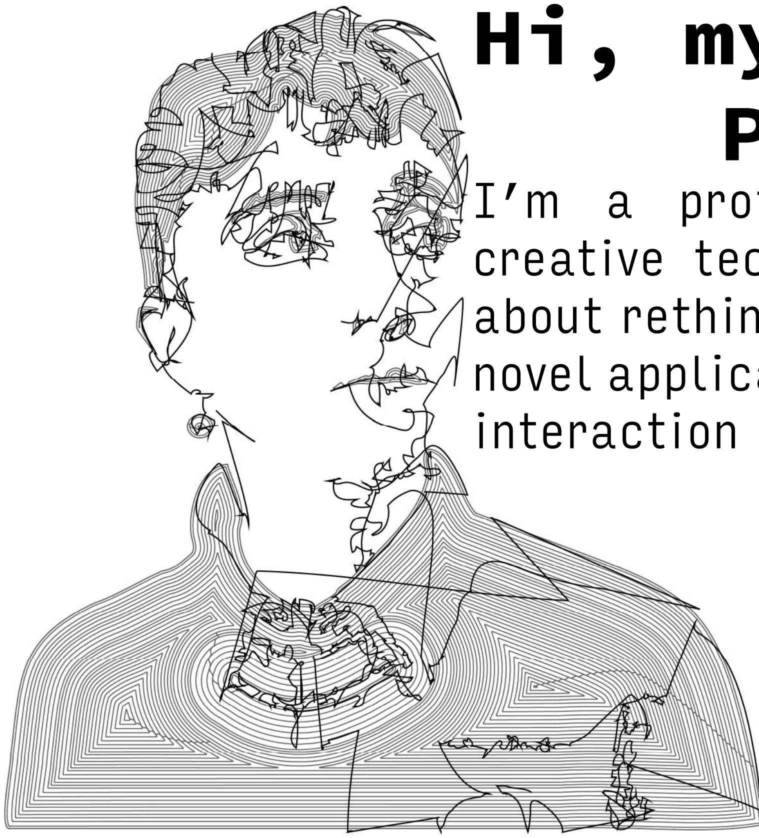

# PHOEBE DEGROOT

PORTFOLIO 2021



# Hi, my name is Phoebe DeGroot

I'm a professional fabricator turned creative technologist who is passionate about rethinking the use of machinery for novel applications in design, automation, interaction and creative expression.

Personal Website

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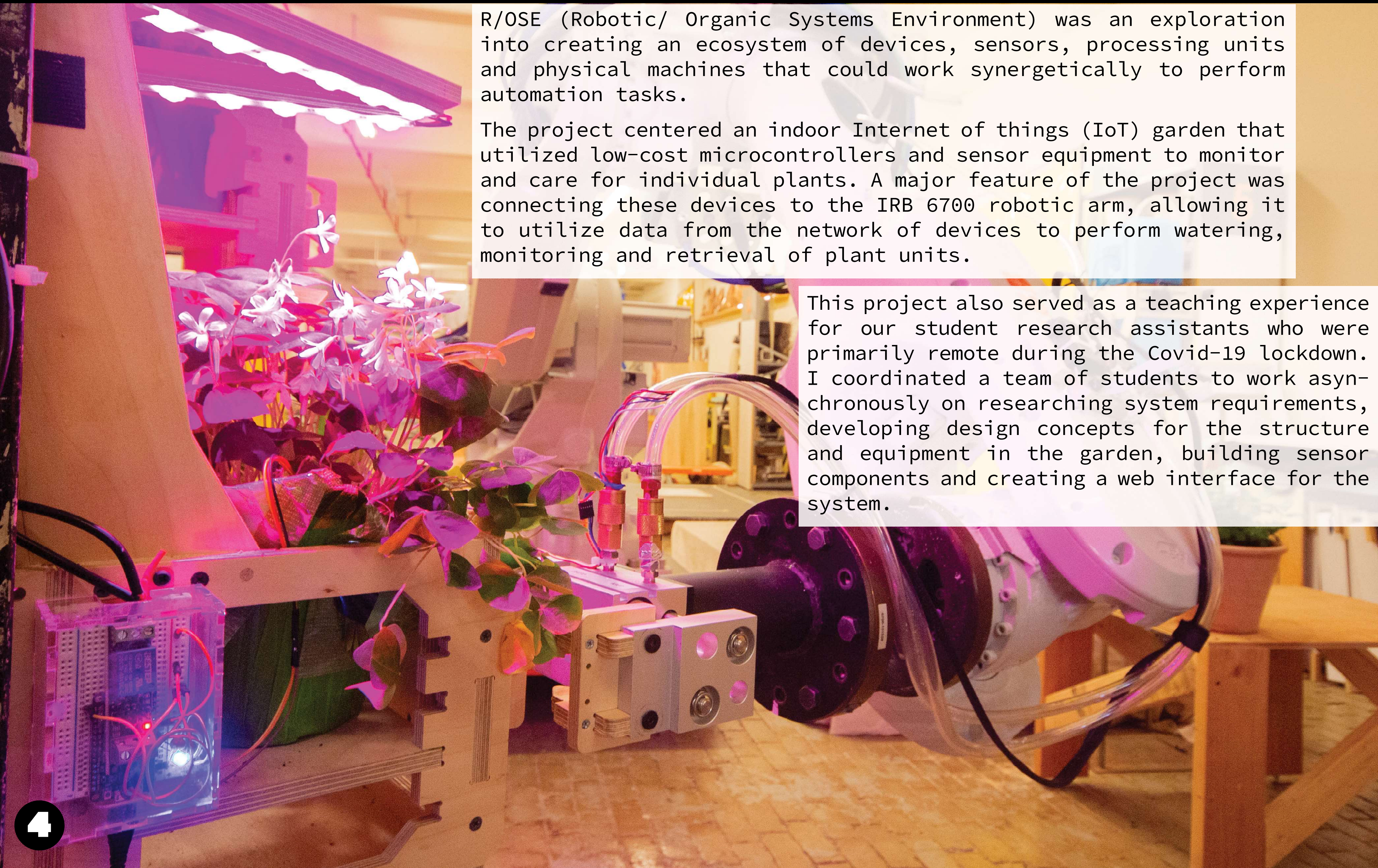
# R/OSE

