(114) TRAILER

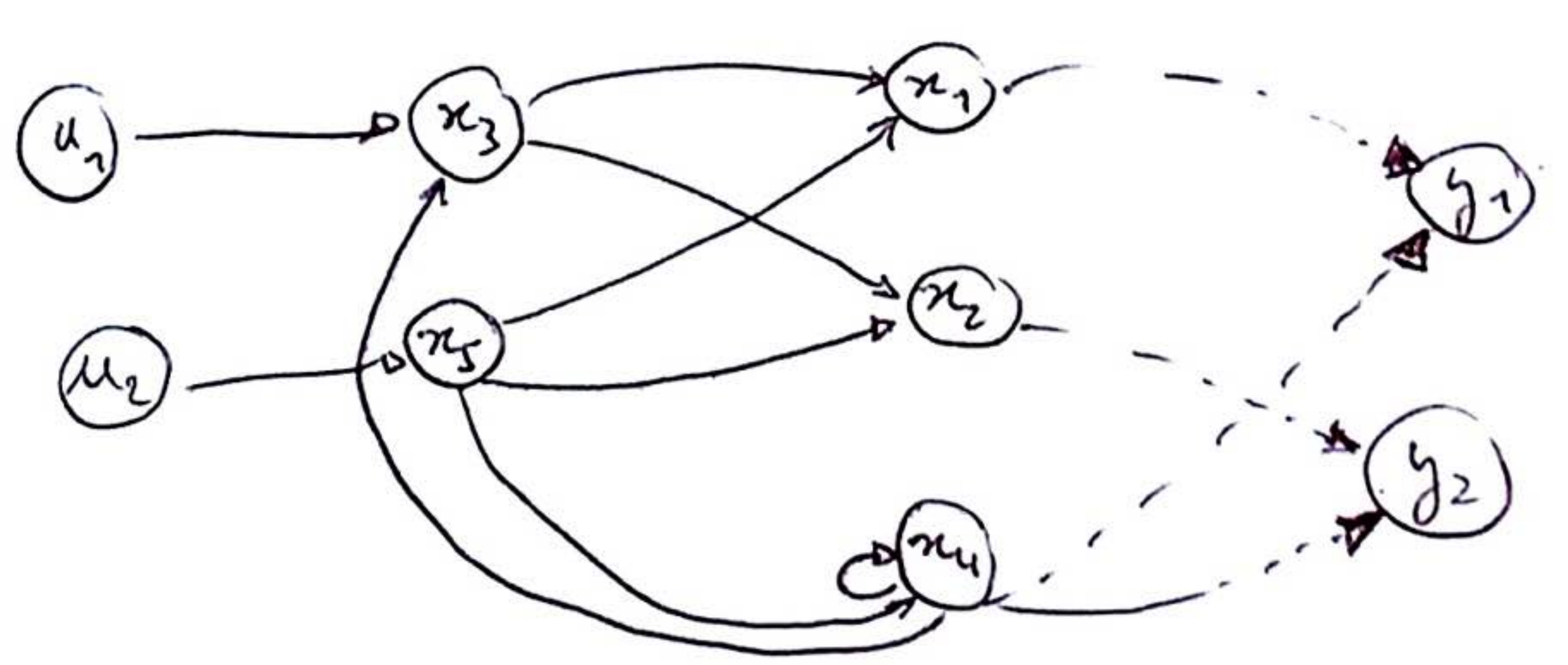
$f(x)$ $\quad$ $g(x)\cdot u$

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \\ \dot{x}_5 \end{pmatrix} = \begin{pmatrix} x_5 \cos x_3 \\ x_5 \cdot \sin x_3 \\ 0 \\ x_5 \cdot (\sin(x_3 - x_4)) \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ u_1 \\ 0 \\ u_2 \end{pmatrix}$$

on veut contrôler le centre de la remorque.

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} x_1 - \cos x_4 \\ x_2 - \sin x_4 \end{pmatrix}$$

graphe des relations :



$\rho_1 = 2$

$\rho_2 = 2$

(1) $\rho_1 + \rho_2 = 2 + 2 = 4 < \dim x = 5$ $\Rightarrow$ la méthode de linéarisation par bouclage va nous donner des équations d'état sans contrôle.

