ANC

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Attitude

Model

$$\begin{align} \boldsymbol{\dot{q}} &= \frac{1}{2} \boldsymbol{q} \otimes \begin{pmatrix} 0 \\ \vec{\omega} \end{pmatrix} \\ \dot{\vec{\omega}} &= \Gamma_n \vec{n} + \Gamma_u \vec{u} - I^{-1} \left(\vec{\omega} \times I \vec{\omega} \right) \\ \dot{\vec{n}} &= k_2 \left(k_1 \vec{u} - \vec{n}\right) \end{align}$$

There are 10 system states: $x = \begin{pmatrix} q_0 & q_1 & q_2 & q_3 & \omega_x & \omega_y & \omega_z & n_x & n_y & n_x \end{pmatrix}^T \in \mathbb{R}^{10\times1}$

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

The input to the system is the control signal to the three torque motors: $u = \begin{pmatrix} u_x & u_y & u_z \end{pmatrix}^T \in \mathbb{R}^{3\times1}$ The output (measurements) of the system are the orientation and the angular velocity: $y = \begin{pmatrix} q_0 & q_1 & q_2 & q_3 & \omega_x & \omega_y & \omega_z \end{pmatrix}^T \in \mathbb{R}^{7\times1}$ Γ_n and Γ_u are first order approximations of the motor torque in function of the motor speed and control signal.

Linearisation

Controller

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

Bias rejection

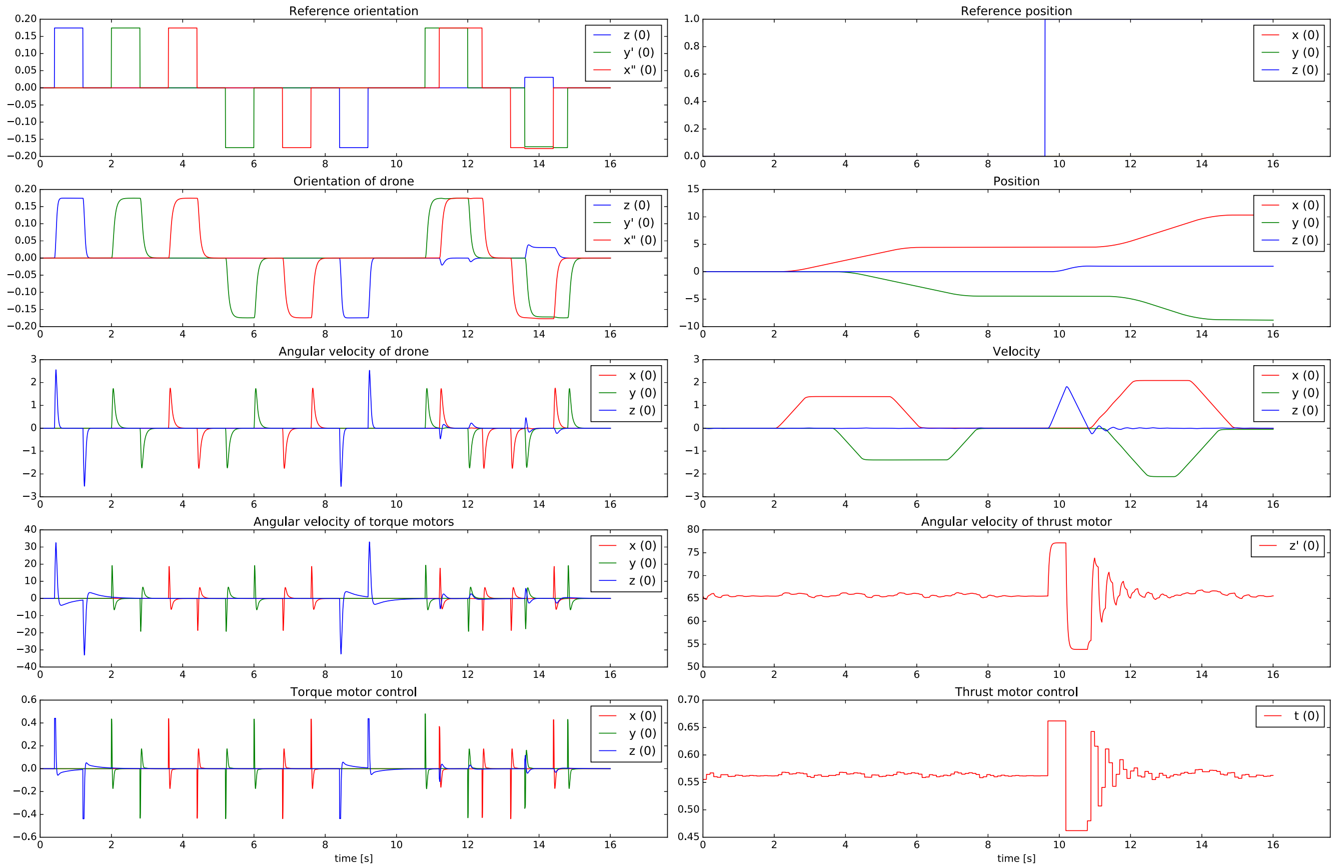
$$\begin{pmatrix}x_{k+1} \\ d_{k+1} \end{pmatrix} = \begin{pmatrix} A & 0 \\ 0 & I_6 \end{pmatrix} \begin{pmatrix} x_k \\ d_k \end{pmatrix} + \begin{pmatrix} B \\ 0 \end{pmatrix} u_k + \begin{pmatrix} I_9 & B & 0 \\ 0 & 0 & I_6 \end{pmatrix} \begin{pmatrix} \delta_x \\ \delta_u \\ \delta_d \end{pmatrix} \\ y_k = \begin{pmatrix} C & I_6 \end{pmatrix} \begin{pmatrix}x_k \\ d_k \end{pmatrix} + D u_k + v$$

