Project Final Report

I. Project Overview

Team Name	Kimchi and Chips
Project Name	State Action Reward
Project Period	2020-08-28 To 2020-12-31
Project Purpose	Study CNC processing of aluminium structural parts Develop open source motion control system Muscle Memory Creation of an artwork prototype incorporating these –
Progress & Achievements	A prototype of the State Action Reward artwork was presented on 22nd October as p art of ARKO (Arts Council of Korea) arts and technology commission.  Exhibition demonstration day

Demonstration of Muscle Memory training

Demonstration of mechanism with integrated motor network

II. Progress Report – Comparative analysis on project execution plan and implementation

Project module	Execution Plan	Key milestones reached	Notes

CNC prototyping	• Discuss with experts at FabLab • Create prototype parts from Aluminum 6061-T6 and Stainless Steel 304 • Design finalization for production by professional CNC company	Due to the limitations of the coolant on the CNC machines at FabLab, the design was changed to produce all parts from Aluminium. Test parts were cut on the machine, and the design was adapted accordingly.	
PCB design	Develop a new generation PCB design incorporating: • Motor driver • High resolution encoder • CAN communication • Current measurement • OLED interface • Dial control • LED indication • Voltage regulator • Fuse protection	New design developed and produced	–

〈 Instructions for project preparation 〉

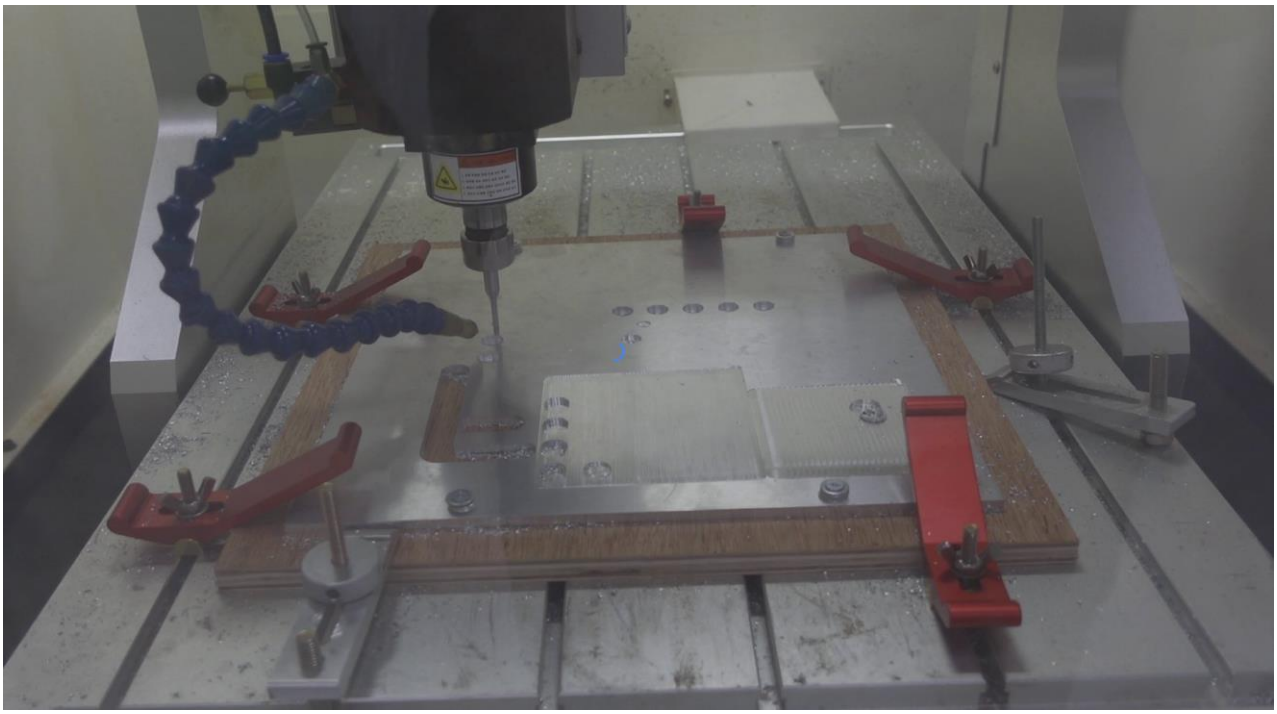
• Please provide your project execution plan and explain your project achievements including quantitative and schematic data.

