CSCI 445 Lab 6 — Go to Goal

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In this lab we will add an integral term to last weeks PD controller to get a full PID controller. We will use the controller in various settings: go-to-angle, and go-to-goal.

1 Prerequisites

- Review your findings from the previous lab.
- Review feedback control (i.e. Lecture 6).
- Review Odometry.
- Bring your laptop.

2 Go To Angle — PD Controller

We want to use a PD Controller to go to a specified angle.

2.1 Controller Design

What is the state here and how can you measure it? How do you use the controller output to drive the robot?

2.2 Simulation

Implement your controller by leveraging the `PDController` class from last week. Test your controller in simulation for angles π, $-\frac{\pi}{2}$, and $\frac{\pi}{2}$. Furthermore, tune your gains until you get a reasonable output and provide a plot of the angle over time for one of the cases showing current and desired state on the y-axis and time on the x-axis.

Hint: The simulator does not know the current state estimate and therefore can not be used for plotting (unlike last lab, where the simulator provided the sonar data).

3 PID Controller

Now we would like to extend our controller to include an integral (I controller) term and compare it to the PD controller.

3.1 Controller Implementation

Copy your existing `PDController` into a new file called `pid_controller.py`. Change the class name to `PIDController` and update the code such that your controller includes the integral term.

Hint: Consider the case where your goal state suddenly changes. Your error would be very big until you manage to reach the goal state. Unfortunately, the integral portion "remembers" the error and might grow very large. Hence, you need to make sure that the accumulated error can be clamped independently (where the clamping range is user-specified and depends on your application).

3.2 Go To Angle in Simulation

Repeat your experiment from the last section this time using the PID controller. Now you have three gains and two clamping ranges to tune. Provide plots of at least three different sets of gains and report a good set of PID gains. How does the PID controller compare to the P and PD Controllers?

3.3 Robot

Try your controller from 3.2 on the robot and re-tune the gains if required. As before, also provide a plot of the angle over time.

4 Go To Goal

We would like to go to a goal rather than rotating just in place.

4.1 Simulation — Base Line

Update your code to go to a specified goal location by controlling only the angular velocity of the robot (ω). What happens when you reach your goal location? Create a plot of the current angle of the robot versus the dynamically changing desired angle to analyze what might be causing the issue.
Suggest two ways to improve the behavior you observe.

4.2 Simulation — Improved Solution 1

Implement and test solution 1 in simulation. Same as in 4.1, generate a plot of the current angle of the robot versus the dynamically changing desired angle.

4.3 Simulation — Improved Solution 2

Implement and test solution 2 in simulation. Same as in 4.1, create a plot of the current angle of the robot versus the dynamically changing desired angle.

4.4 Robot

Now you are ready to try it on the robot (we will pick which of the solutions).
Same as in 4.1, generate a plot of the current angle of the robot versus the dynamically changing desired angle.