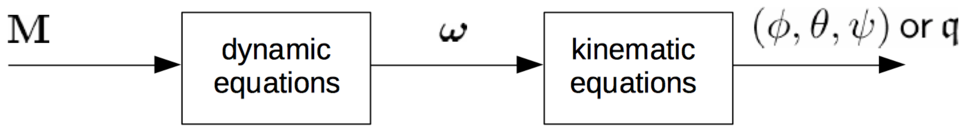
Nonlinear control and aerospace applications - Lab session 6



Exercise 1

Consider a rigid body with inertia matrix $\mathbf{J} = \mathrm{diag}(937.5, 833.3, 270.8)$ kg m^2.

1. For this body, implement in Simulink the block diagram shown in the figure, where:
   - "dynamic equations block": Euler equation
   - "kinematic equations block": quaternion kinematic equations
   - $\mathbf{M}$: moment applied to the body
   - $\boldsymbol{\omega}$: body angular velocity
   - $\mathfrak{q}$: output quaternion.

   The main blocks for this implementation can be found in the "lib_rotations" library.

2. Suppose the following:
   - initial conditions: $\mathbf{x}(0) = (\mathfrak{q}(0), \boldsymbol{\omega}(0))$, $\mathfrak{q}(0) = (1, 0, 0, 0)$, $\boldsymbol{\omega}(0) = (1, 0.1, 0)$ rad/s
   - input moment: $\mathbf{M} = (0, 0, 0)$ Nm
   - simulation time: 50 s.

   Perform a simulation of the simulink model and plot the obtained quaternion signals (the "animation_rot" function can also be used, directly implemented in Simulink).

3. Repeat Step 2, considering different initial conditions and different input signals (try also with non-constant input signals).

4. Convert the obtained quaternion signals into the corresponding Euler angle signals, for the Tait-Bryan 321 and proper Euler 313 rotations.

Exercise 2

1. Repeat Steps 1-3 of Exercise 1, with:
   - "kinematic equations block": Tait-Bryan 321 kinematic equations (choose non-singular initial conditions)
   - (ϕ, θ, ψ): output Euler angles.

2. Convert the obtained Euler angle signals into the corresponding quaternion signals. Compare the obtained results with those obtained in Steps 2-3 of Exercise 1.

Exercise 3

1. Repeat Steps 1-3 of Exercise 1, with:
   - "kinematic equations block": proper Euler 313 kinematic equations (choose non-singular initial conditions)
   - (ϕ, θ, ψ): output Euler angles.

2. Convert the obtained Euler angle signals into the corresponding quaternion signals. Compare the obtained results with those obtained in Steps 2-3 of Exercise 1.