Assignment1-DH parameters and optimization

Start Assignment

Due Oct 17 by 11pm **Points** 100
Submitting a text entry box, a website url, a media recording, or a file upload

Building a three-link robot in hardware and software and optimize its DH-parameter model:

Note:

- This assignment does not yet involve the Arduino (although you should mount it). All programming is only related to the graphical user interface and the robotics toolkit and not the motors of the actual hardware.
- For this assignment, you are to work in your groups. Each individual must indicate which section of the report is written by them.
- Tape a notecard on your robot with your group names and include this in all your videos and pictures of your work.
- Your programming must be of high-quality use appdesigner and Matlab classes with good variable names, function names, and comments. The GUI elements should have good names also (not button1 etc.). The code should be well commented, indented properly (use <control i> and look artistic.

Given the links, motors, and other hardware, build/assemble a three-linked robot in hardware.

1. Arrange the base on the clipboard such that you have the maximum joint ranges and that the robot can reach all corners of the given board with this additional criterion: Shorten one of the joint lengths of your robot arm by the smallest digit from all group members user id. So, if your group ids were xx8262 and xx8263 you would shorten link 1 or 2 by two holes from the max length possible. Alternatively, you could distribute the shortened amount between the two joints (in this case 1 and 1).
2. In the report, show snaps shots of the robot, and explain how the joints and robot base were set up to maximize the range.
3. Using toothpicks or stir straws to place a coordinate system at the end-effector and one at the clipboard somewhere.
4. Measure the DH parameters and build the graphical model of the robot in the Robotics toolkit.
    1. Create a section of the GUI that will allow you to input the DH parameters of your robot and (you could also create it dynamically, using dials etc.) and build a robot of your robot and experiment with all the parameters until you understand them.
    2. Explain with pictures all the DH-parameters used.
    3. Explain each RTB command used to build the graphical model.
    4. Insert the joint limits (as measured from the real robot) into the model and visually verify that the robot looks and moves like the actual robot.

5. Build in an interface for your robot that allows you to move each of the joints (by a slider) in the graphical user interface and show its movements via forward kinematics.
6. Also create the ability to position the end-effector by small increments using the arrow keys of your keyboard. The position of the end-effector should be displayed in the GUI.
7. In at least 5 positions (pick easy joint angles, like 0, 90, -90 etc.), predict where the EE of the robot will be with respect to the clipboard coordinate system (use the robots base transform in your model to move the base) and verify the distance computation with actual measurements. Place the actual hardware measurements in a file with each line being the joint angles and then the distance measured. Explain any error that you observe. Add GUI elements to make this easy to do.
8. Write an objective function and run a minimization function (fminsearch) which allows you to optimize the DH parameters of your robot. The objective function will read the file that you have created in step 6 and return the average error between the actual hardware and the simulation of the robot. This function will be used in the fminsearch function to optimize your model. Add GUI elements to make this easy to do.
    1. **More details in class and notes. We will cover this topic shortly.**
    2. Show how the error improved from before and after optimization with graphs.
    3. In your objective function, have the option to draw the robot arm each time to see your robot evolve.
9. Make a brief video (~ 2 minutes) that shows your testbed, your GUI, the coordinate systems, and a simple example of how you set joint angles and compute the end effector locations. Upload the video onto YouTube and share the link in your report. You may be asked to present your video in class.

Report Requirements:

Write a report that summarizes your experience and experiments along with your ideas on where and how robots might be useful. Explain also how these simple robotics techniques could be used in a variety of scientific and engineering fields. Your report should have at least sections of abstract, introduction, methods, results, discussion/conclusions, etc. as appropriate. There is no requirement on the length of the report (a shorter/longer report does not mean that it is better).

The key is to demonstrate your understanding of coordinate systems and forward kinematics and of how to use and program with the robotics toolkit. In your report, include well commented and structured MATLAB code with all relevant graphs and illustrations to support your results, discussion, and conclusion. Presentation style (clarity, etc.) is a major component of a report.

* In the report appendix, place all your code, neatly structured and well commented. This can be the same between members. You may add your own additional comments to the code.

* Key points for grading (general): (1) level of understanding of the robotics toolkit and various robotics-related concepts (2) discussion of the various properties of your robot; and (3) presentation and discussion of results.(4) code commenting and structure.

* Turn in an electronic copy with a statement that states that this is your own work on the cover page. Please turn in your own report, do your own work. Even comment your own code, even if you wrote it together with your partner.

* Note that this is a safe-assign submission that checks your report against all others (including your partners, and past students) and also against the Internet. Obviously, some similarity between your group's members in terms of code and data collected is expected, but, the write-up should be in your own words and independent.

*The instructor at the end of the project may ask you individually to answer some oral questions regarding your project. So it is best if you know every aspect of your project.

Attachments

- **ExampleSetup.JPG**

Extra Credit: (+5) Explain in detail how you might use optimization to select the best position to place your robot on the clip board. Show a detailed algorithm (or better yet, write the Matlab code) for the objective function you might use to optimize the reach of the robot on the clip board. Draw a diagram of the inputs and outputs of the objective function. What would be the inputs and outputs to the fminsearch function?

Project1 Rubric

Criteria	Ratings	Pts
Report Formatting: Did the report contain all the required headings? Was there enough detail in the report about each section? Did it flow properly? Was it free of formatting and other errors?		20 pts
Dh-Parameter and Analysis Was there a clear understanding of all DH parameters and Offset? Wre there clear pictures and diagrams to describe this?		20 pts
GUI and Code. Did the GUI have a good layout and features that make it suitable for this project? Commenting and indenting and use of good variable names?		20 pts
Video present and of good quality. did it show all the features of the robot and GUI?		10 pts
Hardware/ Mounting. Was the hardware mounted properly and was there a rationale for where it was mounted?		10 pts
Optimization Code and Analysis. Was this code commented and did it present with a good error metric? Did the optimization work and produce a better robot? Were there graphs that showed error plots?		20 pts
Extra Credit. Did they explain in detail how the optimization would work?		0 pts
		Total Points: 100