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Robot Control Assignment 2 Report

We need to find the equilibrium points and then linearise the system about those points after which we should make the system controllable by applying the state feedback control which is defined as $u = -K \times X$. We check controllability by comparing rank of Controllability matrix with rank of A matrix

a) These are the points at equilibrium and the last column has been hard-coded into as it was not possible to find the 4th set of equilibrium point.
Equilibrium points

```
X_eq =
[0, pi,  0, pi]
[0,  0,  0,  0]
[0,  0, pi, pi]
[0,  0,  0,  0]
```

b) Linearisation about equilibrium points:

```
A =
  [     0,    1.0000,         0,         0;
   12.5769,         0,  -11.9611,         0;
         0,         0,         0,    1.0000;
  -16.9227,         0,   46.1565,         0]

B =
[        0,         0;
    1.7250,   -4.4345;
         0,         0;
   -4.4345,   14.8902;]
```

c) Is the system stable?

```
lambda =

 [ -7.1676
  -2.7129
   7.1676
   2.7129]
```

We can see that there are positive eigen values in A.
Thus, the system is unstable since there are positive values.

d) Is the system controllable?

C =

```
[       0         0    1.7250   -4.4345         0         0   74.7378 -233.8759
   1.7250   -4.4345         0         0   74.7378 -233.8759         0         0
        0         0   -4.4345   14.8902         0         0 -233.8759  762.3251
  -4.4345   14.8902         0         0 -233.8759  762.3251         0         0]
```

