Dynamic Model and Parameters

This report describes the equations of motion and dynamic models used by the Coriolis SIH for quadrotor X as well as the QGroundControl parameters associated with it.

This model assumes a North-East-Down (NED) inertial reference frame $\mathcal{F}_I$ as well as a Front-Right-Down body frame $\mathcal{F}_B$ attached to the center of mass (CM) of the vehicle.

Equations of motion

The equations of motion of a rigid body are given by

$\dot{p}_I = v_I$	Inertial position
$\dot{v}_I = \frac{1}{m}(W_I + F_{a,I} + C_{IB}(q)\ T_B)$	Inertial velocity, conservation of linear momentum
$\dot{q} = \frac{1}{2} q \otimes \omega_B$	Quaternion (attitude)
$\dot{\omega}_B = I^{-1}(M_{t,B} + M_{a,B} - \omega_B \times I\omega_B)$	Body rates, conservation of angular momentum

q is the quaternion used for the representation of the attitude. The Direct Cosine Matrix (DCM) C_{IB} can be obtained from q. It allows to perform transformation from the body to inertial frame.

The inertia matrix is assumed constant, so its inversion is computed once. The inertia is a 3x3 matrix composed of six (repeated) entries

$I = [[I_{xx}, I_{xy}, I_{xz}]^T, [I_{xy}, I_{yy}, I_{yz}]^T, [I_{xz}, I_{yz}, I_{zz}]^T]$

Weight force

The weight force in the inertial frame is a constant given by

$W_I = (0; 0; mg)$

where m is the mass in kg and $g = 9.81\ [m/s^2]$

Aerodynamic forces

The aerodynamic forces are modeled as a first order drag in order to stop the vehicle in absence of horizontal thrust.

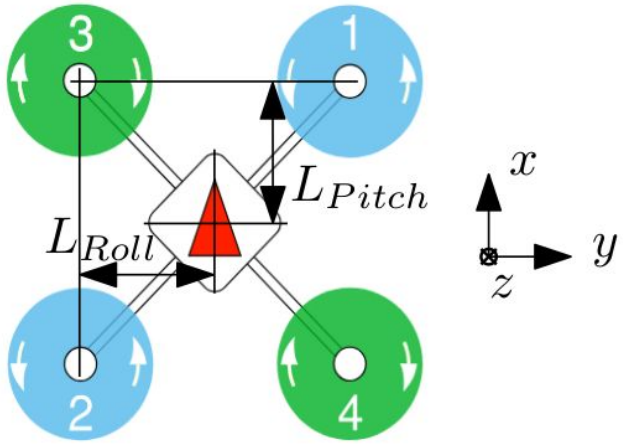
$F_{a,I} = -K_{DV}\ v_I$

Thruster force

The quadrotor is equipped with 4 thrusters, that produce forces T1 to T4 pulling the vehicle upward (opposite to z axis)

$T_B = [0; 0; -(T_1 + T_2 + T_3 + T_4)]$

Thruster moments



The quad thrusters produce moments in the body frame as

$$M_{t,Bx} = L_{Roll}(-T_1 + T_2 + T_3 - T_4)$$
$$M_{t,By} = L_{Pitch}(T_1 - T_2 + T_3 - T_4)$$
$$M_{t,Bz} = Q_1 + Q_2 - Q_3 - Q_4$$

Where L_{Roll} is the arm length generating the rolling moment, i.e. distance from the left motors to the CM, and L_{Pitch} is the arm length generating the pitching moment, i.e. the distance from the front motors to the CM.

Aerodynamic Moments

The aerodynamic moments are modeled as a first order drag moments to stop the vehicle rotation in absence of thruster moments.

$$M_{a,B} = -K_{D\omega}\,\omega_B$$

QGroundControl Parameters

All the SIH parameters start by “SIH_”, so they can be sorted out easily when searching them

Name	Type	Description	Default	Units
SIH_MASS	Float	vehicle mass	1.0	kg
SIH_IXX	Float	vehicle inertia term about x axis	0.025	$kg \cdot m^2$
SIH_IYY	Float	vehicle inertia term about y axis	0.025	$kg \cdot m^2$
SIH_IZZ	Float	vehicle inertia term about z axis	0.035	$kg \cdot m^2$
SIH_IXY	Float	vehicle inertia cross term x and y	0.0	$kg \cdot m^2$
SIH_IXZ	Float	vehicle inertia cross term x and z	0.0	$kg \cdot m^2$
SIH_IYZ	Float	vehicle inertia cross term y and z	0.0	$kg \cdot m^2$
SIH_T_MAX	Float	maximum thrust of one propeller	5.0	N
SIH_Q_MAX	Float	maximum torque of one propeller	0.1	Nm
SIH_L_ROLL	Float	arm length generating the rolling moment	0.2	m
SIH_L_PITCH	Float	arm length generating the pitching moment	0.2	m
SIH_KDV	Float	First order drag coefficient	1.0	$N/(m/s)$
SIH_KDW	Float	First order angular damper coefficient	0.025	$Nm/(rad/s)$

The following parameters are related to the initial location and if modified should be coherent among each others. i.e. the magnetic field should correspond to the magnetic field present at the given latitude and longitude.

Name	Type	Description	Default	Units
SIH_LAT0	INT32	Initial geodetic latitude with 7 digits	454671160	$10^{-7}\ deg$
SIH_LON0	INT32	Initial geodetic longitude with 7 digits	-737578370	$10^{-7}\ deg$
SIH_H0	Float	Ground altitude at this location	32.34	m
SIH_MU_X	Float	North magnetic field at this location	0.2903	G

SIH_MU_Y	Float	East magnetic field at this location	-0.0832	G
SIH_MU_Z	Float	Down magnetic field at this location	0.9500	G