*Robotic / Organic Systems Environment*

CAA INTERNAL R+D
PROJECT LEAD
9.2020-05.2021



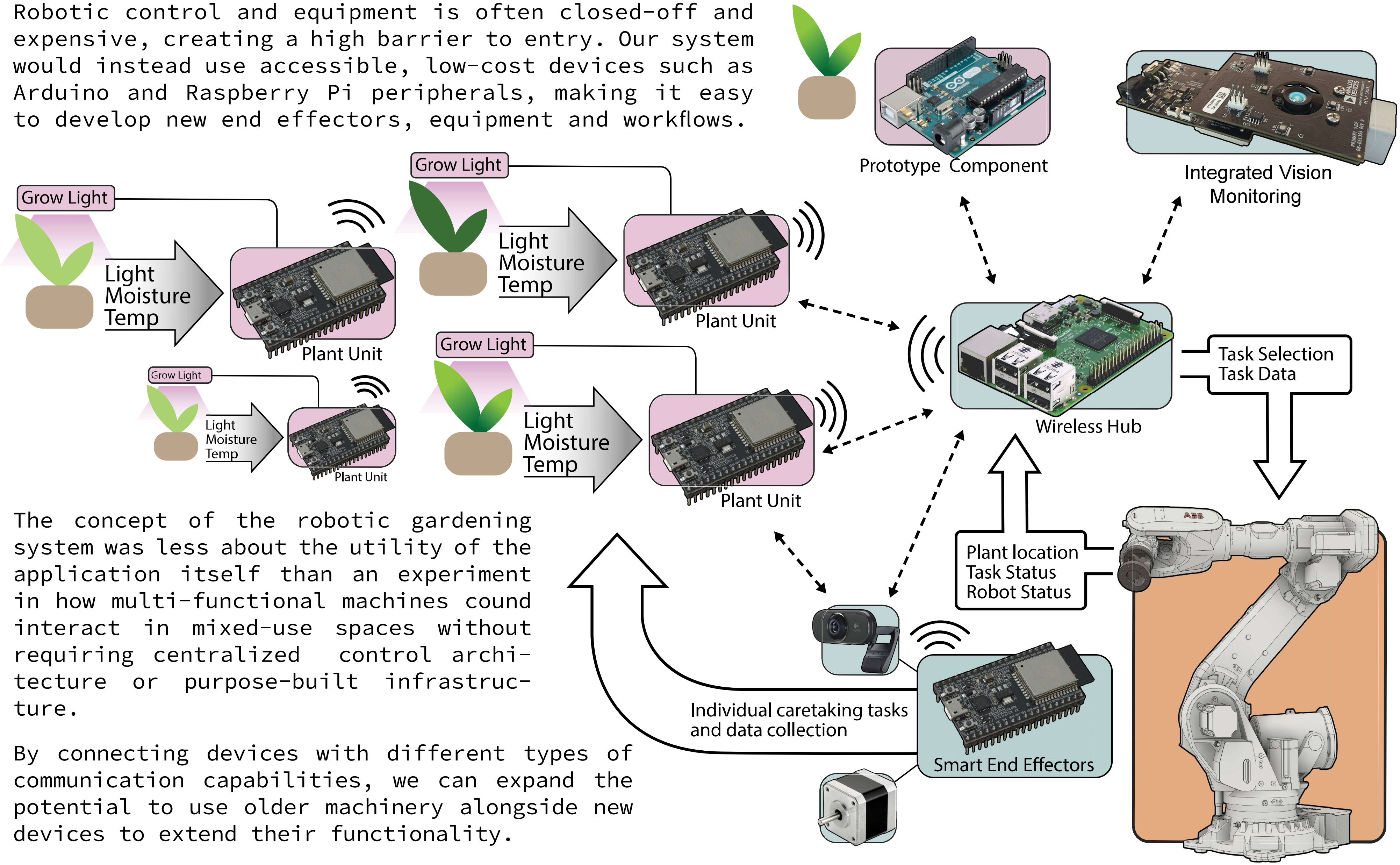
R/OSE (Robotic/ Organic Systems Environment) was an exploration into creating an ecosystem of devices, sensors, processing units and physical machines that could work synergetically to perform automation tasks.

The project centered an indoor Internet of things (IoT) garden that utilized low-cost microcontrollers and sensor equipment to monitor and care for individual plants. A major feature of the project was connecting these devices to the IRB 6700 robotic arm, allowing it to utilize data from the network of devices to perform watering, monitoring and retrieval of plant units.

This project also served as a teaching experience for our student research assistants who were primarily remote during the Covid-19 lockdown. I coordinated a team of students to work asynchronously on researching system requirements, developing design concepts for the structure and equipment in the garden, building sensor components and creating a web interface for the system.

The primary goal of R/OSE was to build a platform for developing interconnected automation systems that made developing robotic applications easier for users without technical experience.