Rank C = 4, Rank A = 4

Thus, System is controllable

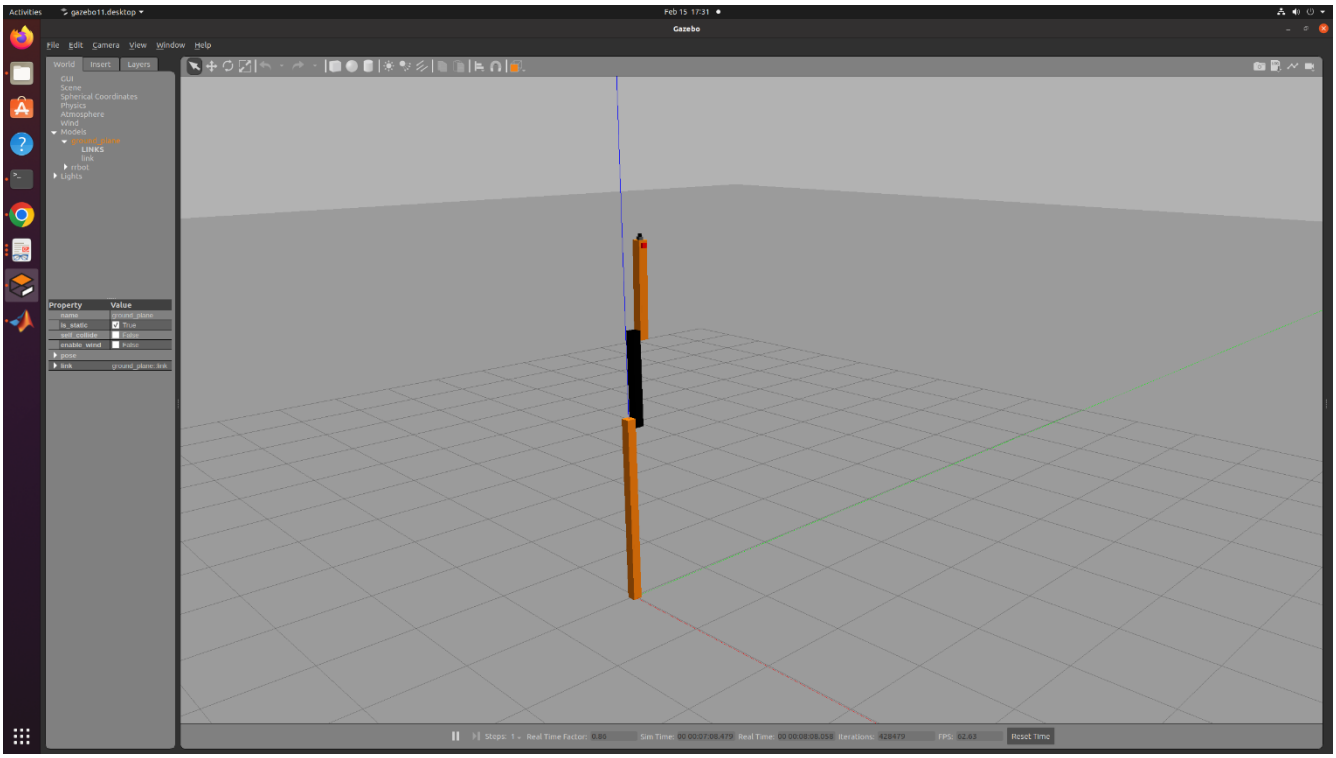
e) Designing State feedback controller

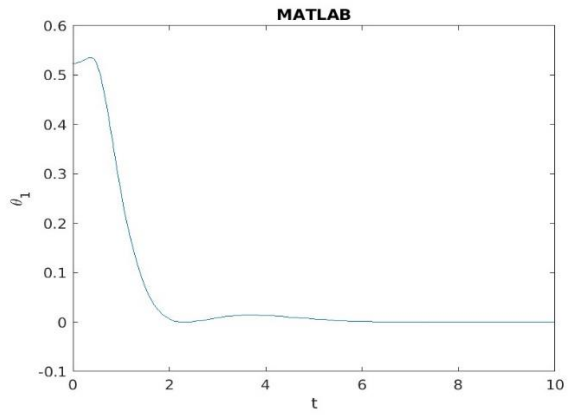
K =

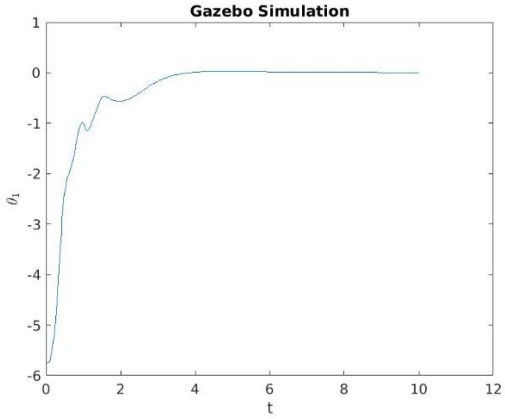
```
 [ 26.0209    9.8769    6.7532    2.9984
    6.5237    2.9059    5.6227    1.2857]
```

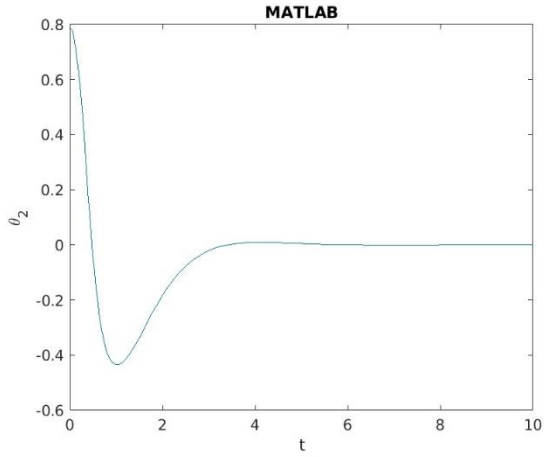
SFC =

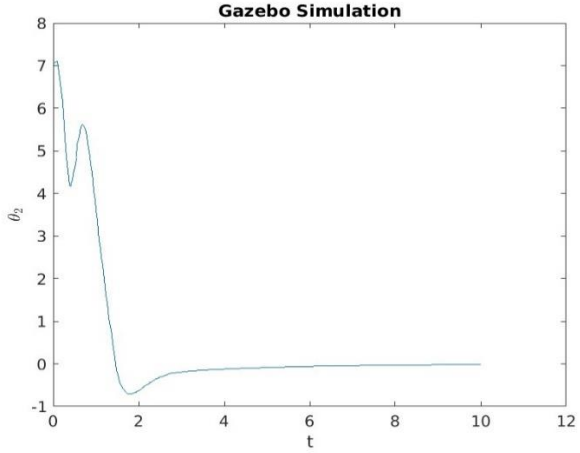
```
[       0    1.0000         0         0
  -3.3806   -4.1520    1.3235    0.5292
        0         0         0    1.0000
   1.3282    0.5310   -7.6194   -5.8480]
```

