Assignment 2: Two-link Robot Arm PID Controller

CS 491/591: Programming Swarm Robots
Assigned September 6th, 2017
Due: Sept. 18th, 6:00pm Mountain Time
Version: 1.1
Last modified: September 6, 2017

1 Change Log

1. Fixed typos in title and introduction.

2 Introduction

In this project you will work with your assigned partners to implement a PID controller to govern a two-link, and two-joint robot arm. The rules for formatting your paper and a description of the grading rubric is on the course website, be sure to follow them in order to get credit for this project.

A good strategy for writing a scientific paper is think about the figures first. The figures provide a structure around which you can write the rest of the paper and which can guide your methods. Casual readers will usually look at your abstract, conclusions, and figures first before deciding whether to read the rest of the paper. We will follow that strategy in this project description.

Maintain your paper under overleaf. Send me links to your overleaf project via email (mfricke@unm.edu).

3 Software

Implement the body of the Matlab function called *PIDController*. Your program must generate all the figures or data in the paper. If you post-process your figures to improve their appearance, add text, etc. that is OK. If your program just produces data and you used an external plotting program such as gnuplot to make the figures that is OK too. Just make sure the figures or data produced by your program are recognisably the basis for the figures in your paper.

Make sure you store your program under github and share the repository with me (github username: gmfricke). Be sure that all the code needed to run your program on the CS lab machines is included in the git repository. If I cannot run your code we cannot give you credit for the assignment.

4 Assignment

For this assignment your group will implement a proportional+integrative+derivative controller using Matlab. The controller will move a robot arm through a pre-planned series of movements. The simulation of the robot arm uses several functions to compute the forces involved.

The inputs to the PIDController function are the actual joint angles, the set points for each joint, and the derivatives of the joint angle errors.

The outputs of the function are a vector of torques the simulated actuators apply to the joints.

The robot arm simulation is run by calling a top-level function named *robotarm*. The function takes the following parameters:

- time_max - How many simulated seconds to run the simulation.
- link1_len - length of the first link in meters.
- link2_len - length of the second link in meters.
- link1_mass - mass of the first link in Kg.
- link2_mass - mass of the second link in Kg.
- torque_limit - maximum angular force that can be applied by the actuators.
- joint1_init_angle - initial angle of the first joint.
- joint2_init_angle - initial angle of the second joint.
- joint1_desired_angles - a two column matrix of *time, joint angle* pairs for the first joint.
- joint2_desired_angles - a two column matrix of *time, joint angle* pairs for the first joint.

For example:
runrobotarm(10,1,1,1,1,500,0.01,0,[0,pi;5,pi/2],[0,pi/2;5,pi])

causes tells the robot arm to move to a position with the first joint at angle $\theta_1 = pi$ at time 0, $\theta_1 = \frac{\pi}{2}$ at time 5 seconds, and the second joint at $\theta_2 = \frac{\pi}{2}$ at time 0, $\theta_2 = \pi$ at time 5 seconds.

For this assignment you will write a 3 page report describing the work you did for the assignment. Include the following figures:

Find the values of K_p, K_i and K_d that provide good control of the robot arm. Plot the joint torques and errors over time.

For K_p show the error plots for values too high or too low. Repeat this for K_d and K_i. Show one set of error plots (1 for each joint) for each (6 plots altogether).

In order to receive a grade above 93/100 you must Implement a version of your PID controller using your own derivative term rather than the derivative passed in to the PID as an argument.

Organize your report as follows:

Introduction

Give a little background on PID controllers. When were they invented and by whom? Whey are they used so often to control robot actuators. Make sure you cite your sources. Cite each fact you state individually at the end of the sentence. Do not provide a single citation for multiple sentences or facts.

Methods

Describe how and why your PID controller works. Briefly describe the code used to model the robotic arm.

Results

Include the figures I ask for here. Make sure each figure has a stand alone caption that can be read and understood independently of the rest of the paper. Do not put any discussion of the figure in the caption.

Discuss the meaning of each figure in the main text of the results section. Make sure every figure is discussed here.

Discussion

Describe what you thought was interesting or surprising about the work you did and the results you obtained.

References

Place references to the sources of information you used in this assignment. Make sure you reference all code you used to implement your PID, scientific papers, and books. You may cite websites. You will be graded on the quality and reliability of your sources. Stackexchange is much less reliable than a published book for example.

Author contributions

Include a contributions statement before the introduction section. The contributions may fall into three categories: analysis, code, and writing. For example your author contribution statement might look like this:

\section*{Author contributions}
J. C. wrote the code that generated Figs. 1, 3, and 5. V. W. wrote the code that generated Fig. 4. Both authors wrote the code that generated Figs. 6 and

7. J.C. wrote sections 1 though subsection 2.3, and section 3.6 of the paper. V. W. wrote subsection 2.4 through 3.5. The authors wrote sections 4 and 5 together. J. C. performed stability analysis for the map and V.W. identified the fixed points for the flow.

5 Notes

Format your paper as described in the project section of the web syllabus. Use the ACM paper template provided. Organise the paper into the following sections:

1. Abstract
2. Introduction
3. Related Work
4. Methods
5. Results
6. Conclusions
7. References

The paper may not exceed 3 single spaced pages including references.