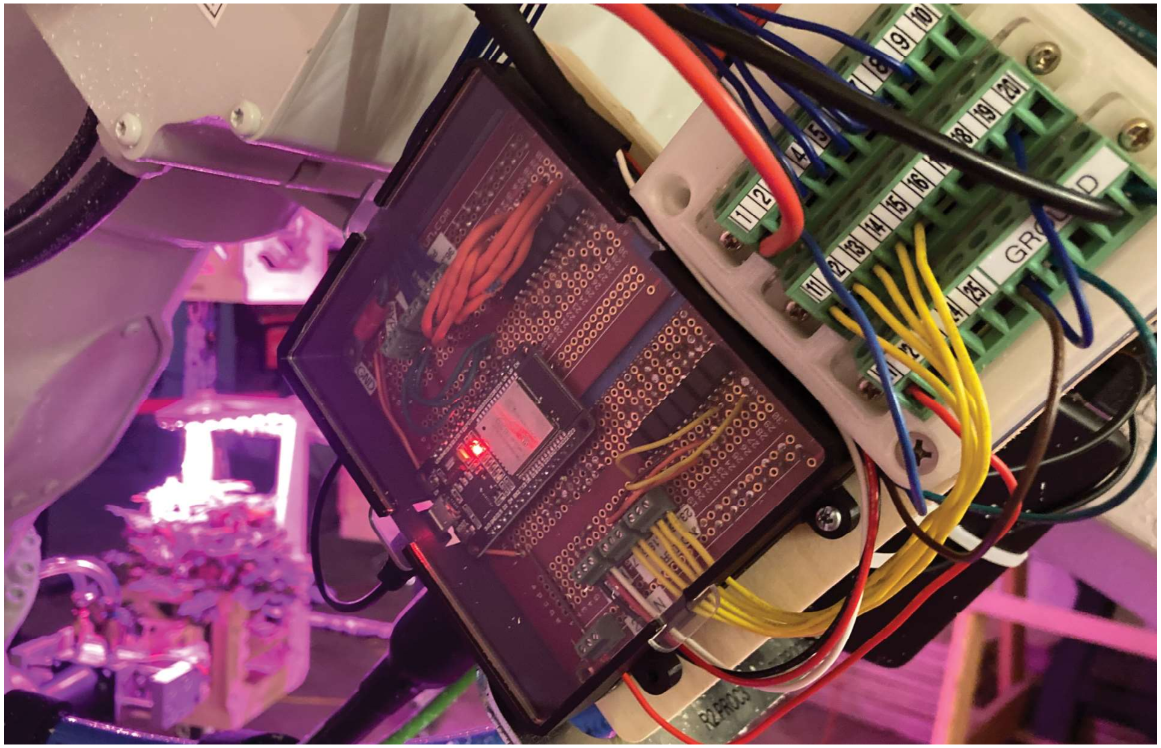
Robotic control and equipment is often closed-off and expensive, creating a high barrier to entry. Our system would instead use accessible, low-cost devices such as Arduino and Raspberry Pi peripherals, making it easy to develop new end effectors, equipment and workflows.



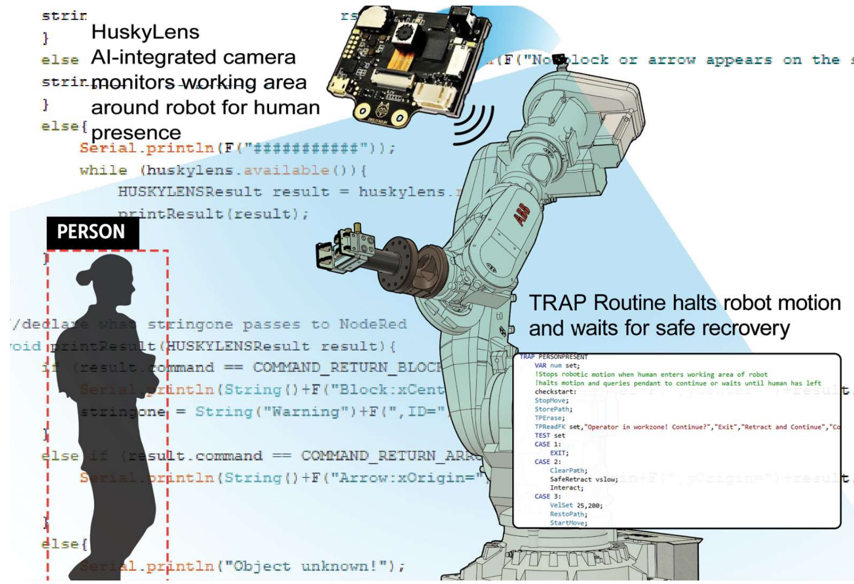

The concept of the robotic gardening system was less about the utility of the application itself than an experiment in how multi-functional machines cound interact in mixed-use spaces without requiring centralized control architecture or purpose-built infrastructure.

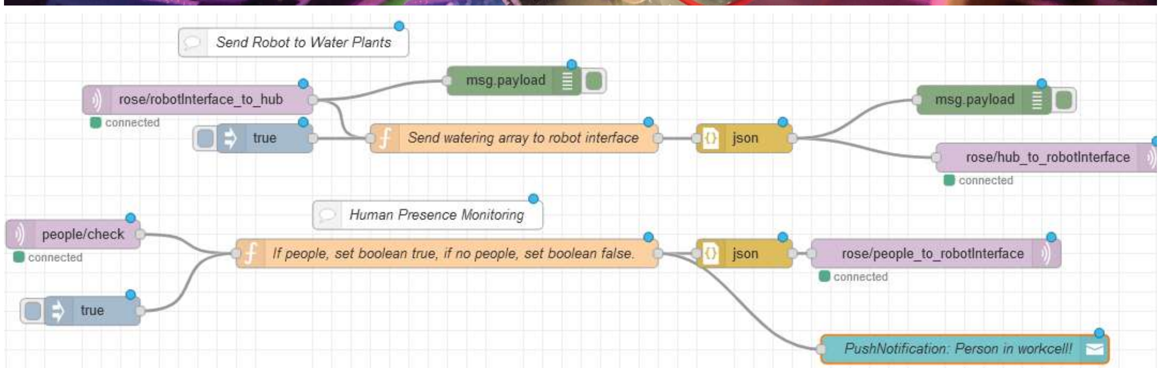
By connecting devices with different types of communication capabilities, we can expand the potential to use older machinery alongside new devices to extend their functionality.