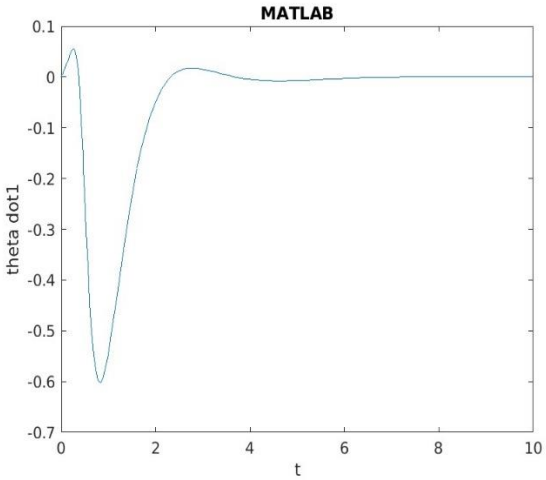


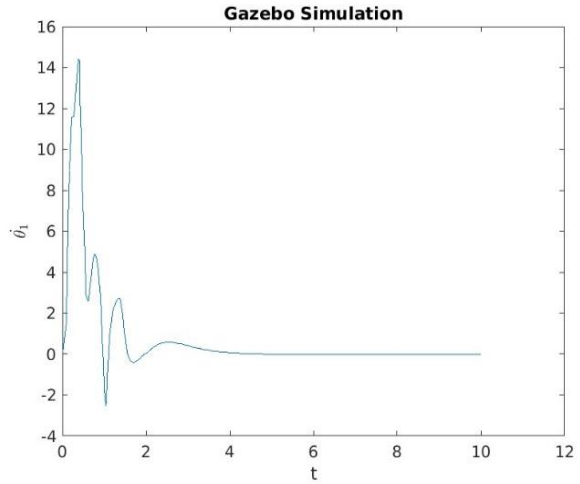

MATLAB
θ_1
t

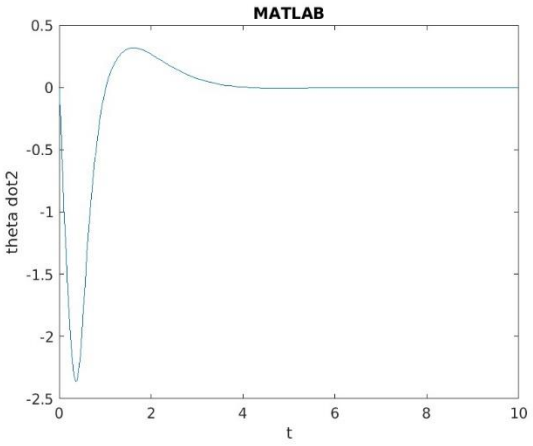

Gazebo Simulation
θ_1
t

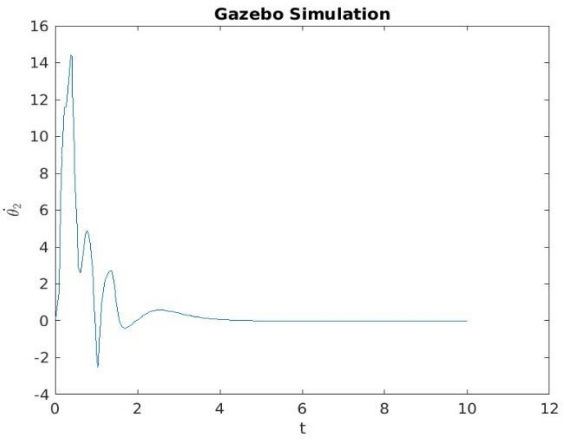

MATLAB
θ_2
t

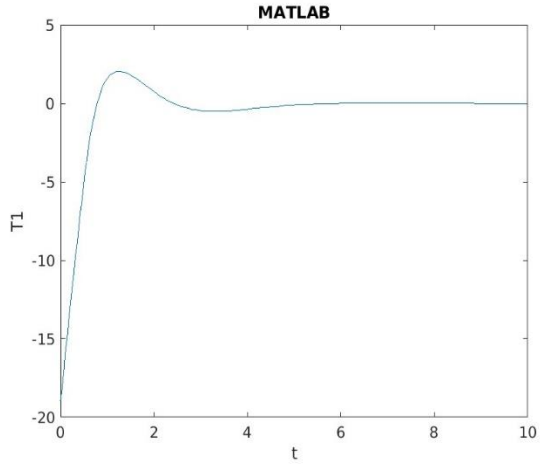

Gazebo Simulation
θ_2
t

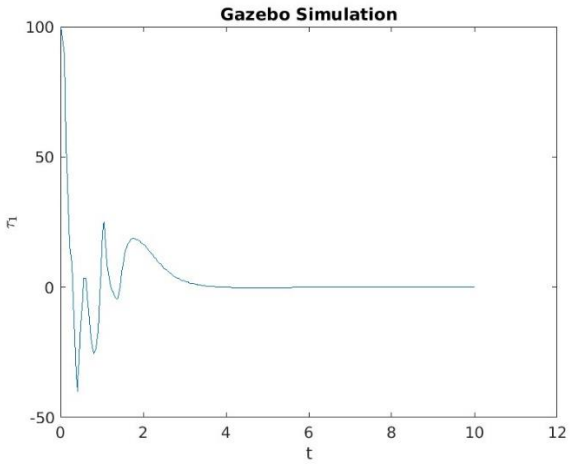

MATLAB
theta dot1
