Autonomous Vehicle Simulation (AVS) Laboratory, University of Colorado

Basilisk Technical Memorandum

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EPHEMERIS DIFFERENCE MODULE

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Status: First Release
Scope/Contents
This module reads in the position and velocity of multiple orbital bodies and outputs position and velocity of each body relative to a single other orbital body position and velocity.

Rev	Change Description	By	Date
1.0	Initial Release	H. Schaub	2019-03-27

Contents

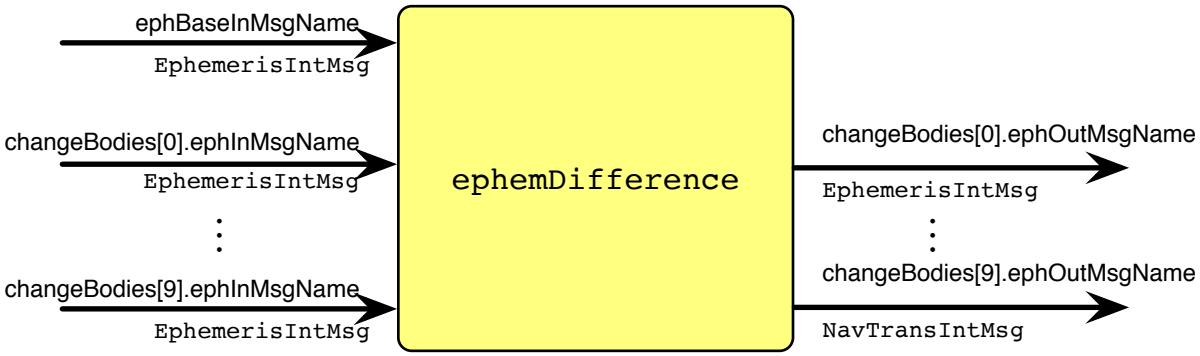

Fig. 1: Illustration of the module input and output messages.

1 Model Description

The purpose of this module is to rebase ephemeris position and velocity vectors relative to another celestial object. All the input messages are assumed to have the vectors taken with respect to the same coordinate frame.

Let $\boldsymbol{r}_{P_i/N}$ be the position vector of the i^{th} ephemeris, while $\boldsymbol{r}_{B/N}$ is the position vector of the bases ephemeris message. The velocity vectors $\boldsymbol{v}_{P_i/N}$ and $\boldsymbol{v}_{B/N}$ are defined similarly. Taking all vectors components with respect to a command inertial frame $\mathcal{N}$, the output is computed using

$$^{\mathcal{N}}\boldsymbol{r}_{P_i/B} = {}^{\mathcal{N}}\boldsymbol{r}_{P_i/N} - {}^{\mathcal{N}}\boldsymbol{r}_{B/N} \tag{1}$$

$$^{\mathcal{N}}\boldsymbol{v}_{P_i/B} = {}^{\mathcal{N}}\boldsymbol{v}_{P_i/N} - {}^{\mathcal{N}}\boldsymbol{v}_{B/N} \tag{2}$$

The number of input messages to consider is determined by searching the `ephInMsgName` names and finding the first zero string where the name was not set.

2 Module Functions

- **Variable input messages**: The user can specify up to `MAX_NUM_CHANGE_BODIES` input messages `ephInMsgName`.

- **Number of messages**: The first zero message string terminates the loop and sets the number of incoming and outgoing messages

3 Module Assumptions and Limitations

The module assumes all vectors are provided with respect to a common coordinate frame.

Only the first n non-empty string names are used to subscribe to the ephemeris input messages. The user must setup the equivalent output messages.

4 Test Description and Success Criteria

The unit test creates input ephemeris messages for Mars, Jupiter and Saturn relative to the sun. The base ephemeris message is created for Earth relative to the sun. The test evaluates the Mars, Jupiter and Saturn position and velocity vectors relative to the Earth. The simulation is run for a single time step to ensure the math is performed correctly.

5 Test Parameters

Test and simulation parameters and inputs go here. Basically, describe your test in the section above, but put any specific numbers or inputs to the tests in this section.

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
r_BdyZero_N	10m
v_BdyZero_N	0.0001 m/s

6 Test Results

The test is expected to pass.

Table 3: Test results

Check	Pass/Fail
Mars	PASSED
Jupiter	PASSED
Saturn	PASSED

7 User Guide

A fixed length array of type `EphemChangeConfig` is setup to contain the input and output message names. The array size is hard coded to `MAX_NUM_CHANGE_BODIES` which is currently set to 10.

To use this module, the user first creates an instance of the `EphemChangeConfig` container to store unique input and output message names.

```
changeBodyMsg = ephem_difference.EphemChangeConfig()
changeBodyMsg.ephInMsgName = 'input_change_body_' + str(i)
changeBodyMsg.ephOutMsgName = 'output_change_body_' + str(i)
```

Next, the container is added to a list of these ephemeris information containers using

```
changeBodyList.append(changeBodyMsg)
```

Finally, the list of these containers is stored in the `ephemDifference` module using

```
ephemDiffConfig.changeBodies = changeBodyList
```