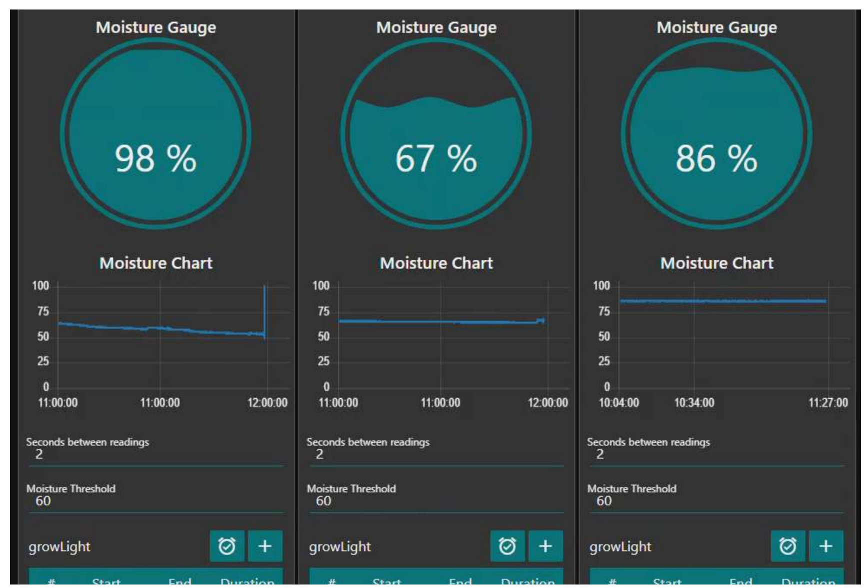
In this sense, the robotic arm and garden serves as a stand-in for other types of automation platforms and outcomes, where machinery can be decoupled from one dedicated function and instead be applied as needed to a variety of uses.



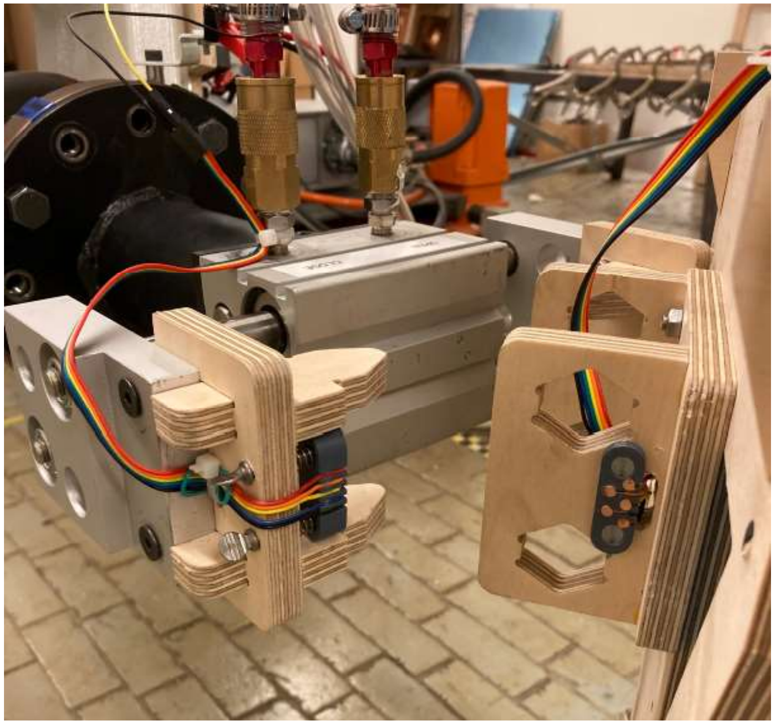
Interfacing the robot with the rest of the system was managed through an ESP32. Lacking the ability to connect to the robot directly through modern protocols I experimented with diffifent communication methods that were availatable such as binary and serial data over IO and RS232 serial. The ESP32 could then pass on data to other devices using more common communication protocols such as I2C or SPI.



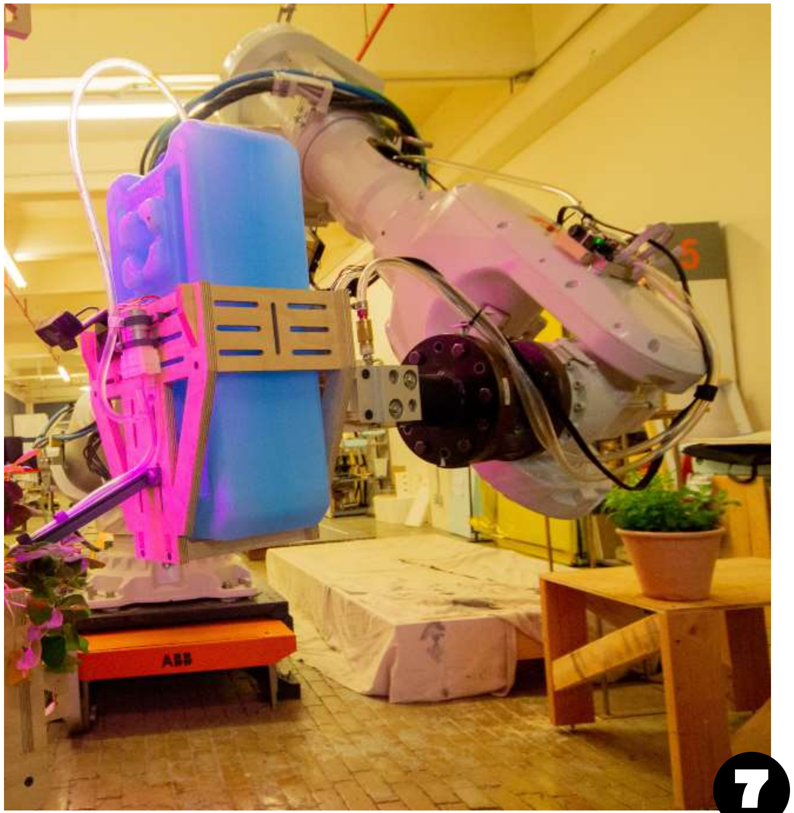




Working with two interactive arts students, we built and tested experimental peripherals for the system. Each planter unit had an ESP8266 board that monitored the plant's light and soil moisture and could control an LED growlight via a set schedule or as needed to supplement natural sunlight. The computer vision enabled HuskyLens identified when humans were present in the robotic workcell, sending an interrupt to halt the robot's operation. These devices were connected through a Json-based IOT platform called NodeRED, making it easy to connect new devices, manage communication streams, and create an online data monitoring and interaction interface.



The implementation of R/OSE also required the design of various physical tooling and components. I worked with the student team to turn their design concepts into working prototypes of the garden structure, planters and watering tool.

