Lab #5: Simulation of Mobile Robots

EE 552: Robotic Control System

by

Md Ali Azam

1. **Controllability of the Segway robot dynamics:**

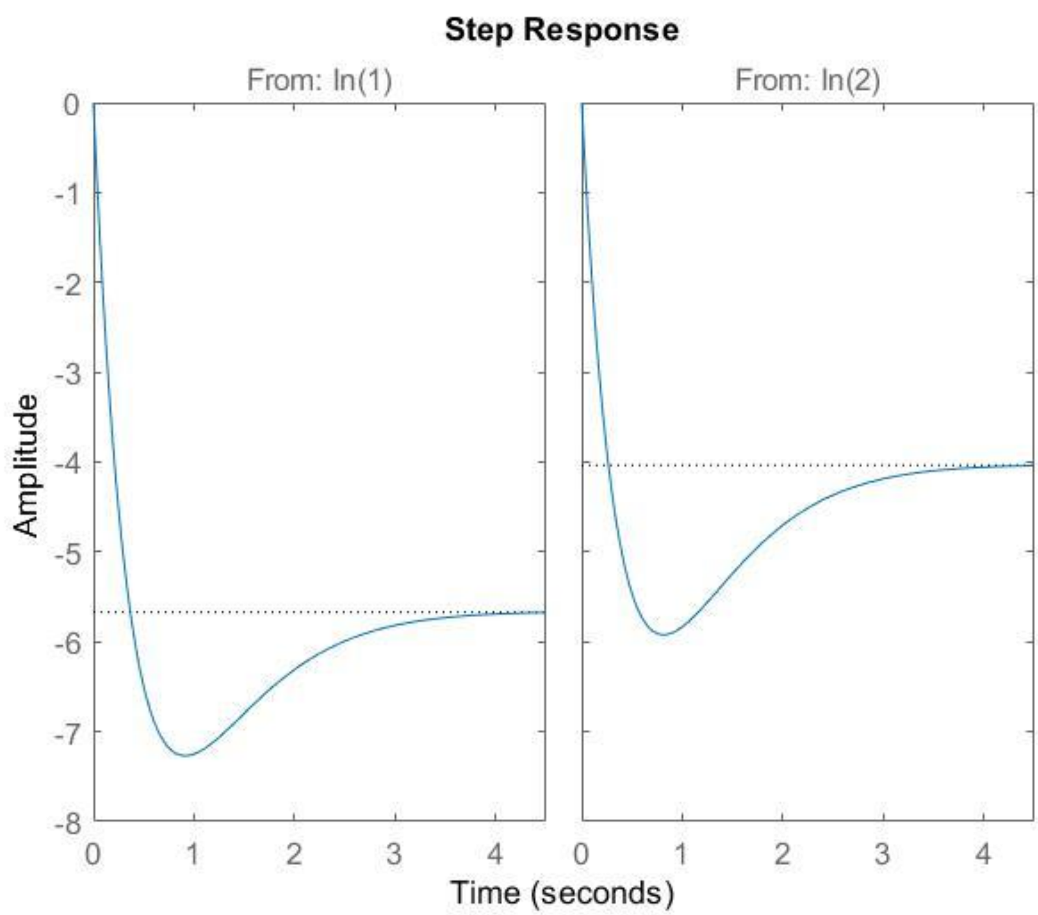
We know that a system dynamics is controllable if and only if the controllability matrix has a full rank. The given dynamics is not controllable because the controllability matrix of the dynamics does not have a full rank.

Matlab code:

```
clc
clear
close all

A = [0 0 1 0 0 0 0;
    0 0 0 0 0 0 0;
    0 0 0 0 0 2.16 0;
    0 0 0 0 1 0 0;
    0 0 0 0 0 0 0;
    0 0 0 0 0 0 1;
    0 0 0 0 0 72.49 0];

B = [0 0;
    0 0;
    -1.67 1.67;
    0 0;
    0.029 -0.029;
    0 0;
    -24.15 -24.15];

c = ctrb(A,B);
r = rank(c)
l = length(A(:,1))


which returns: r = 6 and l = 7
```

1. Now we simplified our system dynamics and removed three states from the state-space (positions and phi). The new system is completely controllable. It has a full rank.
2. We design a state feedback control by placing poles. Our step response says that the system asymptotically stables.
3. Now, we need to simulate a circle suing the state feedback (assuming we have full state information). For radius of the circle 5, we know

Curvature, k=w/v
and k = 1/5
so we get, v = 5w



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A = [0 0 2.16 0;
    0 0 0 0;
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```
    0 0 0 1;
    0 0 72.49 0];

B = [-1.67 1.67;
0.029 -0.029;
0 0;
-24.15 -24.15];
C = [1 1 1 1];
x = [1 1 1 1]';

c = ctrb(A,B);
r = rank(c);
l = length(A(:,1));

p = [-1 -2 -1.5 -2.1];
kcl = place(A,B,p);

delta = [0.05, 0.01, 0, 0]';
x_est = x - delta;

u = -kcl*x_est;

x_est = A*x_est + B*u;

x = x_est + delta;

D = [0];

sys2 = ss(A-B*kcl,B,C,D);
figure
step(sys2)
```