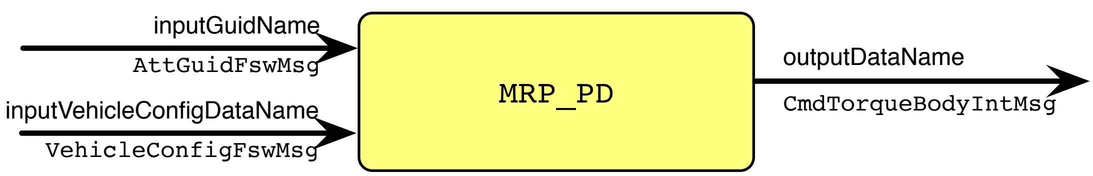

Fig. 1: Illustration of the module input and output messages.

1 Model Description

This attitude feedback module using the MRP feedback control related to the control in section 8.4.1 in Schaub and Junkins.[1]

$$\boldsymbol{L}_r = -K\boldsymbol{\sigma} - [P]\delta\boldsymbol{\omega} + [I](\dot{\boldsymbol{\omega}}_r - [\tilde{\boldsymbol{\omega}}]\boldsymbol{\omega}_r) + [\tilde{\boldsymbol{\omega}}_r]][I]\boldsymbol{\omega} - \boldsymbol{L} \tag{1}$$

Note that this control solution creates an external control torque which must be produced with a cluster of thrusters. No reaction wheel information is used here. Further, the feedback control component is a simple proportional and derivative feedback formulation. As shown in Reference 1, this control can asymptotically track a general reference trajectory given by the reference frame $\mathcal{R}$.

The module input and output messages are illustrated in Figure 1. The guidance message is read in with every time step, while the vehicle configuration message is only read in during the reset function. The single output message contains the commanded body torque vector.

2 Module Functions

- **Compute an external control torque**: The control torque is assumed to be an external control torque
- **Track general attitude trajectory**: The control solution is an asymptotically stabilizing reference trajectory tracking control.

3 Module Assumptions and Limitations

This control assumes the spacecraft is rigid and that the inertia tensor does not vary with time.

4 Test Description and Success Criteria

The unit test for this module is kept as there are no branching code segments to account for different cases. The spacecraft inertia tensor message is setup, as well as a guidance message. The module is then run for a few time steps and the control torque output message compared to a known answer. The simulation only variable is if the known external torque ${}^{\mathcal{B}}\boldsymbol{L}$ is specified, or if the zero default vector is used.

5 Test Parameters

The spacecraft inertia tensor is held fixed. The unit test verifies that the module output torque message vector matches expected values.

Table 2: Error tolerance for each test.

Output Value Tested	Tolerated Error
`torqueRequestBody`	1e-12

6 Test Results

The unit tests are expected to pass.

Table 3: Test results

setExtTorque	Pass/Fail
False	PASSED
True	PASSED

7 User Guide

The following parameters must be set for the module

- `K`: the MRP proportional feedback gain
- `P`: the $\boldsymbol{\omega}$ tracking error proportional feedback gain
- `knownTorquePntB_B`: the known external torque vector ${}^{\mathcal{B}}\boldsymbol{L}$. The default value is a zero vector.

REFERENCES

[1] Hanspeter Schaub and John L. Junkins. *Analytical Mechanics of Space Systems*. AIAA Education Series, Reston, VA, 4th edition, 2018.