

Attitude and Position Control of a Quadcopter in a Networked Distributed System



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Agenda



Introduction

Model

- Attitude Model
- Translational Model
- Linearization

Network

Introduction

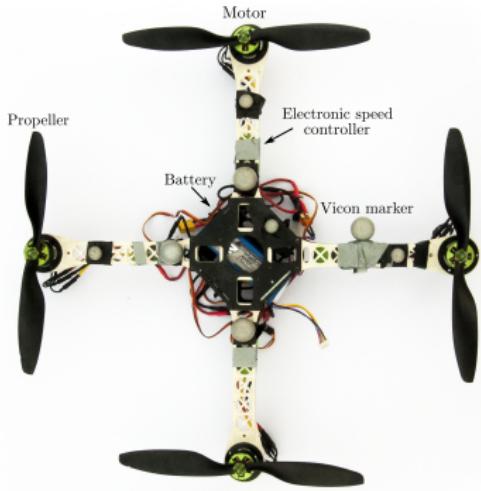


Introduction



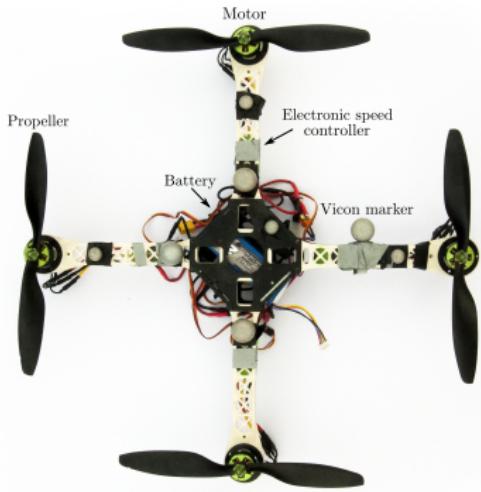