• Explain any changes made to your execution plan and the actual project implementation.

• Provide detailed description of your project achievements for each project module.

III. Project Achievements

Learning CNC techniques for metalwork



Working with the TinyRobo CNC and Fusion 360, we were able to learn how to:

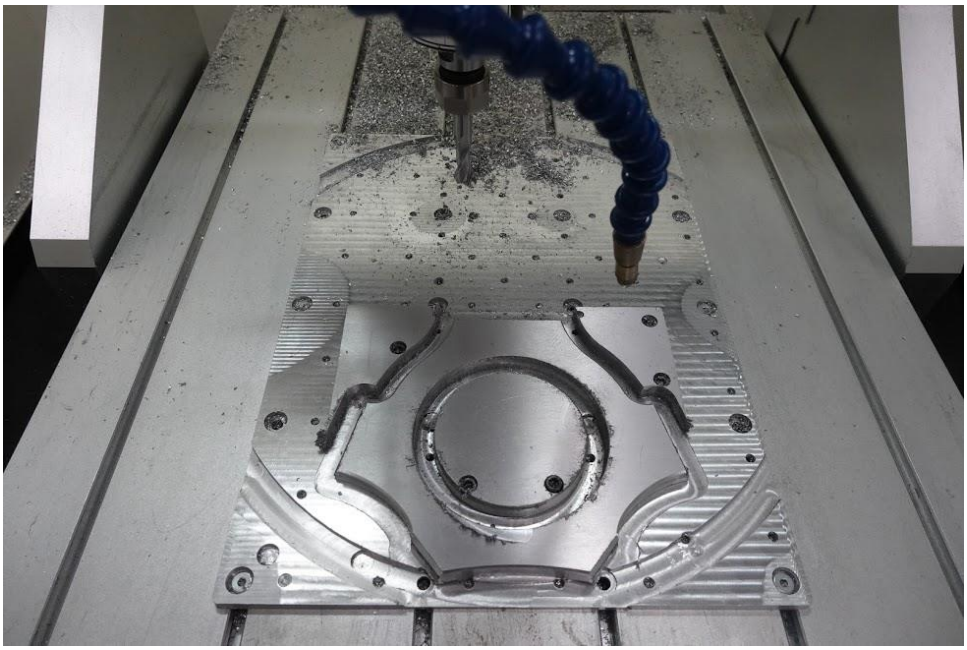
1. Design parts for manufacture
2. Create tool paths for for pocketing, roughing and slotting operations
3. Perform tool paths and successfully create features on aluminium stock

So that it may be useful to future FabLab residents, we published the following information about th e machine, including measurements which are not available in the existing documentation: https://paper.dropbox.com/doc/KC65-CNC-specs--BAwyzq7hH3T7GFxtAhXmgzGNAg-noi43QoQNJfhTcNL9Ls5g

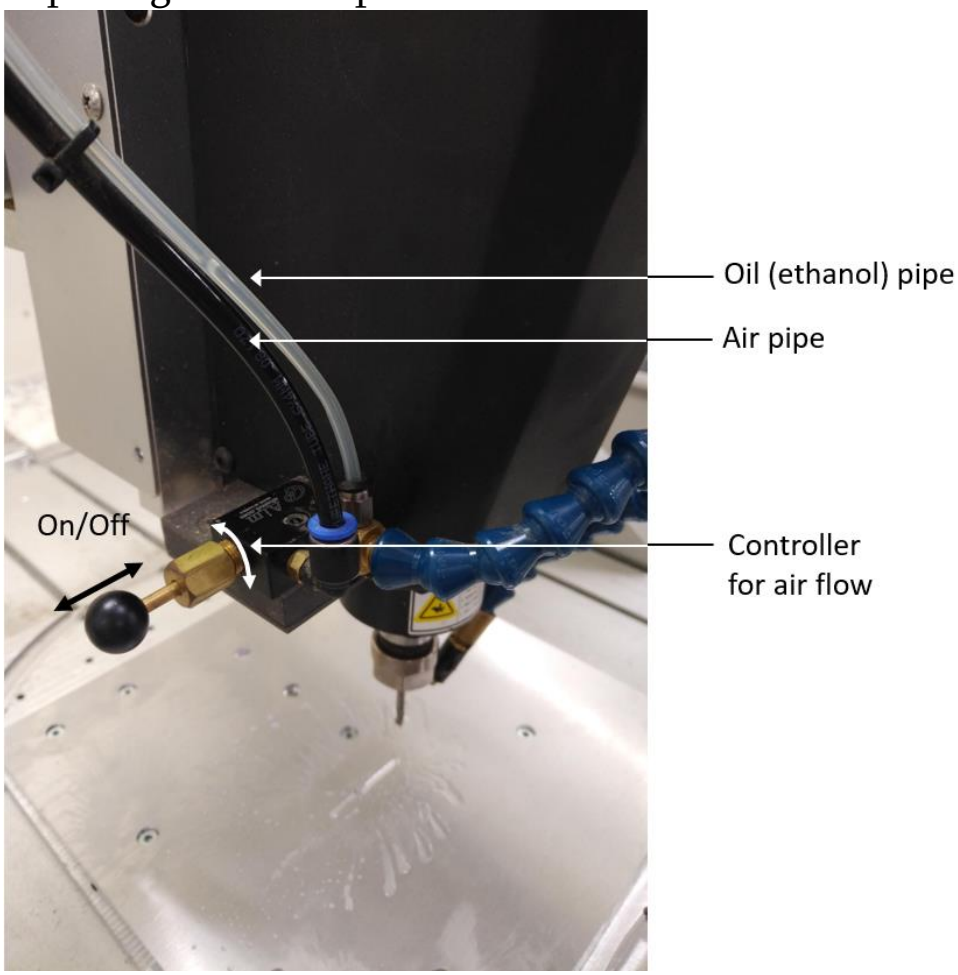
Information on the end-mills is published at: https://airtable.com/shrl4NfBLozkaedL6