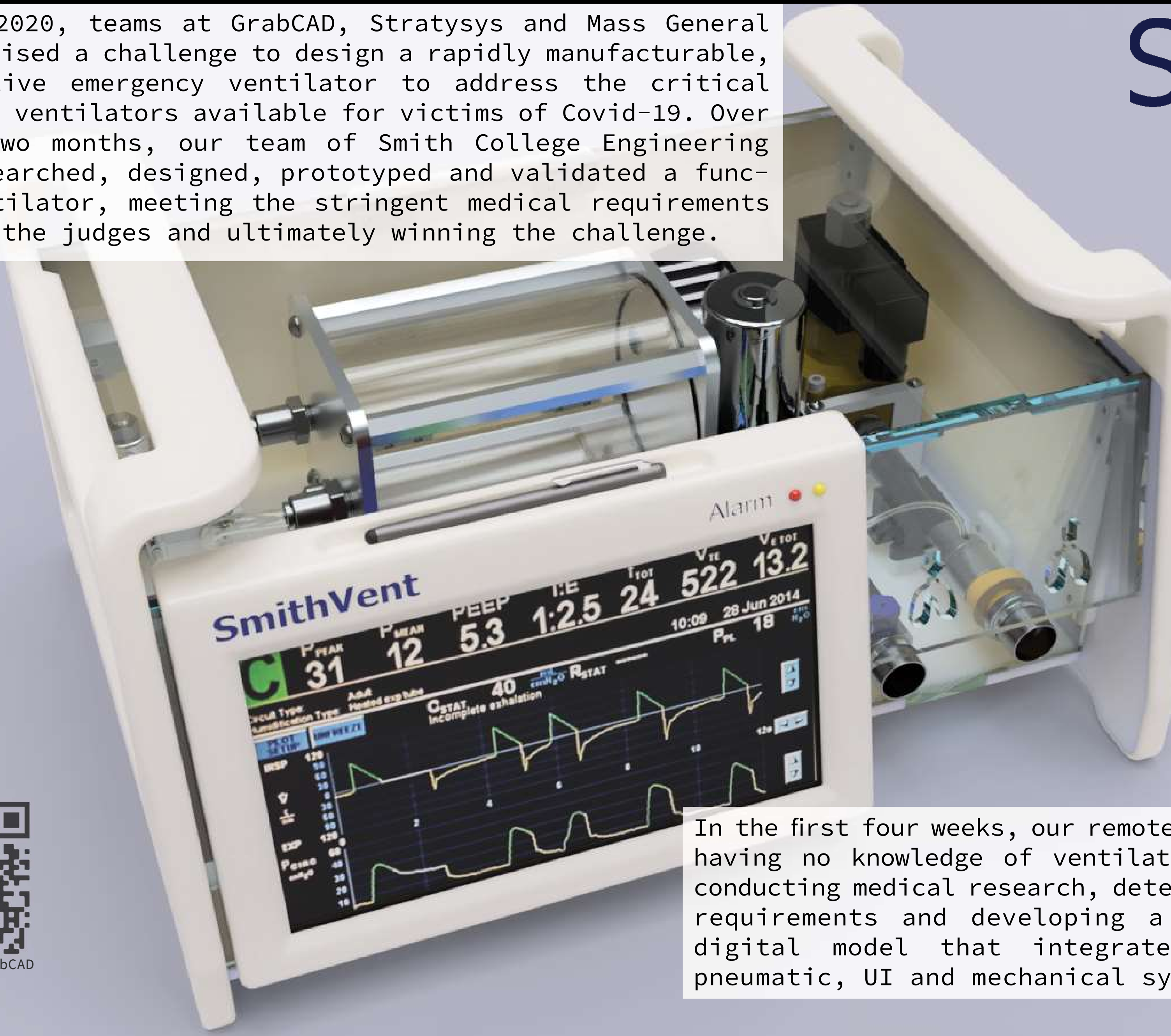
I designed a tool-changing system based around a pneumatic gripper, allowing the robot to load different end-effectors and pick up the plant units. A mechanical interface allowed the gripper to interlock with handle features that could be affixed to different tools. Power and UART signal connections could be delivered over a spring loaded contact plate that was fixed to each side of the gripper, as well as to the back of the planter units, allowing them to be loaded and unloaded automatically with power and data connections.



# SmithVent

COVENT19 CHALLENGE
TEAM PROJECT
04.2020 - 06.2020

In Spring 2020, teams at GrabCAD, Stratysys and Mass General Hospital raised a challenge to design a rapidly manufacturable, cost-effective emergency ventilator to address the critical shortage of ventilators available for victims of Covid-19. Over the span two months, our team of Smith College Engineering alumni researched, designed, prototyped and validated a functional ventilator, meeting the stringent medical requirements set out by the judges and ultimately winning the challenge.




In the first four weeks, our remote team went from having no knowledge of ventilation systems to conducting medical research, determining system requirements and developing a comprehensive digital model that integrated electronic, pneumatic, UI and mechanical systems.

