Report for ECE 5463 Final Project

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PD Controller

I reference the example solution for Homework 4, which is for single-link manipulator, and expand the solution for two-link manipulator.

Therefore, my PD controller is designed as followed:

```
% td1 and td2 are desired theta values
tau1 = -param.kp*(theta1-param.td1)-param.kv*dtheta1;
tau2 = -param.kp*(theta2-param.td2)-param.kv*dtheta2;
```

Tuning Parameters

Before integrating the PD controller into the project, which takes consecutive user inputs, I ran a demo that only took one inputs, i.e. $desired\_\theta_1 = desired\_\theta_2 = 0$, and tuned the parameters on this demo.

There are two parameters for PD controller, i.e. the proportional variable `kp` and the derivative variable `kv`.

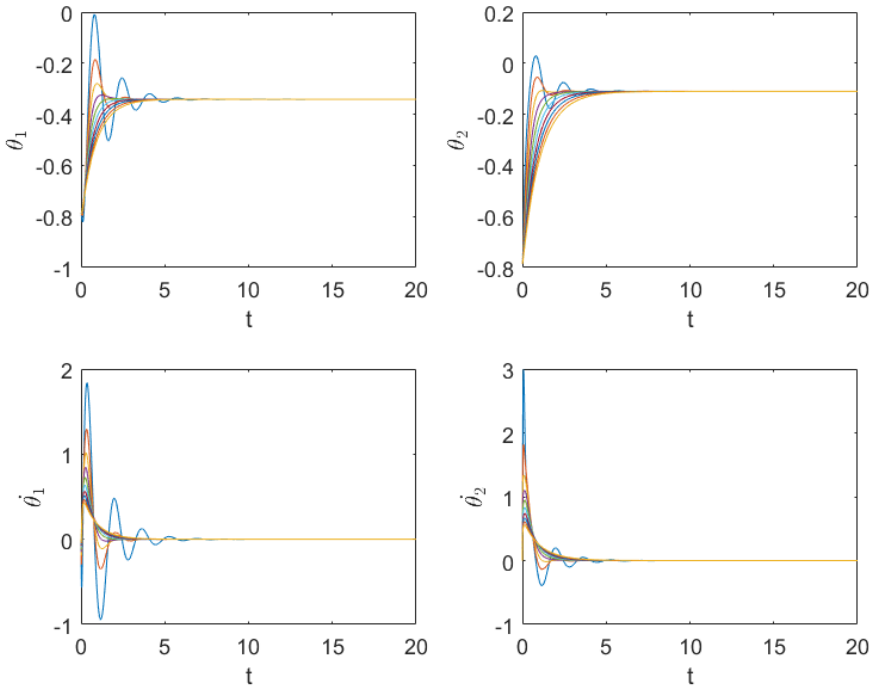
(Sorry that I don't know how to add legend to subplots elegantly. So for all the subplots shown below, from blue to yellow plots, the value of parameter increases.)

Effect of Derivative Variable `kv`

First I tune `kv` and see what happens. The value of `kv` ranges from 100 to 1000, with step=100. The value of `kp` is fixed as 500. Or in Matlab,

```
n = 10;
kv = linspace(10, 100, n)';
kp = linspace(80, 80, n)';
```

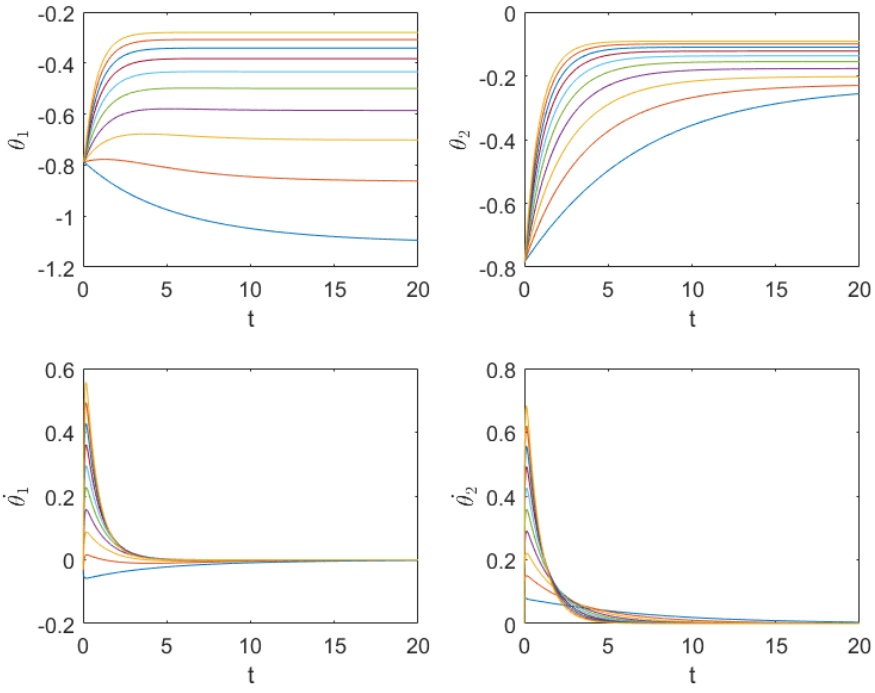
As we can see from the graph, `kv` determines the sensitivity of the system, or in other words, if the system is underdamped, overdamped or critically damped.