CNC Jig for part production

To efficiently create accurate parts and to protect the machine, a specialised CNC jig was designed
This was designed to fit the maximum cutting dimensions of the machine
The jig can be seen holding a part being cut in the machine:



Exploring coolant options for the machine



When cutting with the CNC machine, it is important that suitable coolant is used in order to avoid ch ips becoming stuck in the end-mill and ultimately the cut operation to fail causing either:

1. End mill breakage

2. Ruined part

Based on online research, safety and cleaning considerations, and research into the hardware which was available at the FabLab, we successfully tested using Alcohol as a coolant. So that it may be useful to future FabLab residents, we created the following documentation on this method: https://www.dropbox.com/scl/fi/cx7cw9i4cd39m470vaskv/KC65-_-How-to-use-an-alcohol-as-a-coolant-on-the-CNC.paper?dl=0&rlkey=ybr80xqymnde4g2xanbs71suu

Methods for faster iteration on CNC machine

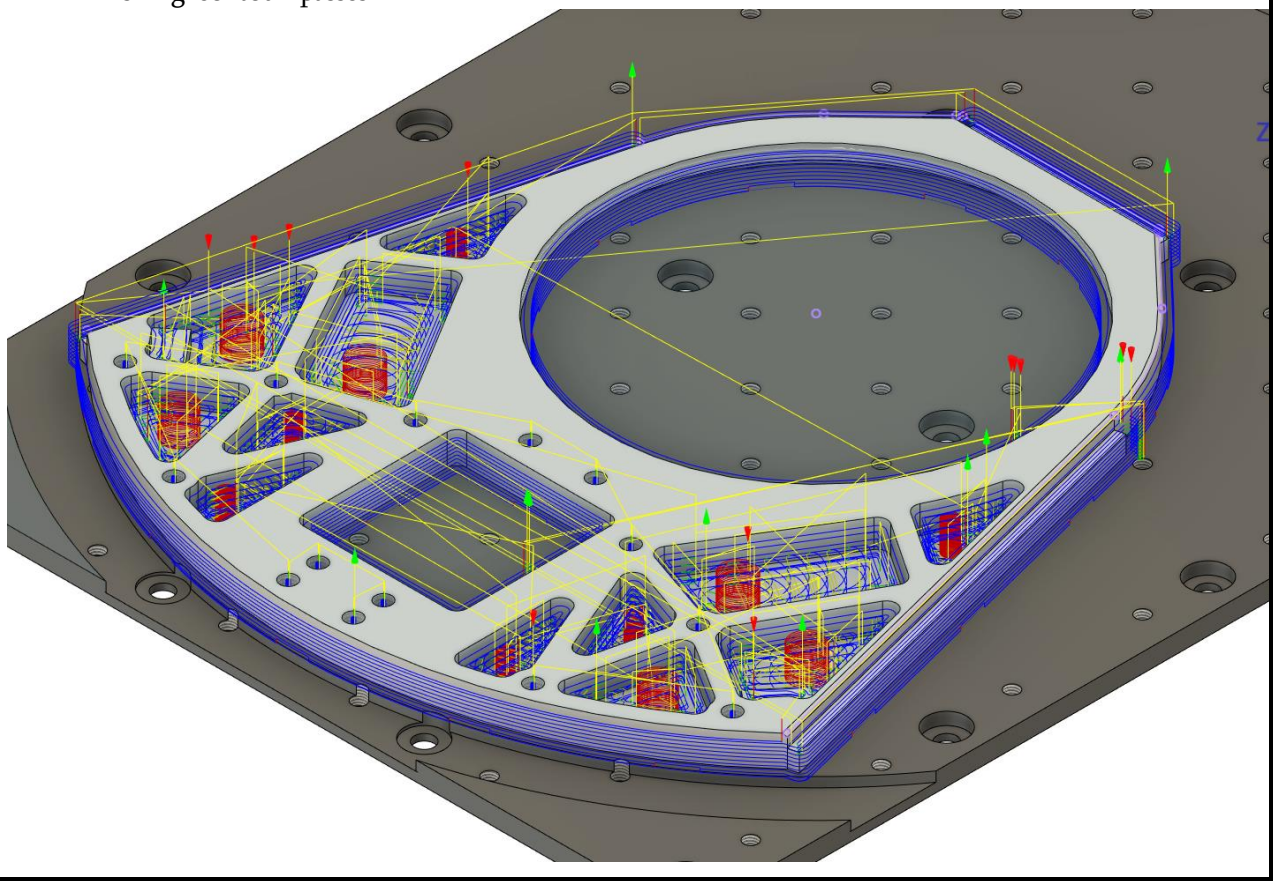
Working with the CNC machine was very time consuming, and in order to iterate faster we implemented the following workflow elements:

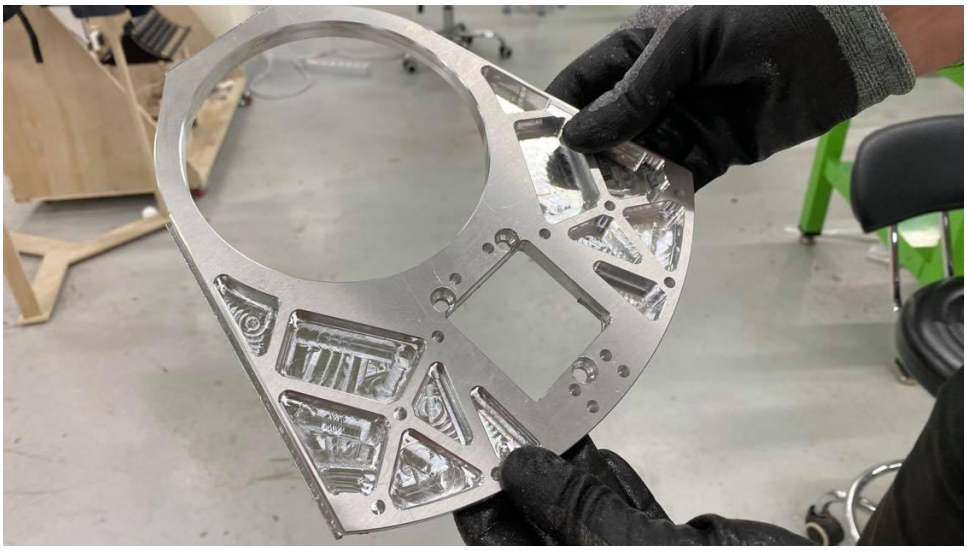
- Secure remote control of CNC machine interface for file loading and monitoring (not for machine operation)
- File sharing scheme between computers in the FabLab space and the CNC control computer, allowing for saving of files directly from Fusion 360 to the CNC control computer.

