**EE 547 (PMP) Lab 1**

Wednesday, January 7, 2015

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**Demo Problem 1** (Linearization around an equilibrium point)

1. Consider a system of nonlinear differential equations:

|  |  |
| --- | --- |
|  | (1) |
| Given equilibrium point , please linearize (1) and find the Jacobian matrix: |  |

1. Now a linearized system is available around equilibrium point. Let B and D be zero matrices and output y = x, please use MATLAB functions to present system responses with respect to different inputs, for example, impulse and step inputs.

**Individual Problem 1** (Linearization around an equilibrium point)

1. Consider a system of nonlinear differential equations:

|  |  |  |
| --- | --- | --- |
|  | |  | | --- | | (2) | |

Given equilibrium point , please linearize (2) and find the Jacobian matrices:

1. Let D be a zero matrix and output y = x. Use MATLAB function to evaluate the outputs of system with respect to step and impulse response.

**Solution to Demo Problem 1:**

1. To find Jacobian matrix A, we have to find the partial derivative and calculate them at the equilibrium point:

The matrix A is therefore derived and the linearized system can be written as below.

1. The code working flow is listed as below:
   * 1. Define parameters
     2. Define A B C D matrices
     3. Define inputs
     4. Apply state space modeling functions
        1. **ss1 = ss(A,B,C,D)**  
           To build *ss class* ss1 in MATLAB.
        2. **ZeroInputResponse = initial(ss1,xini,tspan)**  
           Evaluate unforced response of ss1 with given initial condition and time span.
        3. **[ImpulseInputResponse,t1] = impulse(ss1)**Evaluate impulse response of ss1 and return corresponding evaluation time.
        4. **[StepInputResponse,t2] = step(ss1)**  
           Evaluate tep response of ss1 and return corresponding evaluation time.
     5. Output data or figures

|  |  |
| --- | --- |
|  | \\psf\Dropbox\EE574_Winter2014\LinearResponse.jpeg |
| Figure 1 Unforced response of the system | Figure 2 Response of the system with cosine input |
|  |  |
| Figure 3 Response of the system with step input | Figure 4 Response of the system with impulse input |

MATLAB Code:

%% EE547 Linear Systems Theory Lab 1

close all;

clear all;

%% Define parameters

tspan = 0:0.01:2;

xini = [0.05;0.05];

%% Define A, B, C, D matrices after linearization

A = [0 1 ; 1 1];

B = [0; 0];

C = eye(2);

D = [0 ; 0];

%% Define input

u = cos(tspan);

%% StateSpace Modeling

% Zero input response

ss1 = ss(A,B,C,D);

ZeroInputResponse = initial(ss1,xini,tspan);

% Impulse and step responses

[ImpulseInputResponse,t1] = impulse(ss1);

[StepInputResponse,t2] = step(ss1);

% Step response with cosine input

LinearResponse = lsim(ss1,u,tspan,xini);

%% Output figures

figure(1)

plot(tspan, ZeroInputResponse);

title('Zero Input Response');

xlabel ('Time (second)');

legend('x1','x2');

print -djpeg 'ZeroInputResponse.jpeg'

figure(2)

plot(t1, ImpulseInputResponse);

title('Impulse Input Response');

xlabel ('Time (second)');

legend('x1','x2');

print -djpeg 'ImpulseInputResponse.jpeg'

figure(3)

plot(t2, StepInputResponse);

title('Step Input Response');

xlabel ('Time (second)');

legend('x1','x2');

print -djpeg 'StepInputResponse.jpeg'

figure(4)

plot(tspan, LinearResponse);

title('Cosine Input Response');

xlabel ('Time (second)');

legend('x1','x2');

print -djpeg 'LinearResponse.jpeg'