Effect of Proportional Variable `kp`

Then I tune `kp` and observe its effect. The value of `kp` ranges from 100 to 1000, with step=100. The value of `kv` is fixed as 100. Or in Matlab,

```
n = 10;
kv = linspace(100, 100, n)';
kp = linspace(10, 100, n)';
```



We can see from the graph that at the beginning, `kp` determines the settling value of the system. As `kp` increases, the convergence value increases.

PID Controller

My PID controller has the following control law:

```
tau1 = -kp*(theta1-param.td1)-ki*interror1-kv*dtheta1;
tau2 = -kp*(theta2-param.td2)-ki*interror2-kv*dtheta2;
```

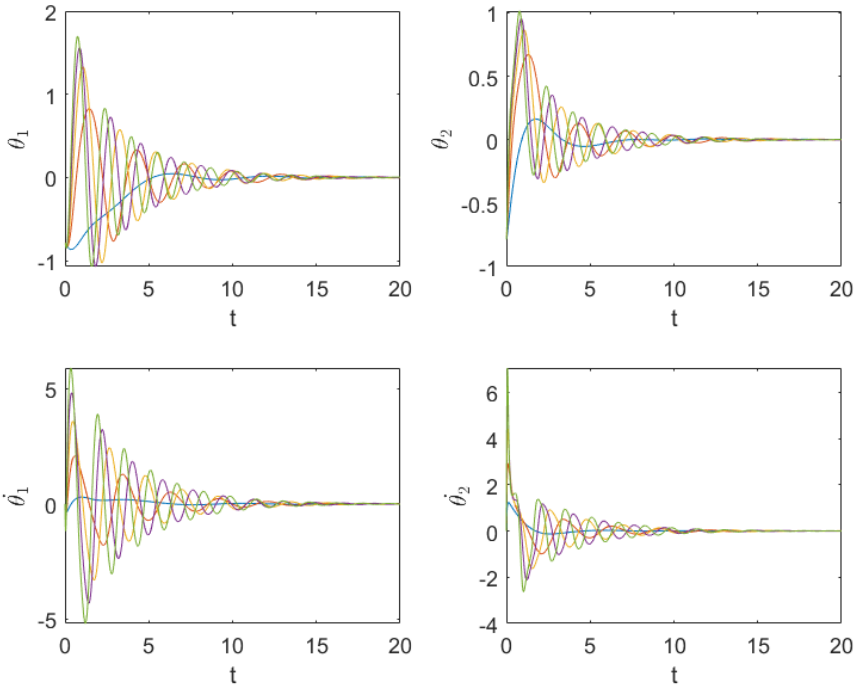
`kp` and `kv` have been discussed in the previous section, so we will only check the effect of `ki`.

Effect of Integral Variable `ki`

I fixed `kv` and `kp`, and change the value of `ki`.

```
n = 5;
kv = linspace(10, 10, n)';
kp = linspace(500, 500, n)';
ki = linspace(100, 500, n)';
```

As we can observe from the graph, `ki` can change the length of period of the responses. The period becomes shorter as `ki` increases.

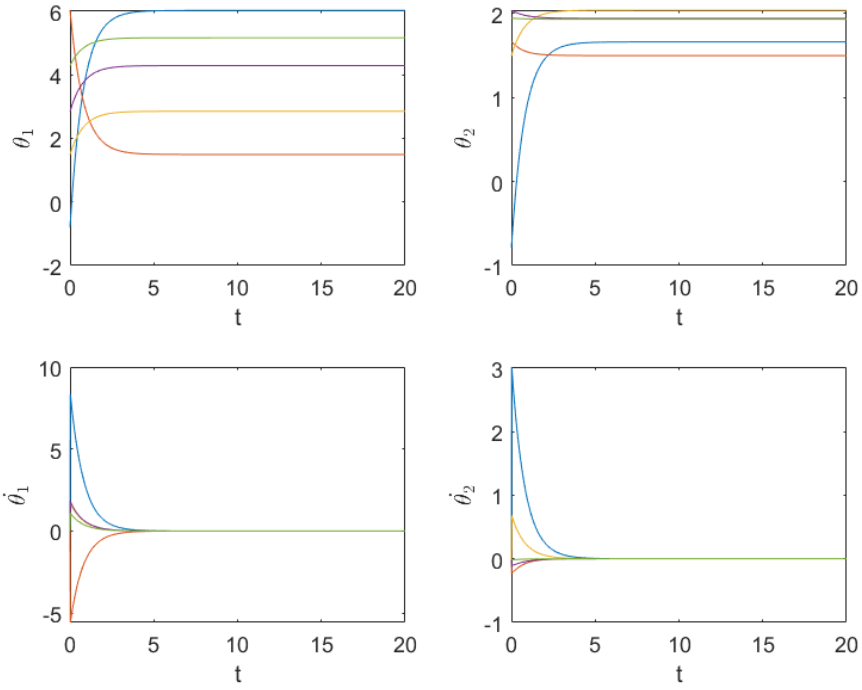


Choice of Parameters

I choose to use PD controller in my simulation. And my final choice of parameters is

```
kp = 100;
kv = 80;
```

After integrating the controller into the whole project (users can select consecutive 5 points), I get a graph like this


6
4
2
0
-2
θ_1
0
5
10
15
20
t
2
1
0
-1
θ_2
0
5
10
15
20
t
10
5
0
-5
$\dot{\theta}_1$
0
5
10
15
20
t
3
2
1
0
-1
$\dot{\theta}_2$
0
5
10
15
20
t