

## 1 Definiendo los estados

$$X = \begin{bmatrix} x \\ y \\ \dot{x} \\ \dot{y} \end{bmatrix} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix}$$

$$U = \begin{bmatrix} roll \\ pitch \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

## 2 Ecuaciones de la dinamica

$$\begin{aligned} \ddot{x} &= 0.29 * U_4 * (\sin(roll) * \sin(yaw) + \cos(roll) * \cos(yaw) * \sin(pitch)) \\ \ddot{y} &= -0.29 * U_4 * (\cos(yaw) * \sin(roll) - 1.0 * \cos(roll) * \sin(pitch) * \sin(yaw)) \end{aligned}$$

## 3 Espacio estados final

$$\dot{x}_1 = x_3$$

$$\dot{x}_2 = x_4$$

$$\dot{x}_3 = 0.29 * d_1 * (\sin(u_1) * \sin(d_2) + \cos(u_1) * \cos(d_2) * \sin(u_2))$$

$$\dot{x}_4 = 0.29 * d_1 * (-\cos(d_2) * \sin(u_1) + 1.0 * \cos(u_1) * \sin(u_2) * \sin(d_2))$$

$$\dot{y}_1 = x_1$$

$$\dot{y}_2 = x_2$$

Transformando variables

$$\dot{x}_1 = x_3$$

$$\dot{x}_2 = x_4$$

$$\dot{x}_3 = 0.29 * d_1 * (u_1 * \sin(d_2) + \cos(d_2) * u_2)$$

$$\dot{x}_4 = 0.29 * d_1 * (-\cos(d_2) * u_1 + u_2 * \sin(d_2))$$

## 4 Input Output

$$\begin{aligned} f &= \begin{bmatrix} L_f^2 y_1 \\ L_f^2 y_2 \end{bmatrix} = \begin{bmatrix} L_f^2 x_1 \\ L_f^2 x_2 \end{bmatrix} \\ &= \begin{bmatrix} L_f x_3 \\ L_f x_4 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \end{aligned}$$

$$\begin{aligned} G &= \begin{bmatrix} L_{g_1} x_3 & L_{g_2} x_3 \\ L_{g_1} x_4 & L_{g_2} x_4 \end{bmatrix} = \begin{bmatrix} 0.29 * d_1 * \sin(d_2) & 0.29 * d_1 * \cos(d_2) \\ -0.29 * d_1 * \cos(d_2) & 0.29 * d_1 * \sin(d_2) \end{bmatrix} \\ &= 0.29 * d_1 * \begin{bmatrix} \sin(d_2) & \cos(d_2) \\ -\cos(d_2) & \sin(d_2) \end{bmatrix} \end{aligned}$$