CNC creation of structural parts

Structural parts were developed incorporating:

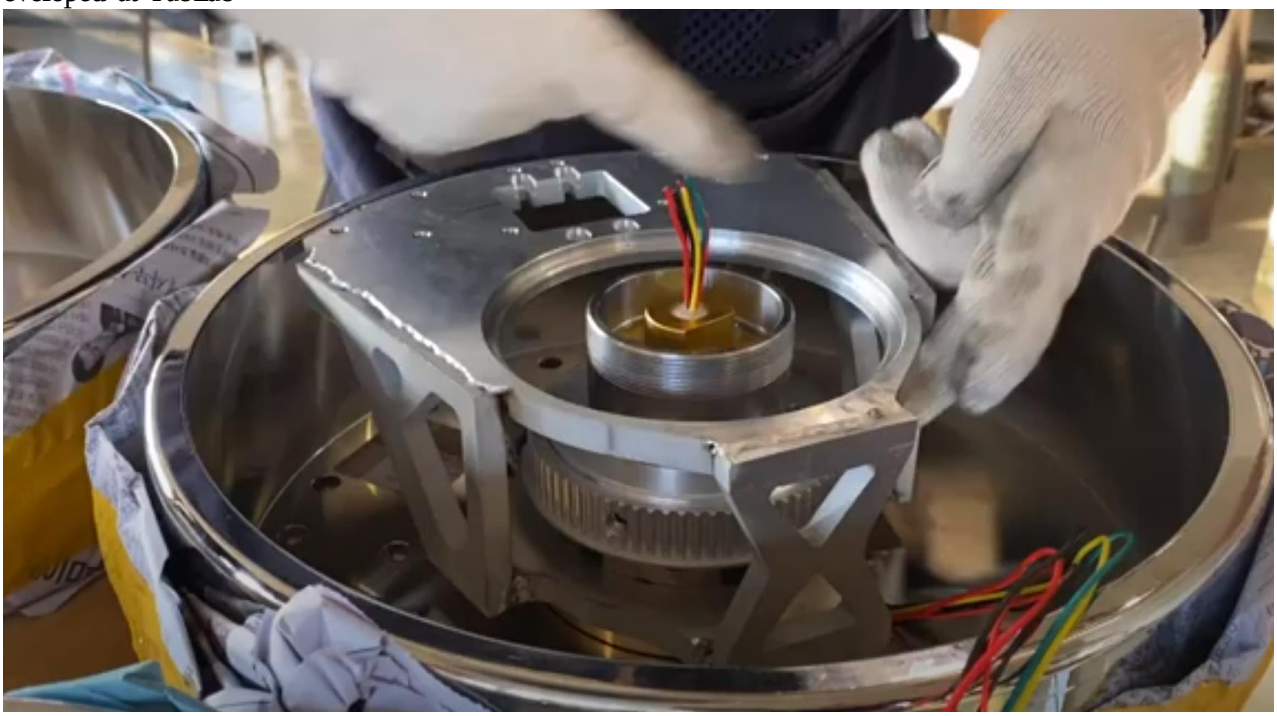
- Slotting
- Shelves
- Chamfer
- Adaptive Clearing (at different tool sizes)
- Finishing contour passes





Develop CNC design for professional manufacture

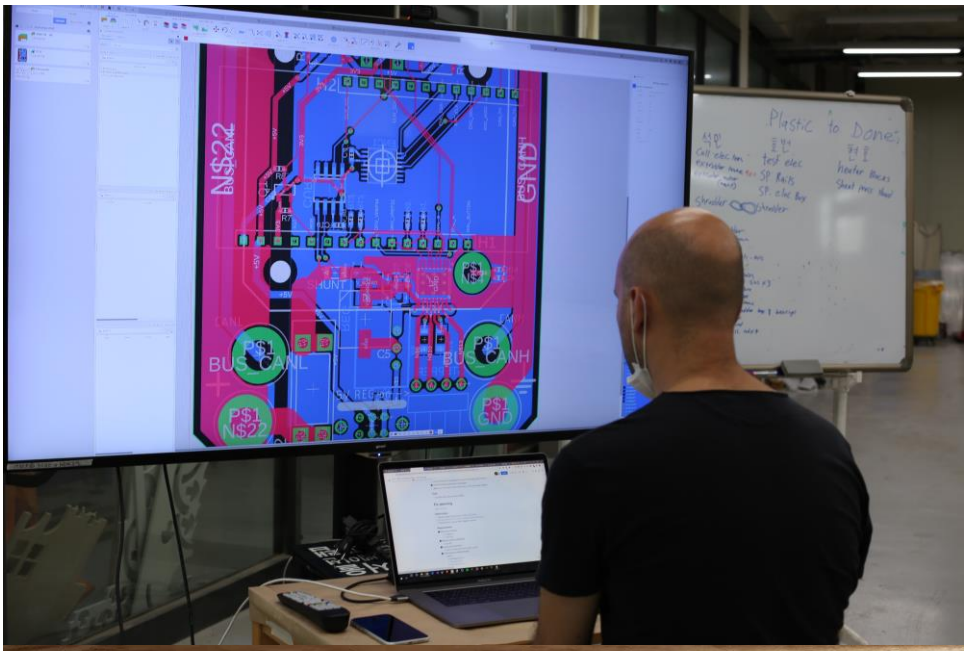
A complete working prototype was developed with a professional CNC company based on the design d eveloped at FabLab