Introduction

Prototype



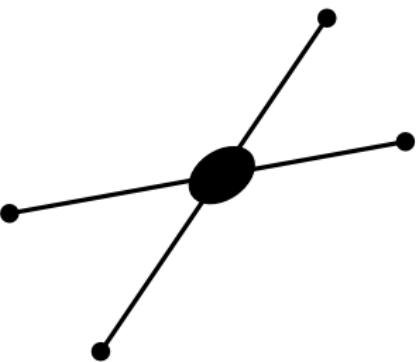
Introduction

Prototype



Model

Attitude Model

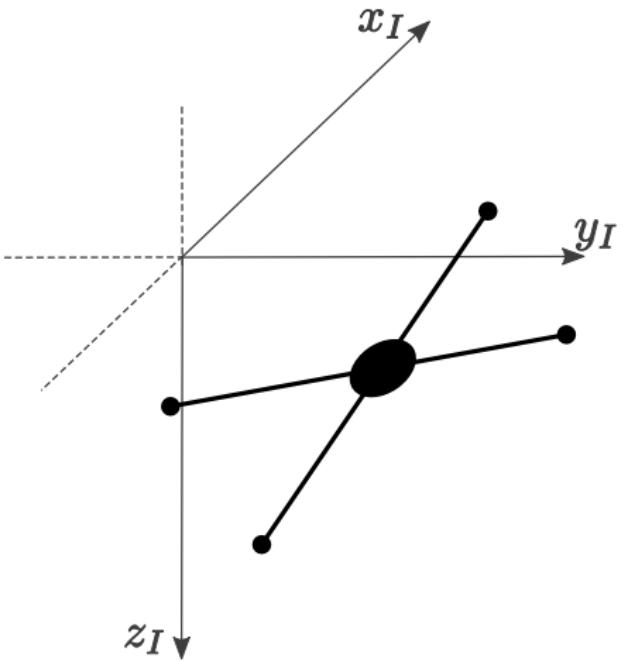


Model

Attitude Model

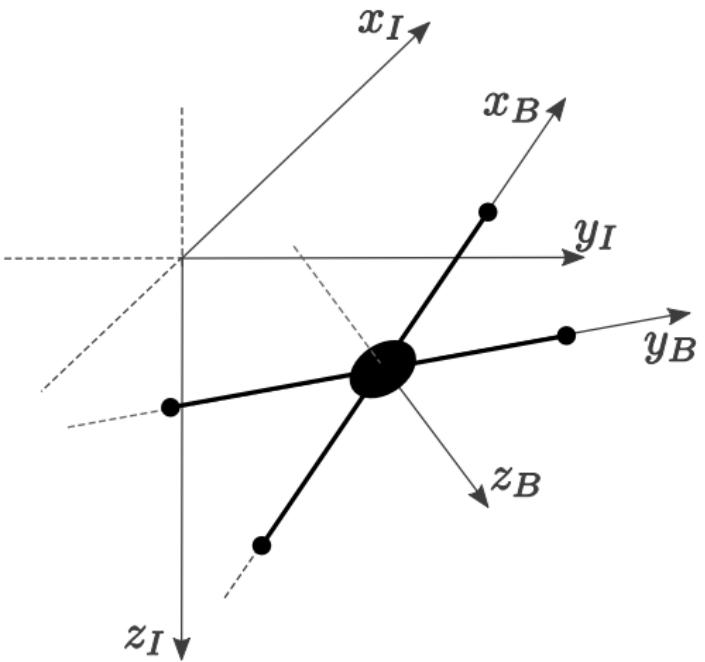


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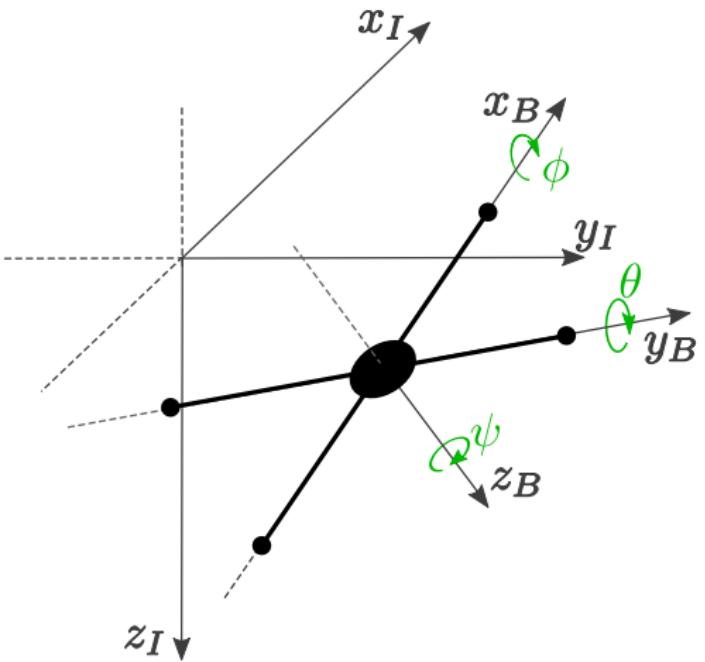
Model