$\Rightarrow$ instabilité.

② régulateur : $\begin{cases} \dot{v}_1 = a_1 \\ u = A^{-1}(x) \cdot \left(\begin{pmatrix} v_1 \\ a_2 \end{pmatrix} - b(x) \right) \end{cases}$

• $y = \begin{pmatrix} x_1 - \cos x_4 \\ x_2 - \sin x_4 \end{pmatrix}$

• $\dot{y} = L_f h(x) + L_g h(x) \cdot u$

$= z_3 \cdot \begin{pmatrix} \cos z_5 \\ \sin z_5 \end{pmatrix}$

on note $g(x) = \begin{array}{c} \begin{array}{cc} g_1(x) & g_2(x) \\ \downarrow & \downarrow \end{array} \\ \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{pmatrix} \end{array}$

$\Leftrightarrow \begin{pmatrix} \dot{z}_3 \\ \dot{z}_5 \end{pmatrix} = \underbrace{A(x)} \cdot \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} + b(x)$

$\begin{pmatrix} L_{g_1} \cdot z_3 & L_{g_2} \cdot z_3 \\ L_{g_1} L_f \cdot z_5 & L_{g_2} \cdot L_f z_5 \end{pmatrix}$

$\Leftrightarrow \begin{pmatrix} \dot{z}_3 \\ \dot{z}_5 \end{pmatrix} = \begin{pmatrix} v_1 \\ v_2 \end{pmatrix}$

ainsi :

$z_1 = y_1 \Rightarrow \dot{z}_1 = \dot{y}_1 = z_3 \cdot \cos z_5$

$z_2 = y_2 \Rightarrow \dot{z}_2 = \dot{y}_2 = z_3 \cdot \sin z_5$

$\dot{z}_3 = v_1 = z_4$

$\dot{z}_4 = \dot{v}_1 = a_1$

$\dot{z}_5 = \dot{x}_4 = x_5 \cdot \sin(x_3 - x_4) = z_6$

$$z_6 = \ddot{z}_5 = v_2 = a_2$$

en somme, on obtient le système suivant :

$a_1 \rightarrow$, $a_2 \rightarrow$

$$\begin{pmatrix} \dot{z}_1 \\ \dot{z}_2 \\ \dot{z}_3 \\ \dot{z}_4 \\ \dot{z}_5 \\ \dot{z}_6 \end{pmatrix} = \begin{pmatrix} z_3 \cdot \cos z_5 \\ z_3 \cdot \sin z_5 \\ z_4 \\ a_1 \\ z_6 \\ a_2 \end{pmatrix}$$

$\rightarrow y_1$, $\rightarrow y_2$

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} z_1 \\ z_2 \end{pmatrix}$$

(4)
$$\begin{cases} \dot{z} = f_z(z) + g_z(z) \cdot a \\ y = h_z(z) \end{cases}$$

$$e(z) = \dot{y} - \psi(y) = L_{f_z} h_z(z) - \psi(h_z(z)) = \begin{pmatrix} z_3 \cdot \cos z_5 - z_2 \\ z_3 \sin z_5 + (z_1^2 - 1) z_2 + z_1 \end{pmatrix}$$

$$\dot{e}(z) = L_{f_z}^2 h_z(z) - L_{f_z}(h_z(z))$$

$$\ddot{e}(z) = L_{f_z}^3 h_z(z) + \left[L_{g_z} L_{f_z}^2 h_z(z) \cdot a - L_{f_z}^2 \psi(h_z(z)) \right]$$

$$e = \begin{pmatrix} e_1 \\ e_2 \end{pmatrix} \qquad \rho_1 = 2 \quad \rho_2 = 2$$

5) $\ddot{e}(z) + 2\dot{e}(z) + e(z) = 0 \quad \rightsquigarrow \quad e(z) \to 0$ con $\lambda = -1$

$$a = \beta(z) = -\left(L_{g_z} L_{f_z}^2 h_z(z)\right)^{-1} \cdot \left(L_{f_z}^3 h_z(z) - L_{f_z} \psi(h_z(z)) + 2\dot{e}(z) + e(z)\right)$$