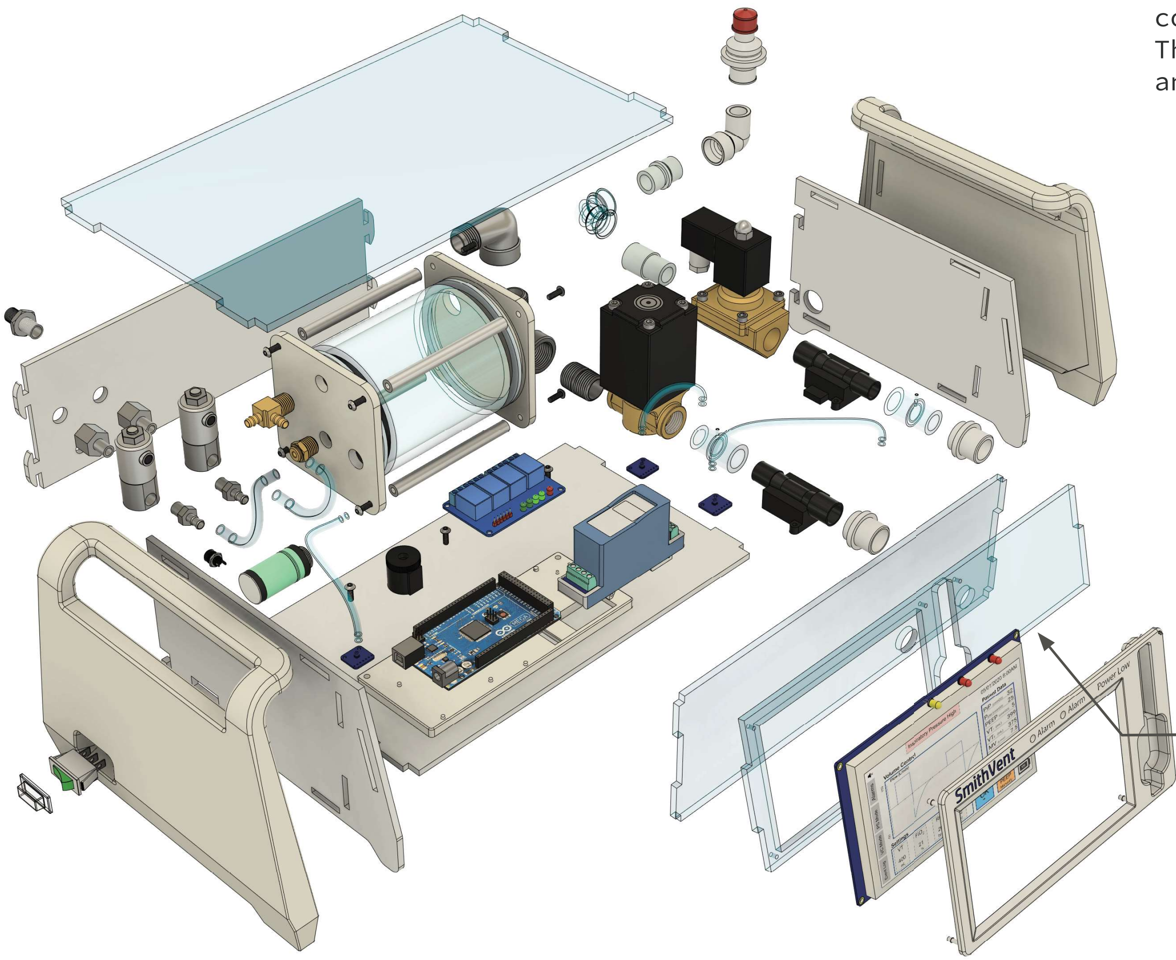
SmithVent GrabCAD
+ submission

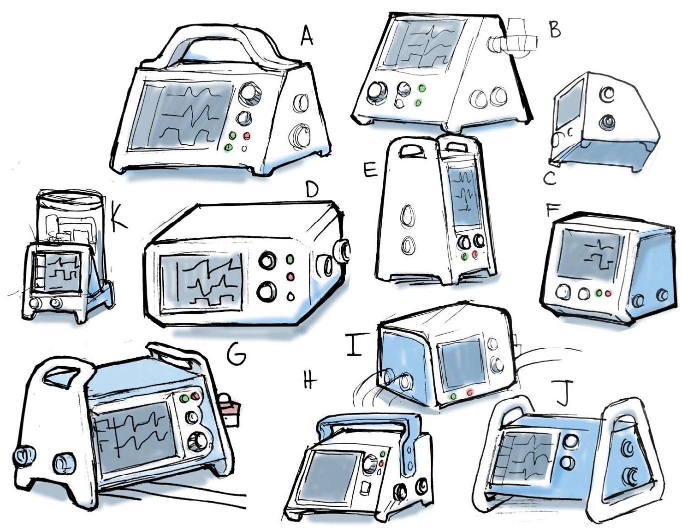
The challenge consisted of two rounds - the first focusing on concept and digital design. My primary role was working on the CAD model and system integration and acted as the lead for the CAD team.

This required project management of modeling tasks as well as coordination with other teams. A major element of my work was bringing the various components and design requirements specified by independently acting teams and building them into a single integrated system- modeling and incorporating various components, validating power requirements, sourcing pneumatic fittings and designing custom parts to create a unified, manufacturable design.

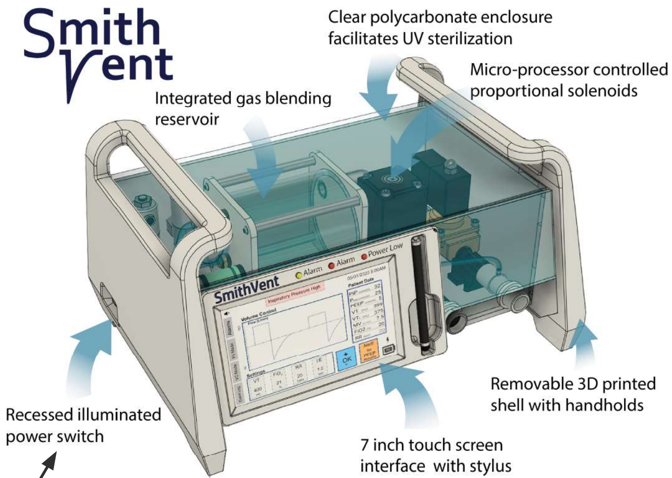
| | | | | | |
|---|---|---|---|---|---|
| 2 | **5.1 Tasks (due MON 4/27 6pm)** | | | | |
| 3 | **Populate CAD component sheet with most current spec'd parts** | pb | | Complete | |
| 4 | **Remove redundant parts/ files from CAD workflow sheet and Fusion folders** | pb | | Complete | |
| 5 | **Finish component modeling of all spec'd parts (SHEET 2) (can run into 5.2)** | | | In Progress | |
| 6 | **Work on/ complete custom part modeling (can run into 5.2)** | | | In Progress | |
| 7 | - Bezel for screen | alex | | Complete | |
| 8 | - add mounting posts with snap fits? | pb | | In Progress | |
| 9 | **Volume / blending chamber** | | | | |
| 10 | - remove screw/piston for fixed volume reservoir | phoebe | | Complete | |
| 11 | - finish adding fasteners, fittings (2x¼ inlet, 15mm or 22mm outlet) | Eric | | Complete | |
| 12 | **Create initial enclosure layout diagram** | Phoebe | | Complete | mostly complete other than inl |
| 13 | **Finalize enclosure design (outside)** | Phoebe | | In Progress | |
| 14 | **Initial assembly layout of all major components** | | | In Progress | |
| 15 | - Determine fitting needs etc | Eric | | Complete | |
| 16 | | | | | |
| 17 | **5.2 Tasks** | | | | |
| 18 | **Create assembly drawing with dimensions and BOM table** | phoebe | | Not Begun | |
| 19 | **Finalize any straggling component models:** | | | Unassigned | |
| 20 | - Custom parts | devin | | Complete | electronics mount |
| 21 | - electronics | devin | | Unassigned | |
| 22 | - Fittings | eric | | In Progress | DISS fittings need check |
| 23 | - Other components etc | alex | | In Progress | |
| 24 | **Finalize component locations in assembly:** | | | Unassigned | |
| 25 | - Add joints and fittings | eric | | Complete | |
| 26 | - Place all electronics | phoebe | | Complete | |
| 27 | - Add mounting points and brackets | phoebe | | In Progress | |