Attitude Model



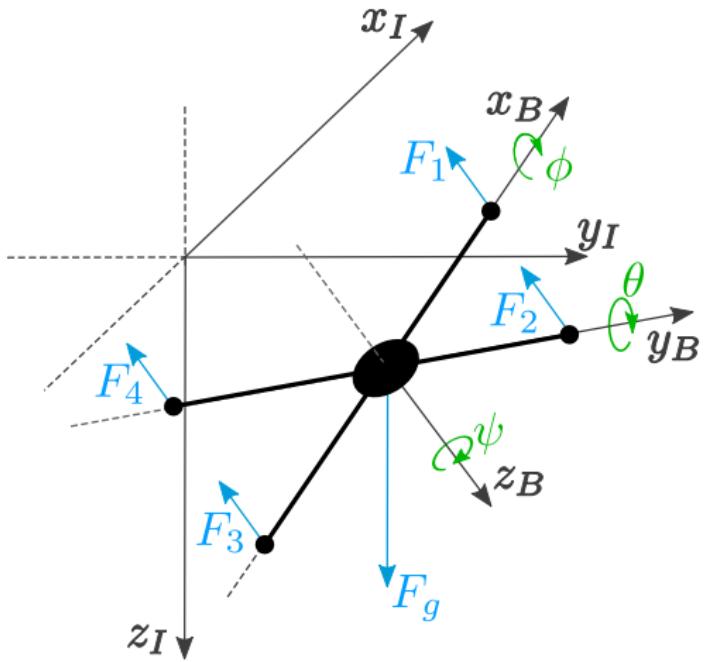
Model

Attitude Model



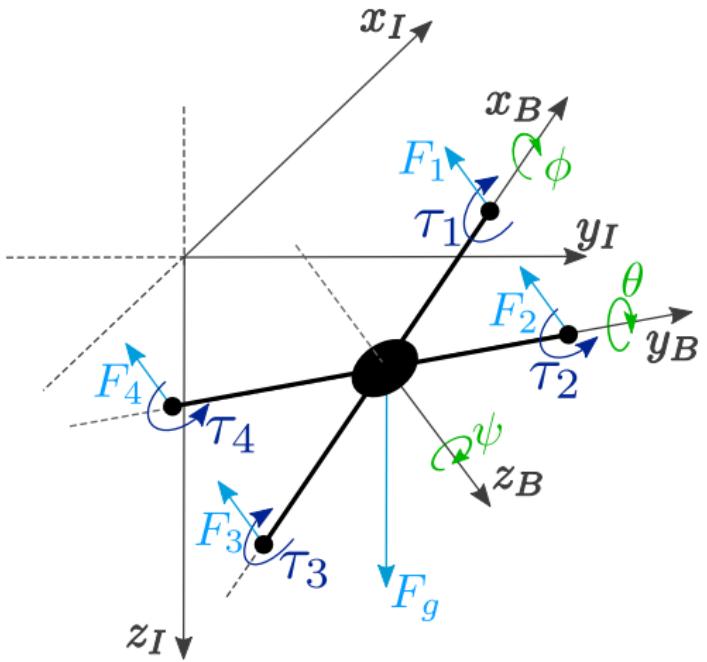
Model

Attitude Model



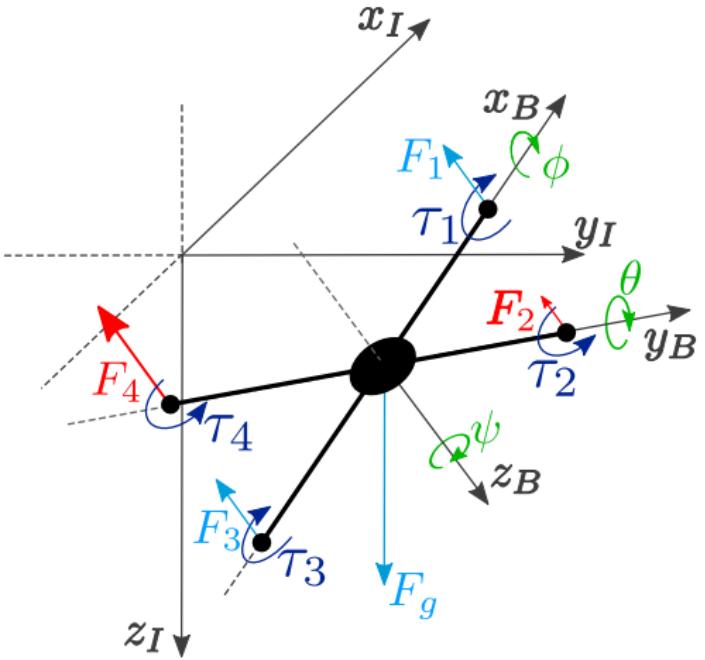
Model

Attitude Model



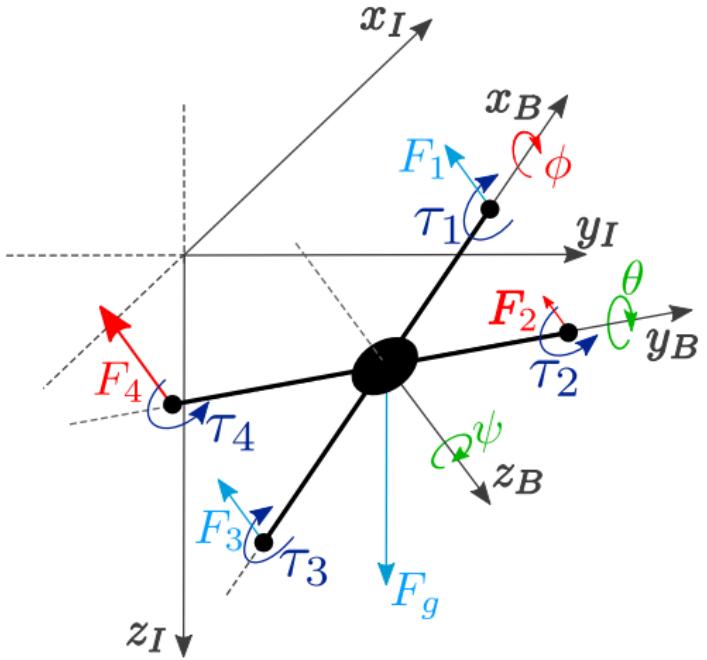
Model

Attitude Model



Model

Attitude Model



Model

Attitude Model



- ▶ Dynamic Equations

Model

Attitude Model



- ▶ Dynamic Equations

$$J\alpha = \sum \tau$$

Model

Attitude Model



► Dynamic Equations

$$J\alpha = \sum \tau$$

$$J_x \ddot{\phi} = (F_4 - F_2)L$$

$$J_y \ddot{\theta} = (F_1 - F_3)L$$

