*The orientation of the body frame with respect to the reference frame is given by satellite's attitude.*

*This orientation is represented by a proper orthogonal matrix called as rotation matrix or attitude matrix.*

**COURSE I: Kinematics: Describing the Motion of Spacecraft**

**1. Performed Attitude Method:**

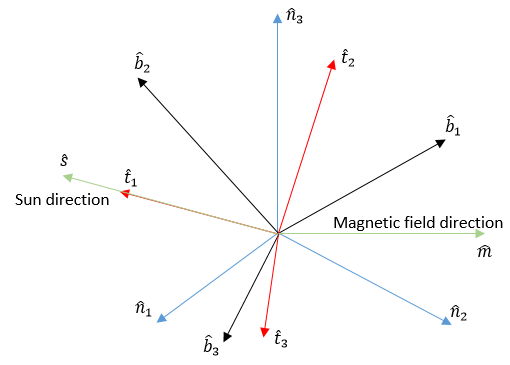
+ A minimum of three coordinates is required to describe the relative angular displacement between two reference frames.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter-  ization | Dimen-sion | Attitude Matrix | Kinematic Equations | Singularities | Constraints |
| DCM | 9 |  |  | None |  |
| Euler Angles | 3 |  |  | Symmetric set:  Asymmetrix set: | None |
| Quaternions | 4 |  |  | None |  |
| CRP | 3 |  |  |  | None |
| MRP | 3 |  |  |  | None |

**2. Attitude Determination:**

+ It needs a minimum of two observation vectors to determine the three dimensional orientation.

* *TRIAD Method:*



+ Input: 2 direction vectors (Sun, Earth, Magnetic field direction, Stars, Moon, …).

+ Output: DCM from Inertial frame to Body fixed frame.

+ Advantage: Easy to operate and calculate.

+ Disadvantage: Exist case that is 2 vectors parallel each other.

* *Wahba’s Problem:*

+ Evaluate the measurements by loss function:

* *Devenport’s q-Method:*

+ Input: 2 direction vectors (Sun, Earth, Magnetic field direction, Stars, Moon, …).

+ Output: A quaternions is eigenvector corresponding the largest eigenvalue of matrix.

+ Advantage: Minimize the loss function J.

+ Disadvantage: Hard to find eigenvalues and eigenvector of matrix.

* *QUEST Method:*

+ Input: 2 direction vectors (Sun, Earth, Magnetic field direction, Stars, Moon, …).

+ Output: A CRP vector corresponding the optimal eigenvalue of matrix.

+ Advantage:

* It uses a classic Newton-Raphson to find optimal eigenvalue. This allows us to avoid the numerically intensive eigenvalue problem.
* It introduces CRP vector that is easier to calculate a matrix.

+ Disadvantage: optimal eigenvalue is a approximate value, therefore accuracy of measurements is lower than q-Method.

**COURSE II: Kinetics: Studying Spacecraft Motion**

**1. Rigid Body Dynamics:**

**+** Total Energy:

+ Angular Momentum:

+ Equations of Motion:

* Euler’s Equation:
* Euler’s rotational equations of motion:

**COURSE III: Control of Nonlinear Spacecraft Attitude Motion**