xDI - Cartilage Bioreactor

Client: Prof. Corinne Henak
Faculty Consultant: Prof. Corinne Henak (ME); Prof. Paul Campagnola (BME)
Team: Griffin Radtke (ME Operational Leader & Communicator)
Jeffery Guo (ME Admin & Accountant)
Sydney Therien (BME Operational Leader & Communicator)
Emilio Lim (BME BWIG & BSAC)

Status

Report Date: 01/31/24
Next Milestone: Individual Presentations
Deadline: 2/20/24
Status: on schedule (green), deadline at risk (Yellow), deadline unachievable (red)

Technical Summary

The team spent the first two weeks creating a semester meeting schedule and identifying next steps for the bioreactor. With Chanul graduated, there was some slight redelegation of team responsibilities (see above). Going forward, Emilio will continue to work on the triangle wave circuit, Jeffery will experiment with an H-bridge/current regulator/microcontroller circuit, Griffin will continue to modify the CAD and spearhead the housing fabrication effort, and Sydney will investigate flexures/bearings for the VCA to prevent horizontal movement.

New Tasks

Task Name	Description and Concrete Outcome	Owner	Est. Time [hrs]
Take point on finding a bearing/flexure for VCAs	Plan to conduct in-depth research about potential solutions to fixing VCA such that force is applied only vertically.	ST	0.5
CAD Improvements	Fine-tune CAD, add fastener locations, etc. to escalate design to a print-ready state.	GR	2
Test Thorlabs VCA	Test functionality of Thorlabs voice coil actuator, verifying operation and ability to output desired amount of force	JG/EL	1.5
Obtain H-bridge and current regulator	Purchase H-bridge and current regulator from the Makerspace	JG	0.5

Old Tasks

Task Name	Description and Concrete Outcome	Owner	Est. Time
Soldering of PCB	Meet up with professor Mark Allie to learn soldering on the PCB board with the components he has in his lab.	EL/JG	2-4
Prepare outreach materials	Work with BMEs to create a lesson plan and slideshow to lead third graders in building cardboard prosthetic hands.	ST/CK/EL	6
Work on overall CAD files, design workaround for imaging	Designed custom, 3D-printable tray for imaging bioreactor samples post-device use	GR	2
Purchase VCA	Fill out purchase form for Thorlabs VCA and send to Patrick	JG	0.5

Gantt Chart

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Jan		Feb				Mar				Apr				
Task	24	31	7	14	21	28	6	13	20	27	3	10	17	24	1
Individual Presentations					O										
Working Prototype										O					O
Bioreactor CAD Model															
Fabricated Bioreactor															
Circuitry with All Six VCAs															
Final Review										O					O
Design Specification Validation															
Bioreactor Assembly with Circuitry															

X = Completed Tasks, O = Milestone Deadlines

Technical Section

Author: Sydney Therien
Editor: N/A

Take point on finding a bearing/flexure for VCAs	Plan to conduct in-depth research about potential solutions to fixing VCA such that force is applied only vertically.	ST	0.5

In the TA meeting that took place on Tuesday as well as after, the team discussed some general next steps for the project. Since the CAD is going to be more fine-tuning (adding fasteners, double checking dimensions, etc.), it doesn't make sense to have this be two people's responsibility (may just end up undoing and redoing each other's edits w/o making progress). In circuit testing, Emilio and Jeff confirmed that the VCA will certainly need something that fixes the horizontal directions so its movement is purely vertical. Therefore, I will be conducting in-depth research about potential methods and products to prevent this horizontal movement. The outcomes will be presented at the faculty meeting this Friday, so stay tuned.

Author: Jeffery Guo
Editor: N/A

Obtain H-bridge and current regulator	Purchase H-bridge and current regulator from the Makerspace	JG	0.5

Another potential method to control the current/voltage input to the VCA and to operate the VCA involves the use of an H-bridge and current regulator. Patrick has suggested this idea to be feasible, and he stated that the H-bridge component can be purchased from the Makerspace. If feasible and convenient to implement and test, Jeffery will purchase the necessary components and test this control method with the VCA while comparing the viabilities between it and the triangle wave generator PCB provided by Prof. Mark Allie.

Author: Emilio Lim
Editor: N/A

Test Thorlabs VCA	Test functionality of Thorlabs voice coil actuator, verifying operation and ability to output desired amount of force	JG/EL	1.5

Upon receiving the voice coil actuator from our TA, Emilio and Jeffery went to the Makerspace to test the functionality of the VCA. We used an oscilloscope to measure the output voltage from the peak-to-peak value, frequency, duty cycle, and wave profile. We tested the VCA without any weights on it to check if the circuit is able to produce an output to drive the VCA. Once we ascertain that it is capable of working, we then proceed to loading weights. We used washers as weight placeholders where each washer weighs exactly 20g. Through calculations, we applied 400g of washers and slowly calibrated the VCA by changing the amplitude using the amplitude potentiometer.

We finalized the setting by slowly turning the potentiometer anticlockwise, starting a relatively large amplitude. We stopped when the pulse was barely visible. The setting used on the

circuit board was 9V. The measured peak-to-peak voltage is 4.38V at a 50.28% duty cycle and 2.6Hz. It was found that there is a slight displacement on the right side of the voice coil making the oscillation to be biased on one end. This will be a problem as the force applied will no longer be under uniaxial loading. This problem can be tackled by exploring the housing and ensuring no side movements are observed. We will also need to verify the force output by using a load cell to ensure the force is accurate.

All photo evidence can be found in our Google Drive under media > testing 1/31; or accessed via: 🗀 Testing for 1/31

Previous Work

Author: Emilio Lim
Editor: N/A

Soldering of PCB	Meet up with professor Mark Allie to learn soldering on the PCB board with the components he has in his lab.	EL/JG	2-4

The electronics team will be meeting up with professor Mark Allie from the ECE department to learn how to solder. Professor Allie also has all the required parts and components for us to experiment with since the PCB board we obtained was designed by him. The planned components to solder on are several circuits such as an integrator and power amplifier circuit. More details will be added after the electronics team meet up with professor Mark next week.

Author: Sydney Therien
Editor: Emilio Lim, Chanul Kim

Prepare outreach materials	Work with BMEs to create a lesson plan and slideshow to lead third graders in building cardboard prosthetic hands.	ST	6

While not directly relevant to the project, my efforts over this period were directed towards fulfilling the outreach requirements set by the BME department. All of our materials are prepared, and we are looking forward to teaching the lesson some time in the next two weeks. If you are interested in hearing more about what our outreach plan involves, please reach out!

Author: Griffin Radtke
Editor: N/A

Work on overall CAD files, design workaround for imaging	Designed custom, 3D-printable tray for imaging bioreactor samples post-device use	GR	2

Given that the bioreactor tray itself is incompatible with the dimensions of a microscope stage, I created a 3D-print (BioMed Clear V1) - compatible tray, aimed to simplify bioreactor-to-microscope transport with a general workflow as follows: remove samples from bioreactor in in-bioreactor tray and transport to BSC; transplant each cartilage sample dish into the mentioned imaging tray (within BSC); either incubate tray (which is biocompatible) until desired imaging timeframe or proceed to imaging. Given that the dimensions of the given tray are identical to commercial 6/12 well plates, the tray will be universally compatible with a wide range of microscope stages.