$$J_z \ddot{\psi} = \tau_1 - \tau_2 + \tau_3 - \tau_4$$

Model

Attitude Model



► Dynamic Equations

$$J\alpha = \sum \tau$$

$$J_x \ddot{\phi} = (F_4 - F_2)L$$

$$J_y \ddot{\theta} = (F_1 - F_3)L$$

$$J_z \ddot{\psi} = \tau_1 - \tau_2 + \tau_3 - \tau_4$$

$$J_x \ddot{\phi} = k_{\text{th}}(\omega_4^2 - \omega_2^2)L$$

$$J_y \ddot{\theta} = k_{\text{th}}(\omega_1^2 - \omega_3^2)L$$

$$J_z \ddot{\psi} = k_d(\omega_1^2 - \omega_2^2 + \omega_3^2 - \omega_4^2)$$

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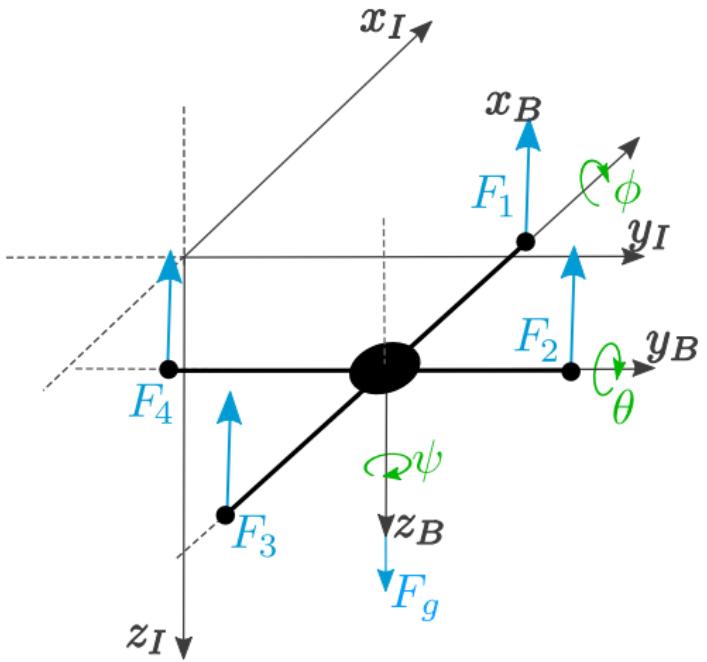
Network