t

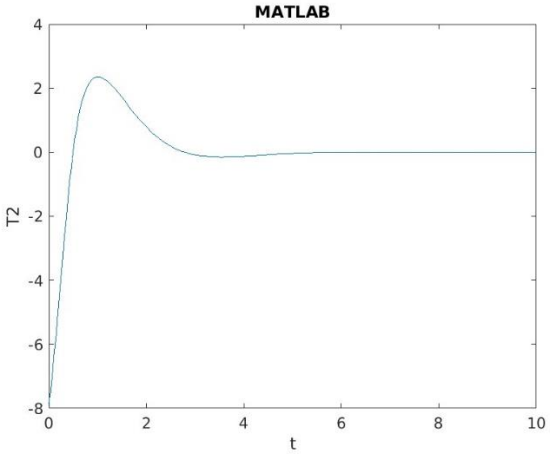

Gazebo Simulation
$\dot{\theta}_1$
t

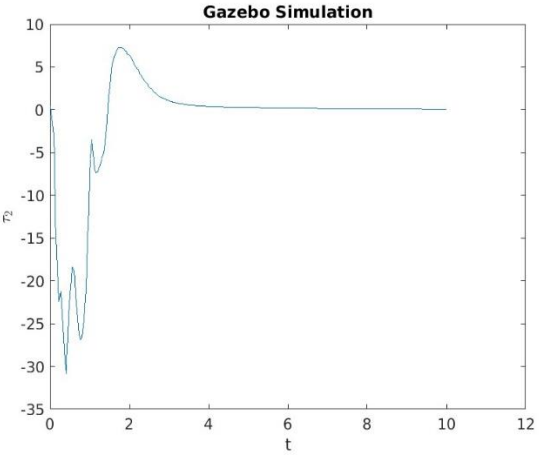












Discussion : It is to be noted that the plots in MATLAB are much smoother in comparison to the plots in Gazebo as MATLAB does not take into consideration the frictional losses which also acts as a damper.