Autonomous Vehicle Simulation (AVS) Laboratory, University of Colorado

Basilisk Technical Memorandum

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GRAVITY EFFECTOR TEST REPORT

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Scope/Contents

This unit test validates the internal aspects of the Basilisk spherical harmonics gravity effector module `test_gravityDynEffector.py` by comparing module output to expected output. The Basilisk gravity effector module is responsible for calculating the effects of gravity on a spacecraft orbiting a body. It utilizes spherical harmonics for calculation given the gravitation parameter for the body, a reference radius, and the maximum degree of spherical harmonics to be used. The unit test verifies basic set-up, single-body gravitational acceleration, and multi-body gravitational acceleration.

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1 Introduction

The Basilisk gravity effector module (gravityEffector.cpp) is responsible for calculating the effects of gravity on a spacecraft orbiting a body. This unit test contains three tests of increasing complexity that verify input/ouput, single-body calculations, and multi-body calculations.

2 `test_gravityDynEffector` Test Description

This test is located in `SimCode/dynamics/gravityEffector/_UnitTest/test_gravityDynEffector.py`. In order to get good coverage of all the aspects of the module, the test is broken up into three sub-tests:

1. Model Set-up Verification This test verifies, via three checks, that the model is appropriately initialized when called.
    - 1.1 The first check verifies that the normalized coefficient matrix for the spherical harmonics calculations is initialized appropriately as a 3×3 identity matrix.
    - 1.2 The second check verifies that the magnitude of the gravity being calculated is reasonable(i.e. between 9.7 and 9.9 m/s^2).
    - 1.3 The final check ensures that the maximum degrees value is truly acting as a ceiling on the maximum number of degrees being used in the spherical harmonics algorithms. For example, if the maximum degrees value is set to 20, an attempt is made to call the spherical harmonics algorithms with a degrees value of 100 and another attempt is made with a degrees value of 20. The results are compared and should be equal due to the enforcement of the maximum degrees value.
2. Single-Body Gravity Calculations This test compares calculated gravity values around the Earth with ephemeris data from the Hubble telescope. The simulation begins shortly after 0200 UTC May 1, 2012 and carries on for two hours, evaluating the gravitational acceleration at two second intervals.
3. Multi-Body Gravity Calculations This test includes gravity effects from Earth, Mars, Jupiter, and the Sun. Calculations are verified by comparing against ephemeris data from the DAWN mission. The simulation begins at midnight, October 24th, 2008 and carries on for just under 22 minutes, evaluating the gravitational acceleration at two second intervals.

3 Test Parameters

This section summarizes the test parameters for each of the checks.

- Error Tolerance

  There are specific error tolerances for each test. Error tolerances are determined based on whether the test results comparison should be exact or approximate due to integration or other reasons. Error tolerances for each test are summarized in table 2.

Table 2: Error tolerance for each test.

Test	Tolerated Error
Gravity Magnitude (test 1.3)	1.0e-01
Single-Body Gravity	1.0e-04
Multi-Body Gravity	5.0e-04

4 Test Results

All checks within test_gravityDynEffector.py passed as expected. Table 3 shows the test results.

Table 3: Test results.

Test	Pass/Fail	Notes
Setup Test	PASSED	
Single-Body Gravity	PASSED	
Multi-Body Gravity	PASSED	