

Autonomous Vehicle Simulation (AVS) Laboratory

AVS-Sim Technical Memorandum

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GUIDANCE MODULE TO PERFORM A SPINNING ABOUT AN ARBITRARY AXIS

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Status: Initial Version
Scope/Contents
Generate the reference attitude trajectory for a general spinning about an arbitrary axis. The spinning is superimposed to a zero reference attitude

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1 Module Input and Output

Table 2 shows the input Configuration Data of the module Single Axis Spin.

Table 2: Input Configuration Data

Name	Type	Length	Description
$\sigma_{R_0/N}$	double []	3	MRP attitude set of the base reference with respect to the inertial frame .
ω_{spin}	double []	3	Angular velocity of the desired spinning reference with respect to the inertial expressed in inertial frame components.

Table 3 shows the Attitude Reference output message of the module Single Axis Spin.

Table 3: Output Attitude Reference Message

Name	Type	Length	Description
$\sigma_{R/N}$	double []	3	MRP attitude set of the reference frame with respect to the inertial frame.
${}^N\omega_{R/N}$	double []	3	Angular rate vector of the reference frame with respect to the inertial expressed in inertial frame components.
${}^N\dot{\omega}_{R/N}$	double []	3	Angular acceleration vector of the reference frame with respect to the inertial expressed in inertial frame components.

2 Introduction

This technical note discusses the mathematics to compute a reference frame \mathcal{R} that superimposes a spinning motion, defined by an input angular vector ω_{spin} , on top of a zero base reference frame $\sigma_{R_0/N} = [0, 0, 0]$, as shown in Figure 1.

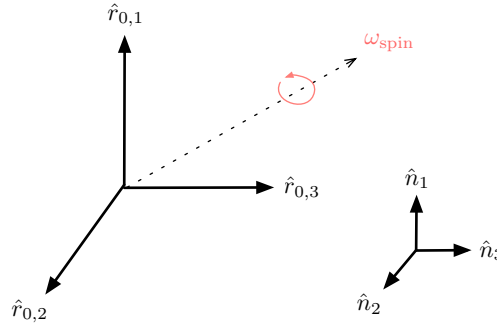


Fig. 1: Illustration of the input base frame $\mathcal{R}_0 : \{\hat{r}_{0,1}, \hat{r}_{0,2}, \hat{r}_{0,3}\}$, the inertial frame $\mathcal{N} : \{\hat{n}_1, \hat{n}_2, \hat{n}_3\}$ and the arbitrary axis about which the spinning is performed at an angular rate $|\omega_{\text{spin}}|$. The orientation of the spinning arbitrary axis is determined by the vectorial part of the input angular vector, while the rate correspond to its magnitude.

3 Reference Frame Generation

Given the inertial nature of the spinning motion, the angular velocity of the desired reference frame is simply the input angular vector ω_{spin} . Since the angular rate is assumed to be constant, the angular acceleration is zero.

$${}^{\mathcal{N}}\omega_{R/N} = \omega_{\text{spin}} \quad (1)$$

$$\dot{\omega}_{R/N} = 0 \quad (2)$$

With respect to the initial attitude reference \mathcal{R}_0 , the orientation of the desired reference \mathcal{R} is defined at each time step through a principal rotation vector:

$$\hat{e}_{\text{spin}} = t_{\text{mnvr}} \omega_{R/N} \quad (3)$$

Where t_{mnvr} is the time elapsed since the start of the spinning maneuver, after the pointing towards the spinning direction had been stabilized. The corresponding Direction Cosine Matrix is computed using the following function from the Rigid Body Kinematics library of Reference 1:

$$[C_{\text{spin}}] = \text{PRV2C}(\hat{e}) \quad (4)$$

The MRP attitude set of the reference \mathcal{R} with respect to the inertial frame \mathcal{N} is then obtained making use of the DCM addition property and several convenient methods from Reference 1:

$$[R_0N] = \text{MRP2C}(\sigma_{R_0N}) \quad (5)$$

$$[RN] = [C_{\text{spin}}][R_0N] \quad (6)$$

$$\sigma_{RN} = \text{C2MRP}([RN]) \quad (7)$$

REFERENCES

- [1] Hanspeter Schaub and John L. Junkins. *Analytical Mechanics of Space Systems*. AIAA Education Series, Reston, VA, 3rd edition, 2014.