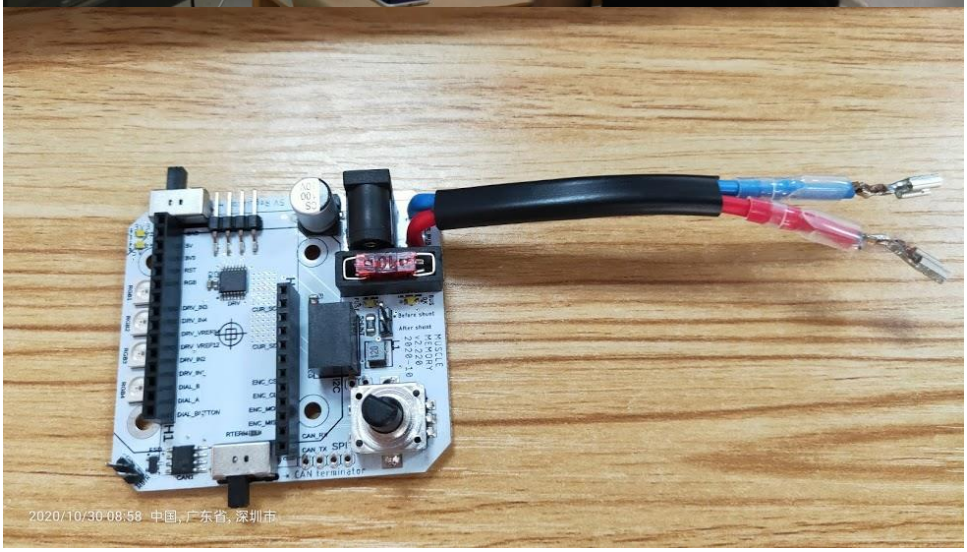


Develop Muscle Memory PCB

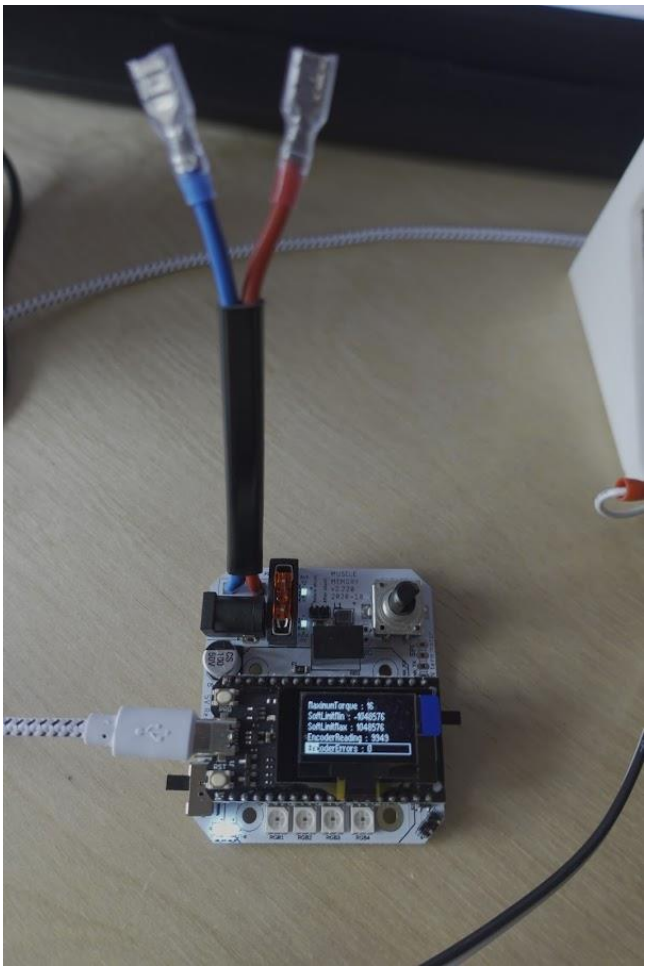
Electronics design was designed, produced and tested.