After research, user interviews and design ideation, about two weeks were left for the specification of components and design of the the ventilator itself. This required intensive project management of tasks and deliverables across the remote teams.




The ventilator was designed with ease of manufacture in mind, utilizing off-the-shelf components and parts designed for rapid prototyping. The final design primarily utilized laser-cut parts for rapid production and scalability. 3D printed components such as enclosure covers and custom pneumatic adapters were included to satisfy the challenge requirements.

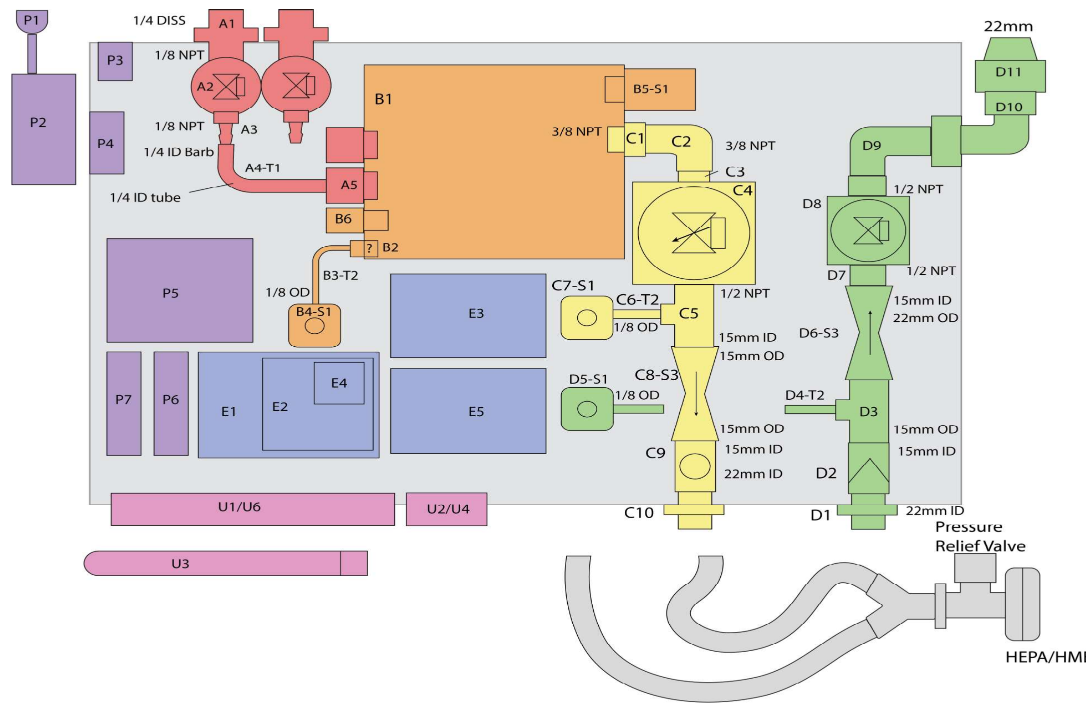



Upon being selected as one of the 7 finalists who went to round 2, the SmithVent team pivoted from concept to implementation. This meant fleshing out aspects of programming, electronic design and supply chain details that had been only loosely defined in the first round.

CAD played a smaller role during this round so my primary function switched to general system integration - sourcing components from vendors, creating a final design package, and assisting in various tasks required for building a testable prototype.

In addition to CAD, I created graphics both for submission materials and for internal organization.

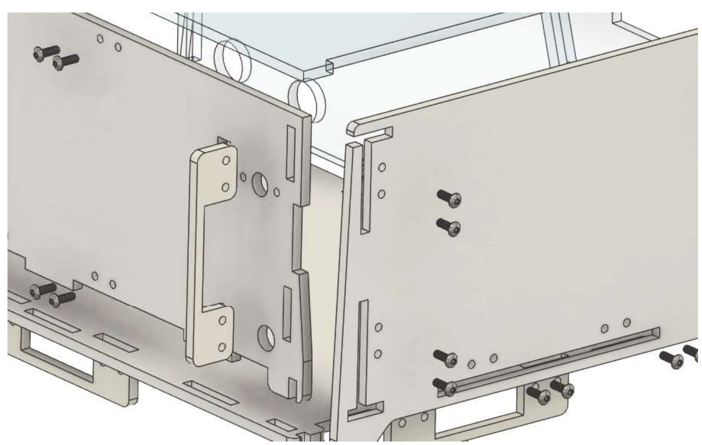
| | | | | | |
|---|---|---|---|---|---|
| 21 | ElectricalComp | 4-pin (mini) DIN-DC socket connector | DigiKey (Kycon) | KPJX-4S-S | 1 |
| 22 | ElectricalComp | Rocker switch (illuminated) | McMaster | 7395K48 | 1 |
| 23 | ElectricalComp | CR-1220 battery | Amazon (LiCB) | B0797NRXZY | 1 |
| 24 | ElectricalComp | 10" Intelligent Capacitive Touch Screen (Nextion) | Seeed (Nextion) | 104990607 | 1 |
| 25 | ElectricalComp | LED Bright Red | Sparkfun | COM-00528 | 1 |
| 26 | ElectricalComp | LED Bright Amber | Digikey (ABOC) | BL-BJC1V4V-AT-ND | 1 |
| 27 | ElectricalComp | Buzzer (piezo alarm) | Robotshop (SparkFun) | RB-Spa-1390 | 1 |
| 28 | Reservoir Assy | O-ring, Buna-N, 4" ID, 3/32" thick | McMaster | 9452K176 | 2 |
| 29 | Reservoir Assy | Acrylic Cylinder, 4" ID, 1/4" wall, 6" long | McMaster | 8486K575 | 0.5 ft |
| 30 | Reservoir Assy | 18-8 SS button head hex screws, 1/4-20 Thread, 3/4" long | McMaster | 92949A540 | 8 |
| 31 | Reservoir Assy | 18-8 SS washers for 1/4" screws | McMaster | 92141A029 | 8 |
| 32 | Reservoir Assy | Aluminum sheet, 1/4" thick; 6"x12" | McMaster | 8975K437 | 1 |
| 33 | Reservoir Assy | Aluminum standoffs, 1/2" Hex, 6" Long, 1/4-20 Thread | McMaster | 91780A210 | 4 |
| 34 | Plumbing | PVC tubing, 1/4" ID, 3/8" OD | McMaster | 5233K56 | 2 ft |

