Flight Control Lab

M2E3A - SAAS

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The objectives of the proposed Lab on Flight Control is to design a feedback controller from the Output-Feedback Exact Linearization technique for spoilers of an aircraft. The spoilers (figure 2) are controlled by hydraulic

FIGURE 1 – Spoiler

cylinders whose dynamics are modelled by the following equations :

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = \frac{ax_3 - kx_1}{m} \\ \dot{x}_3 = -\frac{x_3}{x_1}\left(x_2 - \frac{u}{a}\right) \end{cases} \tag{1}$$

We assume that $x_1 > 0$ the cylinder output distance and x_2 its speed of movement. x_3 denotes the hydraulic pressure and u the electrical voltage for controlling the output of the cylinder. a, k and m are known constant coefficients.

1. We assume that only position x_1 is measured ($y = h(x) = x_1$)
   (a) Compute the relatove degree of the putput $y(t)$ with respect to u ? Conclusion.
   (b) We want to make a transformation of the system in the form

$$\begin{cases} \dot{z}_1 = z_2 \\ \dot{z}_2 = z_3 \\ \dot{z}_3 = f(z) + g(z)u \end{cases}$$

   Find the coordinate transformation $z = \psi(x)$ and calculate its inverse $x = \psi^{-1}(z)$.
   (c) Propose a control law $u = \gamma(z)$ allowing linearization by input-output loop.
   (d) Calculate the control law so as to have the poles of the system thus linearized and in closed loop at -1, -2 and -3.
   (e) Simulate the system on Matlab/Simulink with the computed controller.
2. Now let's assume that the position is no longer measured but only the velocity ($y = x_2$).

(a) Propose a linearizing control law by input-output looping.

(b) Give the characterization of dynamic zeros (internal dynamics).

(c) What can we say about the dynamics of zeros ?

(d) Simulate the system on Matlab/Simulink with the computed controller.

3. In both the two cases, modify the controller in order to track a reference trajectory for the position $x_1(t)$ given by :

$$r(t) = \begin{cases} 1 & t < 10s \\ 2 & t \geq 10s \end{cases}$$