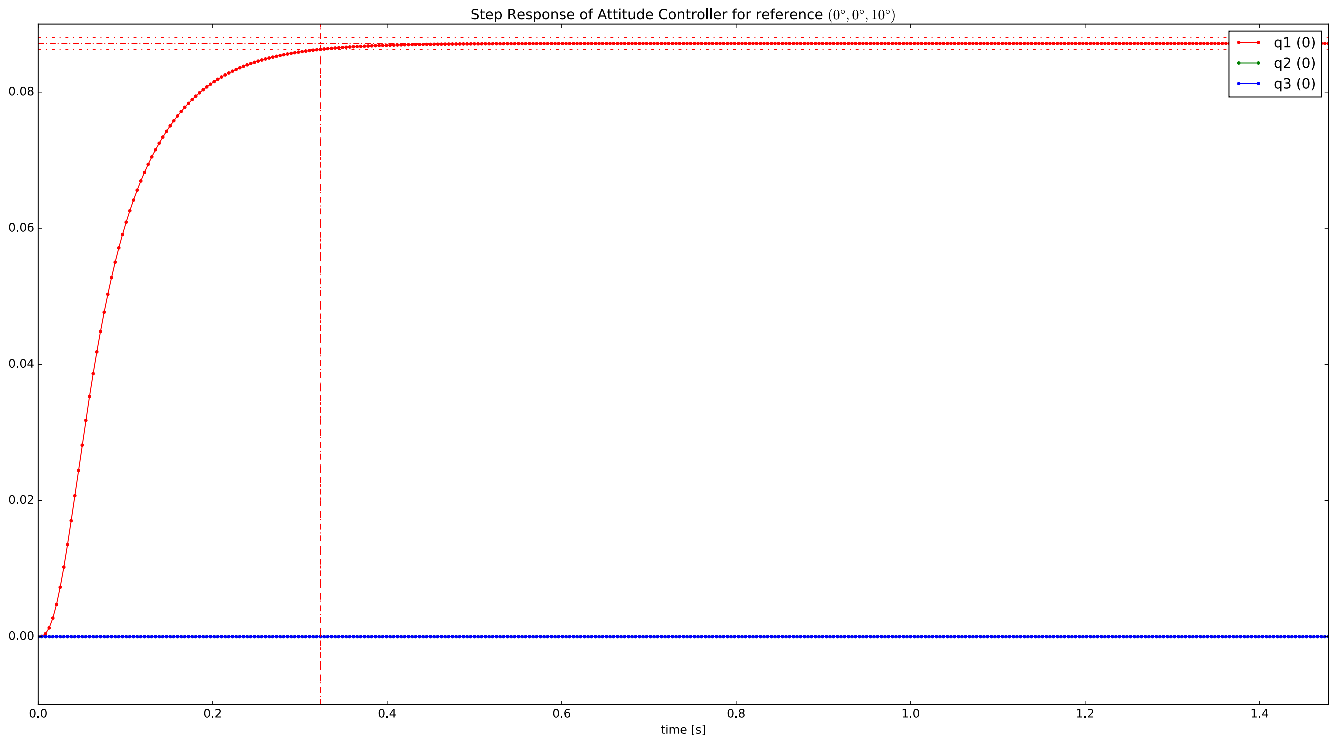
Vragen

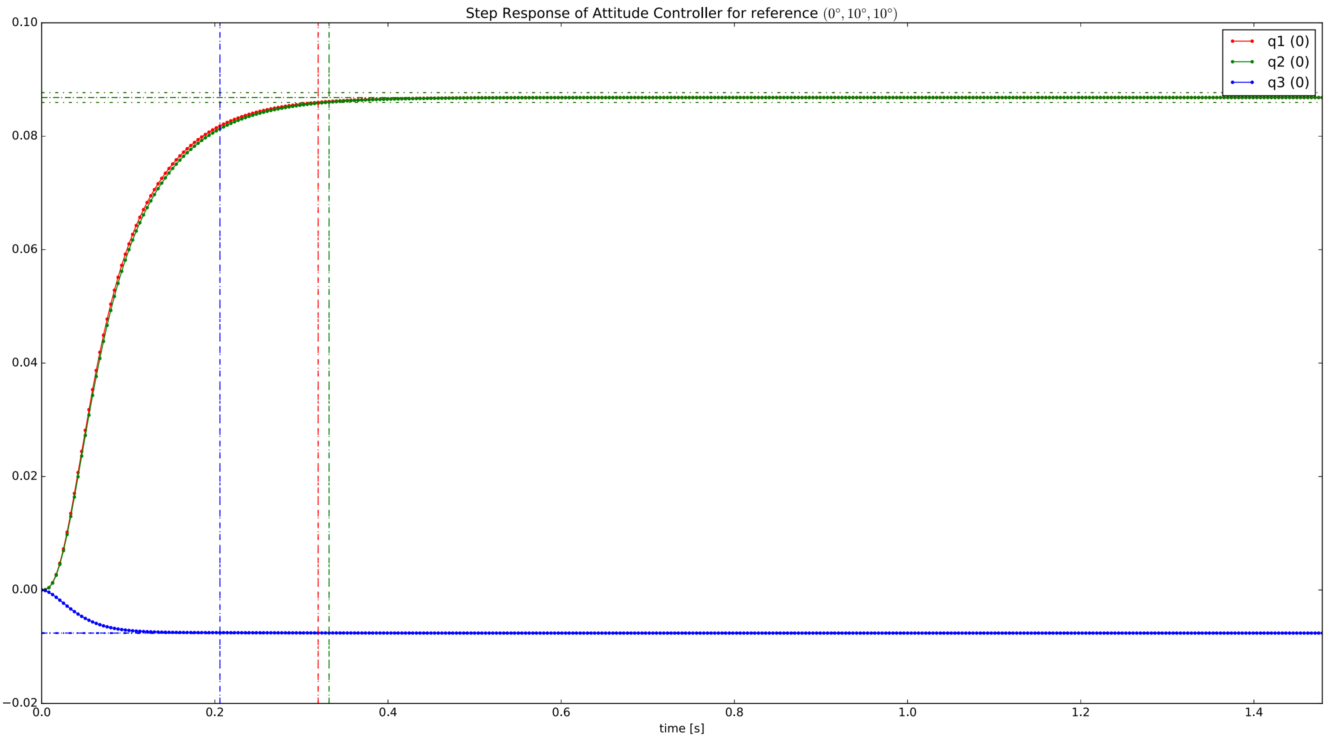
1. Bias rejection attitude controller
2. Integral controller attitude controller
3. Flippen observer als yaw > 90°
4. SSH is traag
5. SSH fingerprint verandert heel de tijd
6. PWM limits: multiple defines
7. Router board bevestigen op de drone
8. Calibratie wanneer thrust geclamped wordt
9. Als de controller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


Reference orientation
z (0)
y' (0)
x" (0)
Reference position
x (0)
y (0)
z (0)
Orientation of drone
z (0)
y' (0)
x" (0)
Position
x (0)
y (0)
z (0)
Angular velocity of drone
x (0)
y (0)
z (0)
Velocity
x (0)
y (0)
z (0)
Angular velocity of torque motors
x (0)
y (0)
z (0)
Angular velocity of thrust motor
z' (0)
Torque motor control
x (0)
y (0)
z (0)
Thrust motor control
t (0)
time [s]
time [s]


Step Response of Attitude Controller for reference $(0°, 0°, 10°)$
q1 (0)
q2 (0)
q3 (0)
time [s]



Processing math: 100%