Overview

The final lab report tests your understanding of EECS 16B Labs 6-9, with an emphasis on conceptual and analytical understanding. It also allows you to look at these labs from a bigger picture and reflect on your design process and choices. You may use your homeworks, pre-labs, labs, lab notes, presentation slides, and any other resources we provided throughout the semester to help you. **However, all of your answers and explanations must be in your own words; you are not allowed to directly copy from those resources.** The lab report questions for each lab will be released at the bottom of the corresponding Jupyter notebook. All of the final lab report questions will also be compiled together in this document and updated as new questions are released.

Requirements

Format

The report is to be done with your lab group using LaTeX or Google Docs/Microsoft Word. **At the top of the report, please include the names and emails of all your group members, as well as the arduino ID you use for checkoffs.**

Deliverables

For each section 1-4, complete the following:

- First, give a summary in your own words of what you did in that lab. Possible details to include: overview of the lab's objective, new components used, issues you encountered, etc. Details NOT to include: how you left your car at home, fried your BJT, or forgot to enable high-Z mode on your function generator.
- Then, answer all of the questions listed under the section header. Remember to fully and clearly explain your answers, and upload your work if necessary.

Submission

The final lab report is due on **Friday, May 03, 2024. Only one group member should submit the lab report to Gradescope and the rest of the group members should be added to the same submission.**

1 System ID

Summary

Give a summary in your own words of what you did in this lab.

Questions

1. What do θ and β represent physically, not mathematically? What are your values of θ and β, and do they reflect the car's performance while collecting data? Why/why not?

2. How did you choose the PWM input range for fine data collection? If there were other data ranges that could have also conceivably been chosen, why did you choose this range over other ranges? Please include a graph of your car's coarse data to support your answers.

3. To implement a higher order polynomial model, what would you need to change in the current lab flow to calculate the coefficients for this new model? Evaluate the benefits and drawbacks between using a higher order model vs. a linear model.

4. As the batteries run low, assume that the corresponding velocities for each PWM input go down linearly. In other words, the velocity vs. PWM input curves for both wheels shift down by some value v_o, where v_o is non-negative and increases as the battery power gets lower. If we still aim for the same operating point velocity and use the same linear model, how will the car's performance change as the battery level decreases?

2 Controls

Summary

Give a summary in your own words of what you did in this lab.

Questions

1. What are the open loop equations of SIXT33N's control scheme for our PWM input, $u[i]$? What are some advantages and disadvantages of open loop control?
2. What are our equations for closed loop control? Why might we want to incorporate closed loop control, rather than open loop, in SIXT33N?
3. What is our system eigenvalue? What are the conditions on f_l and f_r such that our system eigenvalue is internally stable?
4. What is the effect of setting both $f_l = 0$ and $f_r = 0$?
5. What is the purpose of the jolts? Why might we have different jolts for left and right wheels?
6. Why can't we use negative f-values for both wheels? If we wanted to use negative f-values for both wheels, how should we change our closed-loop model equations such that our car goes straight and corrects any errors in its trajectory?
7. What does a zero `delta_ss` value tell you about your car's trajectory? What about a non-zero `delta_ss` value? What kind of error is it supposed to correct when we add it to our control scheme? (**Hint**: Think about the difference between the trajectories for a zero versus a non-zero `delta_ss` value.)
8. How did you change the closed-loop model equations to allow the car to turn? Write the equations below and explain how they change for turning left, turning right, and going straight.
9. Describe how the trajectory of the car would look if we had a constant δ_{ref}, rather than our δ_{ref}, which changes as a function of the timestep.

3 SVD/PCA

Summary

Give a summary in your own words of what you did in this lab.

Questions

1. What 4 words did you choose for classification? What characteristics of this set make your words good for classification? Provide at least two features. Compared to other sets of words with similar ideally good characteristics, why is this set preferable to others?
2. Why is taking the envelope of your voice signals a good choice for classification, especially considering that this classifier is implemented on an Arduino?
3. Why do we need to use SVD/PCA to represent our data set?
4. If we were to use the transpose of our data matrix for SVD, which rows/columns of which matrix correspond to the principal component vectors representing the recorded words? Why?
5. How many basis vectors are you using, and how did you choose this number? What are the benefits vs. tradeoffs of increasing or decreasing the number of basis vectors by a small amount? What about for increasing the number of basis vectors by a large amount?
6. What are length, prelength, and threshold for our data pre-processing? How does changing them affect your alignment? Include both the definitions and the values you chose. What kinds of words are better suited for our pre-processing method with live classification?
7. Why can we simply take the dot product when projecting our recorded data vector onto the principal component vectors?
8. What is EUCLIDEAN_THRESHOLD? What is LOUDNESS_THRESHOLD? Include both the definitions and the values you chose. During live classification, which threshold was more difficult to satisfy, and how do you know?
9. How different was live classification in practice from what you found in the SVD/PCA lab? Why do you think that is?

4 Feedback

1. **Extra Credit:** To receive extra credit, please provide 1-2 sentences for each of the following parts:
   a) How well do you feel that this assignment evaluated your understanding of labs this semester?
   b) How much time do you think this assignment took you to complete? (Just a number is fine for this part.)
   c) What changes to lab reports would improve your experience?
2. Additionally, please feel free to provide any feedback you have about 16B lab or anything we can do to better support you.

5 Collaborators and Sources

Please detail each group member's contributions to the lab report. Also, cite any sources you used that were not provided with the course materials.