Autonomous Vehicle Simulation (AVS) Laboratory, University of Colorado

Basilisk Technical Memorandum

STAR_TRACKER

Rev:	Change Description	By
Draft	Initial document creation	J. Alcorn

Contents

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1 Introduction

The Basilisk star tracker module star_tracker.cpp is responsible for producing sensed Euler parameters from true simulation attitude. Given the true spacecraft structure to inertial attitude as a Modified Rodriguez Parameter (MRP) set, the module outputs an Euler Parameter (EP) set and time stamp. A Gauss-Markov process model is used to add noise to the Euler parameter measurement.

2 `test_star_tracker` Test Description

This test is located in `simulation/sensors/star_tracker/_UnitTest/test_star_tracker.py`. In order to get good coverage of all the aspects of the module, the test is broken up into several parts:

1. <u>Attitude I/O</u> The check validates conversion of a random MRP input to EP output without added noise. The simulation is propagated.

2. <u>Time Stamp I/O</u> The check validates conversion of a random J2000 input to J2000 output. The simulation is propagated to ensure the time stamp progresses.

3. <u>Structure to Body Transformation</u> The check verifies that the module correctly applied the structure to body frame transformation to the attitude coordinate output.

4. <u>Process Noise</u> The check verifies that the Gauss-Markov model applies noise of appropriate mean and standard deviation to the attitude coordinate output. This check does not consider bias random walk.

5. <u>Bias Random Walk Bounds</u> The check verifies that the Gauss-Markov model correctly applies bias random walk to the attitude coordinate output. Specified walk bounds are validated.

3 Test Parameters

This section describes the test input/output for each of the checks. Table 2 shows the input/output parameters for the test. Attitude I/O consists of simply matching the MRP input to EP output. Time Stamp I/O simply echos the J2000 date as passed to SPICE. The T_str2Bdy transformation check involves multiplying the inertial to structure DCM by the specified structure to body DCM. Process noise is verified by converting EP output to a principle rotation vector (PRV) and ensuring the error standard devation does not exceed specified. Walk Bounds are verified by converting output EP to PRV and ensuring the random walk does not exceed the specified walk bounds plus three noise standard deviations.

Table 2: Test I/O.

Test	Input	Expected Output
Attitude I/O	MRP: [-0.3906, -0.5036, 0.4630]^T	EP: [0.2341 -0.4821 -0.6216 0.5714]^T
Time Stamp I/O	J2000: 6129.15171032306	J2000: 6129.15171032306
str2Bdy Transformation	T_str2Bdy: $\begin{bmatrix} 0.0041 & 0.5277 & -0.8494 \\ 0.0794 & -0.8469 & -0.5258 \\ -0.9968 & -0.0654 & -0.0454 \end{bmatrix}$	EP: [0.8911 0.3713 0.0179 0.2603]^T
Process Noise	$\sigma_\gamma = 0.1$	Convert EP to PRV: $\sigma_\gamma = 0.1$
Bias Walk Bounds	$\sigma_{\gamma_i} = 0.01$, $\gamma_{\mathrm{max}_i} = \pm 0.1$	Convert EP to PRV: $\gamma_i < \gamma_{\mathrm{max}_i} + 3\sigma_{\gamma_i}$

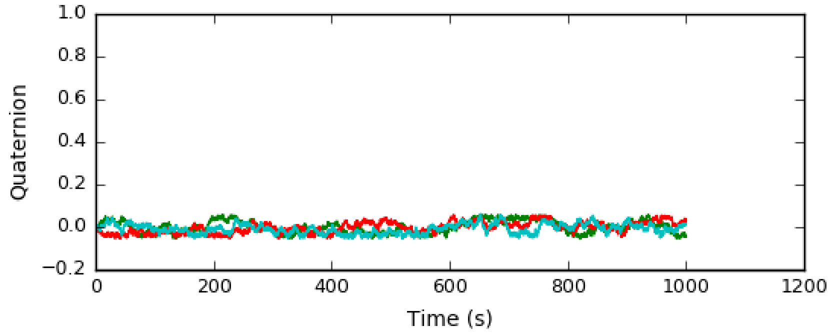

Fig. 1: Module output for the quaternion walk bounds check.

4 Test Results

All checks within test_star_tracker.py passed as expected. Table 3 shows the test results. Figure 1 shows the module output for the quaternion walk bounds check.

Table 3: Test results.

	Attitude I/O	Time Stamp I/O	T_str2Bdy	Process Noise	Bias Walk Bounds
Pass/Fail	Passed	Passed	Passed	Passed	Passed