Correction to Flexible Joint Model

Lab 4: Linear Quadratic Regulator (LQR) and Observer Design for Flexible Joint

ECE 758: Control System Implementation Laboratory

In the Laboratory Design Challenges document, the state-space model of the flexible joint has a typo, and so the state-space model will not produce the MATLAB results shown below it. To remedy this problem, replace every R with Rm. The effect of R is already included in the Kstiff parameter, and the typo omits any influence of the Rm parameter.

The correct model has

\[ x = \begin{bmatrix} \theta \\ \dot{\theta} \\ \alpha \\ \dot{\alpha} \end{bmatrix}, \quad u = v\text{in}, \quad \dot{x} = Ax + Bu, \quad \text{and} \quad y = Cx \]  

(1)

where

\[ A = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & \frac{Kstiff}{J_{hub}} & -\frac{K^2 m^2 g^2}{Rm J_{hub}} & 0 \\ 0 & -\frac{Kstiff (J_{load} + J_{hub})}{J_{hub} J_{load}} & \frac{K^2 m^2 g^2}{Rm J_{hub}} & 0 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ \frac{K m K_g}{Rm J_{hub}} \\ -\frac{K m K_g}{Rm J_{hub}} \end{bmatrix}, \quad \text{and} \quad C = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}. \]  

(2)

These corrections have already been applied to the following MATLAB code.

```matlab
A = [ 0, 0, 1, 0; 
      0, 0, 0, 1; 
      0, Kstiff/J_hub, -mpower(Km,2)*mpower(Kg,2)/(Rm*J_hub), 0; 
      0, -Kstiff*(J_load+J_hub)/(J_hub*J_load), mpower(Km,2)*mpower(Kg,2)/(Rm*J_hub), 0 ];
B = [ 0; 0; Km*Kg/(Rm*J_hub); -Km*Kg/(Rm*J_hub) ];
C = [ 1 0 0 0; 0 1 0 0; 1 1 0 0 ];
```

This code uses `mpower(Km,2)` in place of `Km^2` so that you can copy and paste from this PDF into MATLAB. Using this code, your results should match the ones from the laboratory design challenge. That is,

```matlab
format short e; A, B
```

should give you

```matlab
A =

0 0 1.0000e+00 0
0 0 0 1.0000e+00
0 7.6705e+02 -5.2795e+01 0
0 -1.0401e+03 5.2795e+01 0
```

```matlab
B =

0
0
9.8333e+01
-9.8333e+01
```