

Attitude

Model

$$\begin{aligned} \dot{\mathbf{q}} &= \frac{1}{2} \boldsymbol{\mathbf{q}} \otimes \begin{pmatrix} 0 \\ \boldsymbol{\omega} \end{pmatrix} \\ \dot{\boldsymbol{\omega}} &= \boldsymbol{\Gamma}_n \mathbf{n} + \boldsymbol{\Gamma}_u \mathbf{u} - \mathbf{I}^{-1} \left(\boldsymbol{\omega} \times \mathbf{I} \boldsymbol{\omega} \right) \end{aligned}$$
 There are 10 system states: $\mathbf{x} = \begin{pmatrix} q_0 & q_1 & q_2 & q_3 & \omega_x & \omega_y & \omega_z & n_x & n_y & n_z \end{pmatrix}^T \in \mathbb{R}^{10 \times 1}$

- $\boldsymbol{\mathbf{q}}$ is the orientation of the drone, expressed as a unit quaternion.
- $\boldsymbol{\omega}$ is the angular velocity of the drone.
- \mathbf{n} is the speed of the torque motors.

The input to the system is the control signal to the three torque motors: $\mathbf{u} = \begin{pmatrix} u_x & u_y & u_z \end{pmatrix}^T \in \mathbb{R}^{3 \times 1}$ The output (measurements) of the system are the orientation and the angular velocity: $\mathbf{y} = \begin{pmatrix} q_0 & q_1 & q_2 & q_3 & \omega_x & \omega_y & \omega_z \end{pmatrix}^T \in \mathbb{R}^{7 \times 1}$ $\boldsymbol{\Gamma}_n$ and $\boldsymbol{\Gamma}_u$ are first order approximations of the motor torque in function of the motor speed and control signal.

Linearisation

Controller

Linear Quadratic Regulator $\mathbf{Q} = \begin{pmatrix} 1.4e+02 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1.4e+02 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2.4e+02 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.15 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.15 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.041 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1e-10 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1e-10 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1e-10 & 0 \end{pmatrix}$ $\mathbf{R} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

Bias rejection

$$\begin{pmatrix} \mathbf{x}_{k+1} \\ \mathbf{d}_{k+1} \end{pmatrix} = \begin{pmatrix} \mathbf{A} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_6 \end{pmatrix} \begin{pmatrix} \mathbf{x}_k \\ \mathbf{d}_k \end{pmatrix} + \begin{pmatrix} \mathbf{B} \\ \mathbf{0} \end{pmatrix} \mathbf{u}_k + \begin{pmatrix} \mathbf{L}_9 & \mathbf{B} \\ \mathbf{0} & \mathbf{0} \end{pmatrix} \begin{pmatrix} \Delta \mathbf{x} \\ \Delta \mathbf{u} \end{pmatrix} + \begin{pmatrix} \mathbf{C} & \mathbf{I}_6 \end{pmatrix} \begin{pmatrix} \mathbf{x}_k \\ \mathbf{d}_k \end{pmatrix} + \mathbf{D} \mathbf{u}_k + \mathbf{v}$$

Vragen

1. Bias rejection attitude controller
2. Integral controller attitude controller
3. Flippen observer als yaw > 90°
4. SSH is traag
5. SSH fingerprint verandert heel de tijd
6. PWM limits: multiple defines
7. Router board bevestigen op de drone
8. Calibratie wanneer thrust geclamped wordt
9. Als de controller wegvalt, moet de drone stoppen!

To do

1. ✓ Bias rejection attitude controller
2. ✓ Clamp thrust to 80%
3. ✓ Vliegen RC attitude + filmpje
4. ✓ Vliegen met altitude + filmpje
5. ✓ Schema controllers/observers afwerken
6. ✓ Montage GA
7. ✓ Blender animation
8. Keep q_0 positive (slide 135)
9. ✓ Observer reset als thrust 0
10. Mousse IMU
11. When switching from altitude to attitude, gradually change thrust



