ECE 4950 Project 3

Closed-Loop Motor Control, Life-Cycle Analysis, and Employee Training Program

Goals

1. Understand closed-loop control through position control experiments on a real motor (hardware-in-the-loop).
2. Appreciate "Life-Cycle Assessment (LCA) output as a design constraint.
3. Understand overhead rate calculations for a business.
4. Understand the concept of lifelong learning through an Employee Training Program
5. Appreciate the Design Failure Modes Effects Analysis as a part of the design process.

Customer Requirements for Motor Control

A pointer made up of a rigid material (including but not limited to wood, metal, laser-cut acrylic or cardboard) must be placed on the shaft of the supplied DC motor in order to point to any position in a circular space when the shaft spins. Note that the supplied motor will also serve as an actuator for the final project.

This motor must have closed-loop motor control implemented using the real-time workstation and will start its motion from a reference position of the designer's choice.

There are two options for implementation:

1. A sticker color/shape will be chosen by the user in Matlab either from a command prompt, a GUI consisting of at least simple push buttons or something similar. The sticker colors/shapes and positions on the game board will have been processed using the game state sensor (camera) and Matlab image processing and will display in the GUI available for selection by the user.

2. Colors, shapes, and gameboard of the final project assigned to your team can be used to demonstrate closed-loop motor control. To get ahead with your final project, consider partially building your system – at least one of the axes you plan to use the motor on and mount it there for demonstration. Your system will have to identify the colors and location of the provided chips, and display in the GUI, allowing the user to select any one for the motor to smoothly move or point to.

The quality of the user interface and mounted arm motion (directly correlated to motor control) will be used to judge the implementation.

Life-Cycle Assessment

Life-Cycle Assessment is a "cradle-to-the-grave" approach for assessing the environment or economical impact for a given industrial system. The purpose of this exercise is to perform the LCA on a single part of your system, in this case, the system storage and shipping box. Follow the instructions here to complete the analysis: http://akapadi.people.clemson.edu/ece4950files/LifecycleAnalysis.pdf

Startup Company Financial Analysis

Use the Excel Spreadsheet found here to calculate costs/expenses associated with a startup company. Using the Description in column F, fill in the blanks in column A (noting that some cells in column A will populate themselves based on the inherent formulae).

1. Consider the field of the startup and thus the hardware and software requirements.
2. Consider the amount of furniture required based on the number of employees.
3. Consider amount of travel for the engineers.
4. Consider the bank loan amount required to get started.
5. The Fringe Benefit rate varies by state and company. Clemson University has a 36% rate for faculty and staff. Consider where the startup will be located and look up Fringe Benefit Rates in that area. Fill the % in cell A7.
6. Once the Excel sheet is populated, transfer the totals to the MS Word Document (found here) in the requisite colored boxes. Complete the Overhead Calculations and Client Billings.

Note that the calculations and estimates should be based on your own idea of what your startup would look like, with estimates for salaries and costs to be researched by you dependent on the location (for example, an engineer in SC would make less than an equivalent engineer in CA given the cost-of-living difference etc. Rental costs, utilities etc. would also be different)

Employee Training Program

Assume that your team is working as a start-up company upon graduation, similar to the one whose startup costs were analyzed above. An important responsibility of the company and the employees themselves is to ensure that each employee continues to develop their skills and knowledge. Design a training schedule that describes the specific training activities, the reason for the activity and an estimated cost of each activity (for example if it costs $150 for each employee hour).

Describe a training program tailored to each team member that will ensure everyone in the startup will maintain their current skill level while also obtaining new skills. Plan for the next year and include a schedule, description of activities, estimated time commitment and cost (use the cost-per-hour from the financial analysis).

Lifelong learning is important for the career of an engineer. How much time and money does the team think it needs to spend on maintaining/improving an employee? State the amounts and rationale in one paragraph.

Define specific activities that the trainee will perform over the next year and explain what they will get from that activity. Consider two generic archetypes instead of addressing each group member individually:
1. A newly graduated engineer such as yourselves who will solve technical problems/projects.
2. A newly graduated engineer such as yourselves who will manage technical projects.

