Autonomous Vehicle Simulation (AVS) Laboratory, University of Colorado

Basilisk Technical Memorandum

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SUNLINE EPHEMERIS HEADING

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Status: Initial Document
Scope/Contents
Module to compute an ephemeris-based sunline heading

Rev	Change Description	By	Date
1.0	Initial Version	J. Martin	20181203
1.1	Small documentation tweaks	H. Schaub	2019-04-24

Contents

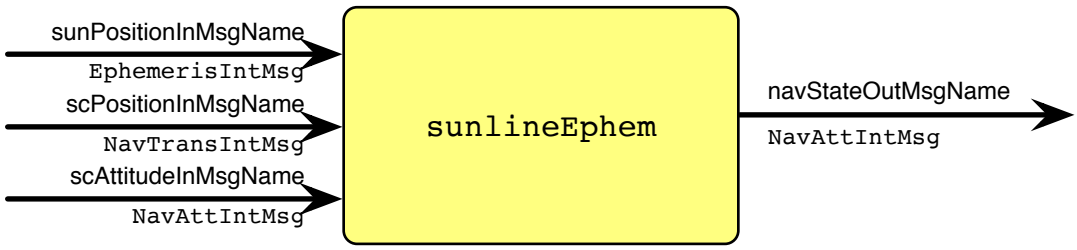

Fig. 1: Sample Figure Inclusion.

1 Model Description

The sunline ephemeris module is responsible for calculating a sunline heading based exclusively on ephemeris data. This provides a estimate for the sun heading without relying of filtering results from the course sun sensors.

The math is straightforward; subtract the position of the sun from the position of the spacecraft, and divide it by its norm, to compute the sun heading in the inertial frame $\hat{\boldsymbol{r}}_{h_N}$.

$$^{\mathcal{N}}\hat{\boldsymbol{r}}_{S/B} = \frac{\boldsymbol{r}_{\text{sun}} - \boldsymbol{r}_{sc}}{|\boldsymbol{r}_{\text{sun}} - \boldsymbol{r}_{sc}|} \tag{1}$$

Rotate the unit vector into the body frame by multiplying it by the appropriate direction cosine matrix defined by the spacecraft's attitude properties, $\boldsymbol{\sigma}$.

$$^{\mathcal{N}}\hat{\boldsymbol{r}}_{S/B} = [BN(\boldsymbol{\sigma})] * {}^{\mathcal{N}}\hat{\boldsymbol{r}}_{S/B} \tag{2}$$

2 Module Functions

- **Calculates Sunline Heading Vector in Body Frame**
- **Outputs NavAttIntMsg**: This module sends out a NavAttIntMsg to be used for initial attitude determination.

3 Module Assumptions and Limitations

This module is exclusively based on ephemeris data. Should the ephemeris data be incorrect, so too will the sunline heading.

4 Test Description and Success Criteria

The unit test configures the sun to sit at the origin, and a spacecraft to be located along each of the coordinate axes, with an orientation 90 degree rotate about the z-axis. The body-frame sun-heading is then computed to confirm that the vectors produced from the module do reflect the unit vector in the body frame pointing to the sun.

5 Test Parameters

The sun was placed at $[0, 0, 0]$ and the spacecraft is tested at each of the unit coordinate axes $[1, 0, 0]$, $[0, 1, 0]$, $[-1, 0, 0]$, etc.

The unit test verify that the module output guidance message vectors match expected values.

Table 2: Error tolerance for each test.

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

6 Test Results

All of the tests passed:

Table 3: Test results

Check	Pass/Fail
1	PASSED
2	PASSED
3	PASSED
4	PASSED
5	PASSED
6	PASSED

7 User Guide

The messages must be set as such:

- `sunlineEphemConfig.scPositionInMsgName = "simple_trans_nav_output"`
- `sunlineEphemConfig.scAttitudeInMsgName = "simple_att_nav_output"`
- `sunlineEphemConfig.sunPositionInMsgName = "sun_position_output"`
- `sunlineEphemConfig.navStateOutMsgName = "sunline_ephem_output"`