Model

Translational Model

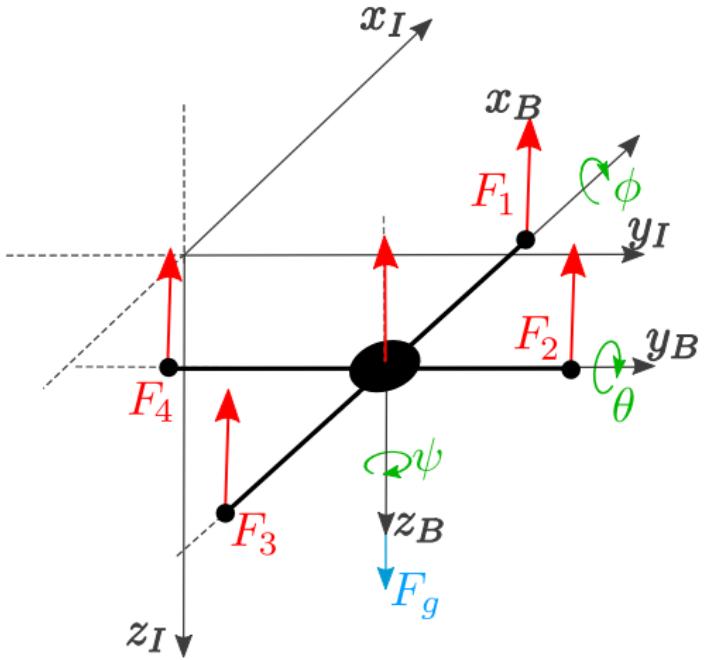


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Model

Translational Model

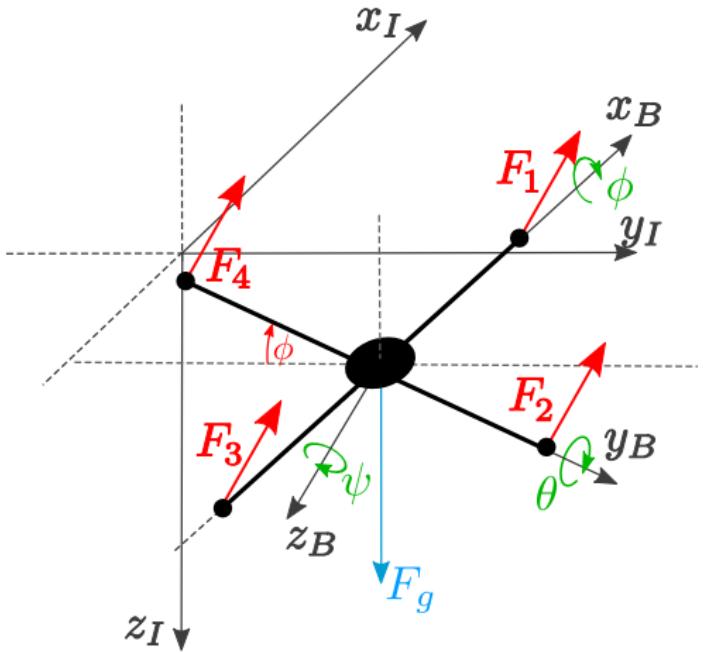


Model

Translational Model

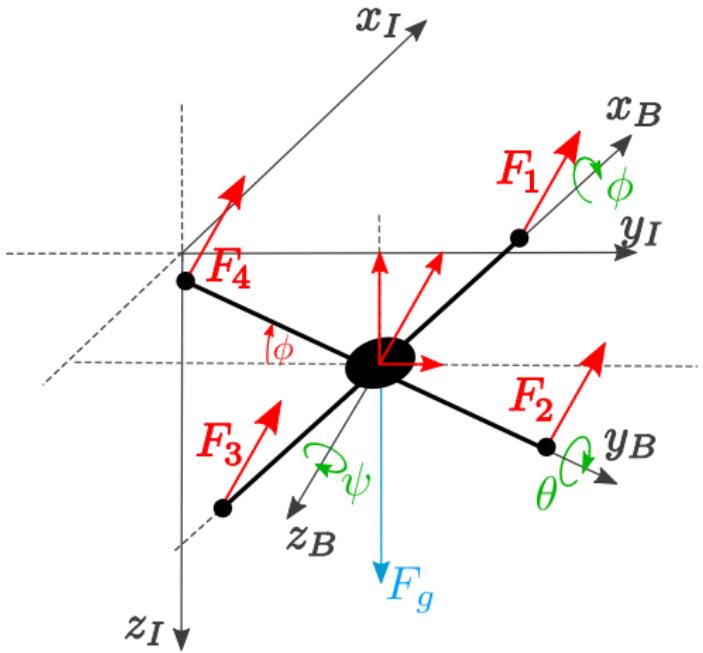


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Model

Translational Model



Translational Model



- ▶ Rotation Matrix

$$R = R_Z R_Y R_X$$

$$v_I = R v_B$$

Model

Translational Model



- ▶ Dynamic Equations

Model

Translational Model



- ▶ Dynamic Equations

$$ma = \sum F$$

Model

Translational Model



► Dynamic Equations

$$ma = \sum F$$

$$m\ddot{x}_I = -(F_1 + F_2 + F_3 + F_4)(\cos \phi \sin \theta \cos \psi + \sin \phi \sin \psi)$$