A three-column may be an easy way to handle this. As an example of an activity for a newly graduated engineer working on robotics/controls projects:

Activity	Benefit	Cost
Attend the 2021 American Control Conference in New Orleans, LA	See state-of-the-art control solutions that could be applied to robotics. See vendors of control hardware and software.	Travel to New Orleans, LA $1,500 + Conference Registration $600 + Food and lodging for 3 days $1,000 + cost of missing work (company hourly rate * 3 days) = $$$$
Pay IEEE membership	Exposure to updates in technology	Membership $400

At least 2 activities per archetype are expected.

Safety and Risk Assessment

The project must be safe for use by the customer. Perform and document a DFMEA for the final project. Document your analysis using the DFMEA table and Risk Assessment Matrix shown in the class lectures. Show that the results of the analysis have been implemented to make the design safe, that is, describe what changes have been made as a result of the safety analysis.

Appendix A: Implementing Closed-Loop Motor Control

Please follow the steps listed below:
1. Download the Simulink file.
2. Mount the DC motor preferably along an axis that you will use for your final design.
3. Connect the supplied DC motor and adjust the gains carefully to see their effect on the position response.
4. Document your observations and take video recordings as well.

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Use the guidelines below to complete your report and add at the end of your report.

Group Number and Member Names:

Score	Pts	
	5	**General Format - Professional Looking Document/Preparation (whole document)** a)Fonts, margins (11pt, times new roman, single spaced. 1" margins on all sides). b)Spelling and grammar are correct c)Layout of pictures – all figures need numbers and captions and must be referenced inthe text d)Follows the page limitations below. e)References. Use IEEE reference format. f)This grading sheet is included as the final page.
	5	**Page 1: Title, Group Name, Group Members, and Date** **Executive Summary** (1 concise, well-written paragraph) Provide an overview of this project. Briefly describe what you did and what you learned.
		Control Subsystem Design
	5	**Page 2: Overview of Hardware-in-the-Loop** (~1/2 page) Describe in your own words what Hardware-in-the-Loop means. What is the difference between a full simulation and a Hardware-in-the-Loop simulation? What are the strengths of HIL?
	10	**Pages 2-3: Document Hardware** (1 page) Describe and show images of the equipment used, connection diagrams, calculation of resolution – pixels per square inch/cm on game board etc. Is the camera an appropriate sensor?
	10	**Pages 4-5: Document Software** (2 pages) Using Flowcharts, state diagrams, data structures etc. describe how the software is implemented. There is no need to include the source code.
	10	**Page 6: Document Motor Experiments** (~1 page) Plot the effect of changing gains using the reference, actual position and error signals. What happens when the proportional, derivative and/or integral gains are changed?
	15	**Pages 7: Document and Evaluate your User Interface** (~1 pages) How does the user interface connect the Camera-As-A-Sensor and the motor? What information is provided to the user and why? Document using screenshots and similar images.
	10	**Pages 8-9 Life Cycle Analysis (2 pages)** You are proposing a design that consumes resources. Follow the "Life Cycle Assessment (LCA) Exercise" for the shipping box for your project to examine the life cycle for this one part of your design. Be sure to interpret the results of the computer program. Complete this section of the report by saying that a similar analysis could be done on the entire project to reduce environmental impact.
	10	**Page 10-11: Financial Analysis** Provide a financial analysis that examines turning your group into a start-up company. Use the spreadsheet provided to make calculations and report your results using the MS Word document template and include here.
	15	**Page 12: Employee Training Program**
	15	**Pages 13-14: Safety Analysis** The project must be safe for use by the customer. Perform and Document a DFMEA for your project. Document your analysis using the DFMEA Table and Risk Assessment Matrix shown in the class slides. Show that you have implemented the results of the analysis to make your design and workspace safe – that is document what changes you made to make your system and space safe as a result of the safety analysis. Can you conclude your system is safe?
		Page 19: Grading Sheet