M.E. 530.647 Lab 4

Revision 01

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1. Consider the system and the controller you developed in Question 2(a) of Problem Set 3 for model reference control of a linear algebraic system.
   (a) Implement a numerical simulation of this system. Choose a reasonable $r(t)$, and clearly stare your choice.
   (b) Simulate, plot, and annotate solutions for at least two initial conditions and reference signals. Hand in one representative example. Your plot should show the plant output $y_p(t)$, the adaptive parameter of your design, the control input $u(t)$ versus time, the reference model input $t(t)$, and the reference model output $y_m(t)$.
2. Simulate the performance of the closed loop system comprising the given plant, the given reference model, and the adaptive controller you derived for Question 2 of Problem Set 4.
   (a) Write a function `CARDYN1(t,v,u)` which accepts the scalar real argument `t` and the scalar `v` and returns the scalar value $\dot{v}$. Choose values for m, g, and c_d. Explicitly note the values you selected.
   (b) Write a function $\mathtt{CARREF1}(\mathtt{t}, \mathtt{v_r}(\mathtt{t}), \mathtt{r}(\mathtt{t}))$ which accepts an appropriate list of scalar arguments and returns the scalar $\dot{\hat{v}}_r(t)$.
   (c) Write a parameter estimate update function $\mathtt{CAREST1}(\mathtt{t}, \cdots)$ which accepts an appropriate list of scalar and vector arguments and returns the time derivative vector $\dot{\theta}(t)$ of your adaptive control parameter vector θ.
   (d) Write a function $\mathtt{CARCON1}(\mathtt{t}, \cdots)$ which accepts an appropriate list of scalar and vector arguments and returns the scalar control input to the car $u(t)$.
   (e) Write a function $\mathtt{SYSCAR1}(\mathtt{t}, \mathtt{y})$ which accepts the scalar real argument `t` and the $n \times 1$ vector `y` where

$$y = \begin{bmatrix} v \\ v_r \\ \vdots \\ \theta \end{bmatrix} \tag{1}$$

   and **uses the the functions specified above** to compute the return value

$$\dot{y} = \begin{bmatrix} \dot{v} \\ \dot{v}_r \\ \vdots \\ \dot{\theta} \end{bmatrix} \tag{2}$$

for the reference input

$$r(t) \quad = 5; \tag{3}$$

(f) Use SYSCAR1(), ODE45(), and PLOT() simulate, print, and annotate the solutions to this system for at least two initial conditions. Hand in one representative example.

Note the following:

i. Choose non-trivial initial conditions.

ii. Run the simulation for enough time for the system to clearly reach steady-state.

iii. Plot and annotate $v(t)$ and $v_r(t)$ versus time on a single graph. Label each curve with its name, initial value, and final numerical value.

iv. Comment on the time-history of the $v(t)$ and $v_r(t)$ values. Does $\lim_{t\to\infty} v(t) = v_r(t)$? Be specific.

v. Plot and annotate the elements of the parameter vector $\theta(t)$ versus time. Label the curve with its name, initial value, and final numerical value.

vi. Comment on the time-history of the parameter values. Do they converge to a fixed value? Do they converge to "correct" values? Be specific.

vii. Plot the value of a Lyapunov function for this error system as a function of time. Label the curve with its name, initial value, and final numerical value.

3. (a) Write a function SYSCAR2(t, y) which is identical to SYSCAR1(t, y) in all ways except that the reference input is $r(t) = 5 + 3 * sin(\pi * t)$.

(b) Repeat the simulations specified in 2f for this new system. Use the same initial conditions you used in 2f.

Hand in *ANNOTATED* printouts of your plots and printouts of your m-files. Hand in your m-file functions by emailing them to me as ZIP file attached to your email. Put "530.647 LAB #4 m-files from YOUR FULL NAME" in the subject line.

Check to verify that the files you hand in run. If your matlab functions call custom matlab m-files that you have written (for this course or otherwise) be sure to include *all* necessary files.