A space and cost efficient design was produced with high efficiency, accuracy and useability





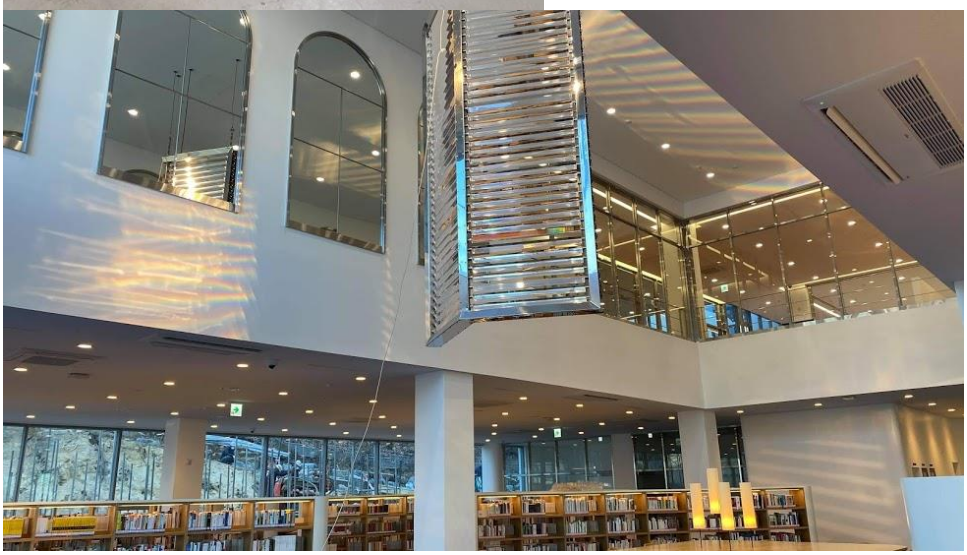
Development of Muscle Memory firmware



The Muscle Memory firmware is open source and available for download at https://github.com/elliotwoods/MuscleMemory

Deploy Muscle Memory system into kinetic artworks

To test and demonstrate the capabilities of the Muscle Memory system, the motors were installed in a public artwork. 80 motors work together in a network. As the artwork is installed in a library, it is important that the artwork be quiet, efficient and reliable.



〈 Instructions for project preparation 〉

- Please explain your achievements in detail.
- Provide a comparative evaluation on the project preparation and implementation.
- Attach any other supporting material including press release, photographs and other references.

IV. Self-evaluation

CNC DESIGN

Cutting parts on the CNC machine was more time-consuming than expected, and therefore not as many iterations could be performed as was hoped. Furthermore, it was not possible to work with Stainless Steel due to the limitations of the machine setup.

Alcohol coolant was explored, but needs further investigation to achieve optimum performance.

Common strategies for cutting tool profiles (feeds and speeds) did not work well with the machine. It is expected this is either because of

1. Insufficient cooling
2. Low torque on spindle axis

Due to this, much higher RPMs with lower feed and plunge rates needed to be applied. This creates issues with lower quality parts, shorter tool life and significantly longer cut times. Further investigation is needed.

We were not able to iterate the design for the 'Top' part, and subsequently it was overweight when produced by the professional CNC company. It is difficult to prototype this part on the machines available at the FabLab due to its size.

PCB DESIGN

The PCB mostly performs as expected. Some components had issues (e.g. the USB-Serial component on the daughter-board would overheat). A new iteration of the PCB design is now underway to replace the daughter-board with components directly on the PCB.

V. Suggestion for Improvement – for Fab City Project Progress

In general, the FabLab was a fantastic place to work with a good culture, and the team performed exceptionally well. We would love to work at the Fab Lab again in the future.

FABLAB AVAILABILITY ANNOUNCEMENTS

During a visit to the FabLab close to our deadline (perhaps October 8th), 3 team members came to the FabLab for a final day of working on the CNC machine. After we arrived, we were informed that the FabLab was not available that day due to a workshop, this was really unfortunate timing for our project.

As per the contact, this should be announced sufficiently in advance (e.g. at least one day) as it caused

a significant disruption to our schedule. This rule is already noted in Article 6.2 of the Terms of Use Agreement.

DD MM 2020

Team Name : Kimchi and Chips

Representative : Elliot Woods

(Signature)

to Seoul Innovation Center