$$m\ddot{y}_I = -(F_1 + F_2 + F_3 + F_4)(\cos \phi \sin \theta \sin \psi - \sin \phi \cos \psi)$$

$$m\ddot{z}_I = F_g - (F_1 + F_2 + F_3 + F_4) \cos \phi \cos \theta$$

Model

Translational Model



► Dynamic Equations

$$ma = \sum F$$

$$m\ddot{x}_I = -(F_1 + F_2 + F_3 + F_4)(\cos \phi \sin \theta \cos \psi + \sin \phi \sin \psi)$$

$$m\ddot{y}_I = -(F_1 + F_2 + F_3 + F_4)(\cos \phi \sin \theta \sin \psi - \sin \phi \cos \psi)$$

$$m\ddot{z}_I = F_g - (F_1 + F_2 + F_3 + F_4) \cos \phi \cos \theta$$

$$m\ddot{x}_I = -k_{th}(\omega_1^2 + \omega_2^2 + \omega_3^2 + \omega_4^2)(\cos \phi \sin \theta \cos \psi + \sin \phi \sin \psi)$$

$$m\ddot{y}_I = -k_{th}(\omega_1^2 + \omega_2^2 + \omega_3^2 + \omega_4^2)(\cos \phi \sin \theta \sin \psi - \sin \phi \cos \psi)$$

$$m\ddot{z}_I = F_g - k_{th}(\omega_1^2 + \omega_2^2 + \omega_3^2 + \omega_4^2) \cos \phi \cos \theta$$

Model Linearization



Model

Linearization



$$m\ddot{\bar{z}}_I = F_g - k_{th}(\bar{\omega}_1^2 + \bar{\omega}_2^2 + \bar{\omega}_3^2 + \bar{\omega}_4^2) \cos \bar{\phi} \cos \bar{\theta}$$

Model

Linearization



$$m\ddot{\bar{z}}_I = F_g - k_{th}(\bar{\omega}_1^2 + \bar{\omega}_2^2 + \bar{\omega}_3^2 + \bar{\omega}_4^2) \cos \bar{\phi} \cos \bar{\theta}$$

$$\bar{\omega}_i = \sqrt{\frac{F_g}{4k_{th}}}$$

Model Linearization



Network



Network



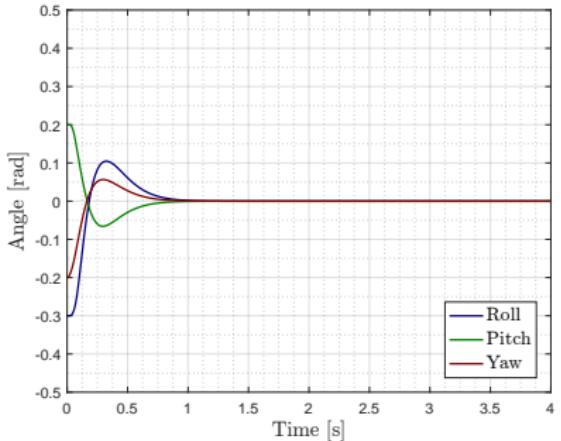
- ▶ Delay
- ▶ Missed packets

Network

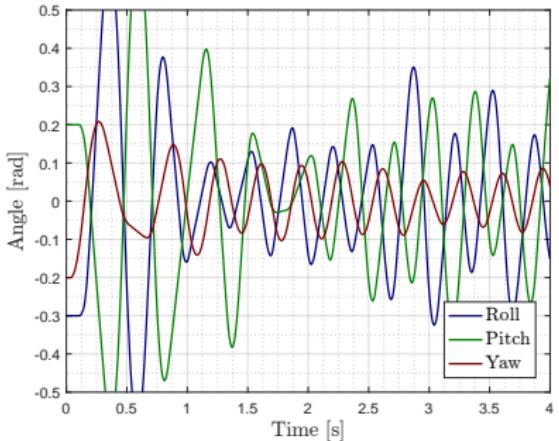


- ▶ Delay
- ▶ Missed packets

Network



Control design only taking the model into account



Same controller with the effect of the network

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