Task Report

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Inverted Pendulum

I received a task to balance an inverted pendulum using a cart. The task has three goals.

Goal 1:

I created a controller package and started the inverted pendulum simulation. I used the given parameters (pendulum weight = 2kg, cart weight = 0.5kg, pendulum length = 300units, cart position= in the centre, pendulum orientation = vertical down) to initialise the robot system. Result can be seen in the setParams video.

Goal 2:

Second goal is to provide a sinusoidal force input to the cart to make it oscillate. I made the cart stable using the Goal1 code. A sinusoidal input with different amplitudes {A : 50,80,150} and frequencies was published to the '/inverted_pendulum/control_force' topic. Due to the parameters given to the system (like mass of pendulum is greater than the cart and length of pendulum), though a continuous sinusoidal input is given, the cart won't get a perfect oscillation. This is due to the time taken by the cart to react to the immediate negative forces in a cycle . Unless large discrete forces are given, the cart goes in the direction the force it gets at the start. The result can be seen in the sinusoidal video.

Goal 3:

Third goal is to balance the inverted pendulum on the cart. I tried to understand the theory from the link given in the assignment task. I learned how to do force analysis and the transfer functions of both cart and the pendulum. I researched about how pid can be introduced using the transfer functions but couldn't connect the dots and get it into implementation. I got to know about the LQR algorithm and also checked if I can use the cascade pid for the given system. Apart from all these learnings, I tried to balance the inverted pendulum using a simple pid algorithm which takes the pendulum angle as an input and outputs force.

Assumptions:

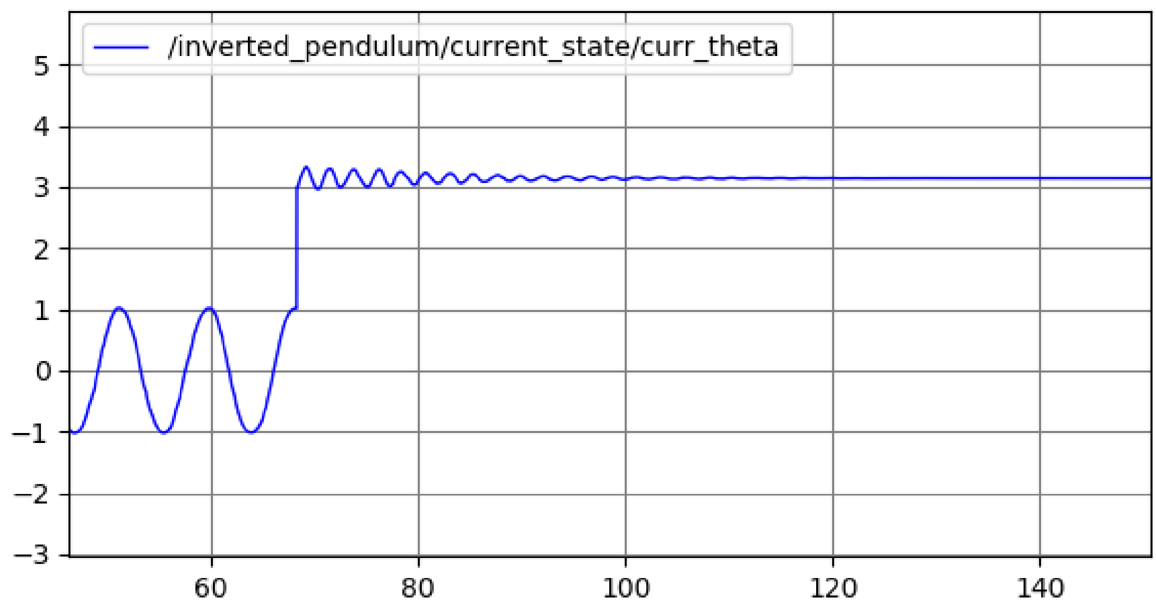
- Pendulum starts at theta = 3.0 to stabilise the cart in the given window

Equation:

$$F = K_p\theta + K_d\dot{\theta} + K_i \int \theta dt$$

- I used a library called simple_pid for easy, robust control and tuned the kp,ki and kd parameters to balance the inverted pendulum.
- Though I assumed that theta =3.0, I also tried to balance the pendulum with theta =0, i.e., pendulum at vertically down position. The cart is able to oscillate and balance the pendulum at theta = 3.14. But, it cannot be seen in the animation window given.

Graph



Graph1: Theta change using pid controller

Result:

- As we can see in the graph, when the pid algorithm is implemented, the theta value changes to 3.14 after a certain amount of time which can be seen in the balance_pendulum video.

Conclusions:

- I couldn't complete the position control but it was great learning.
- If I could get some inputs to understand the theory, I could have achieved the task in the given time.
- If there is no deadline, I will be researching more about control algorithms and try to do a better optimization.
- Thank you for giving me this task.