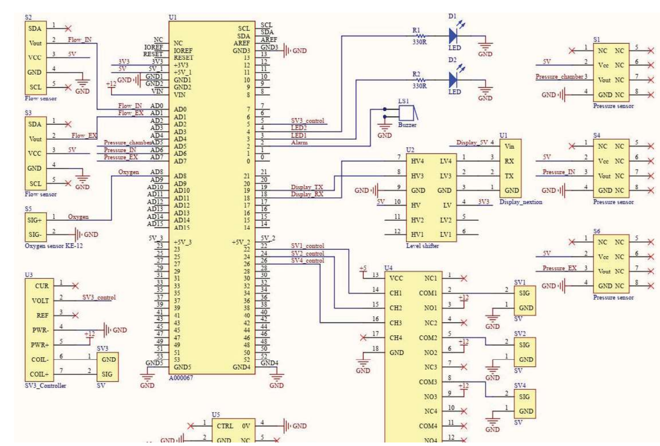



With only 5 weeks to build and test, many design decisions were made to accomodate easy prototyping.

Only in-stock, US based components were utilized so we could acquire all the components as soon as possible. The enclosure design was updated with tabs and threaded components for ease of assembly and modification.

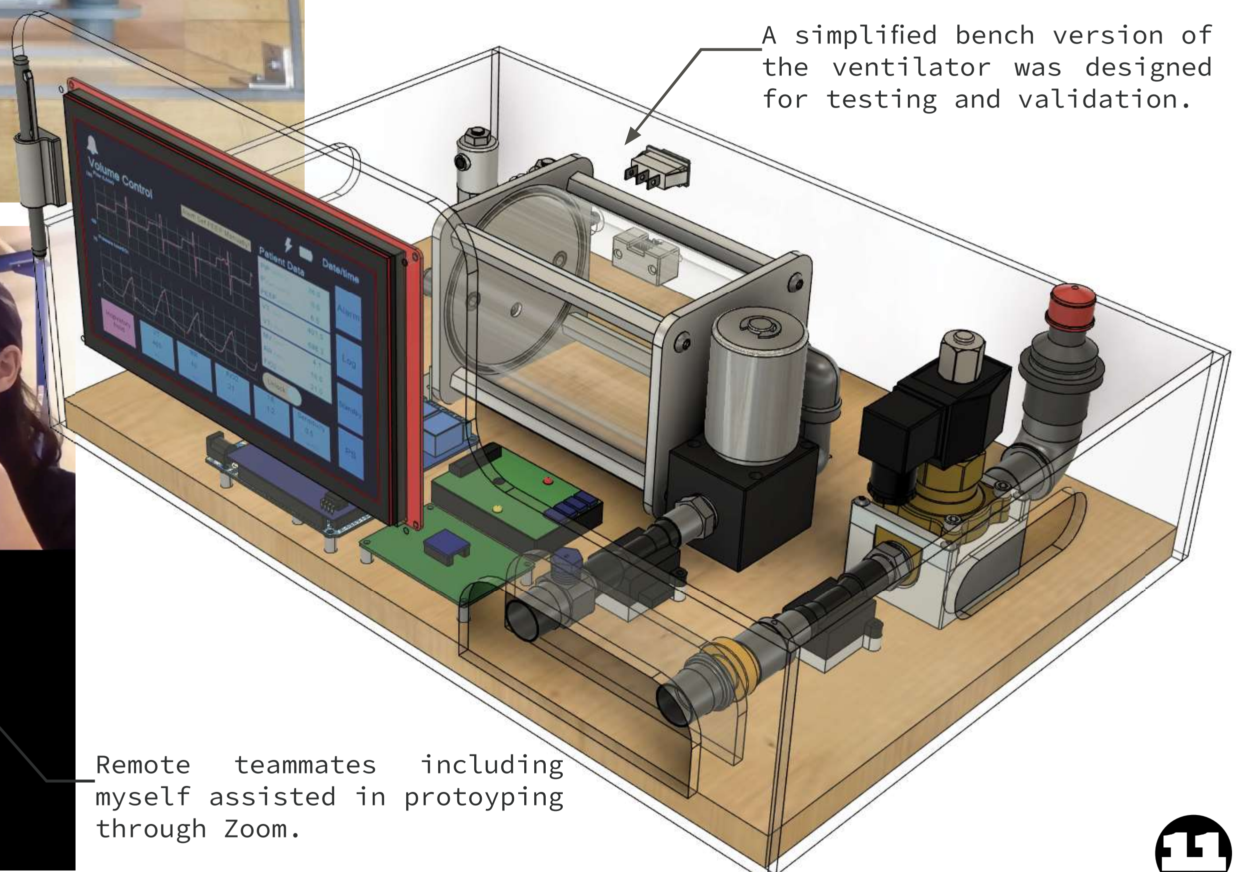
Arduino was used as a basis for the control system allowing remote team members to asynchronously build and test sub-functions.



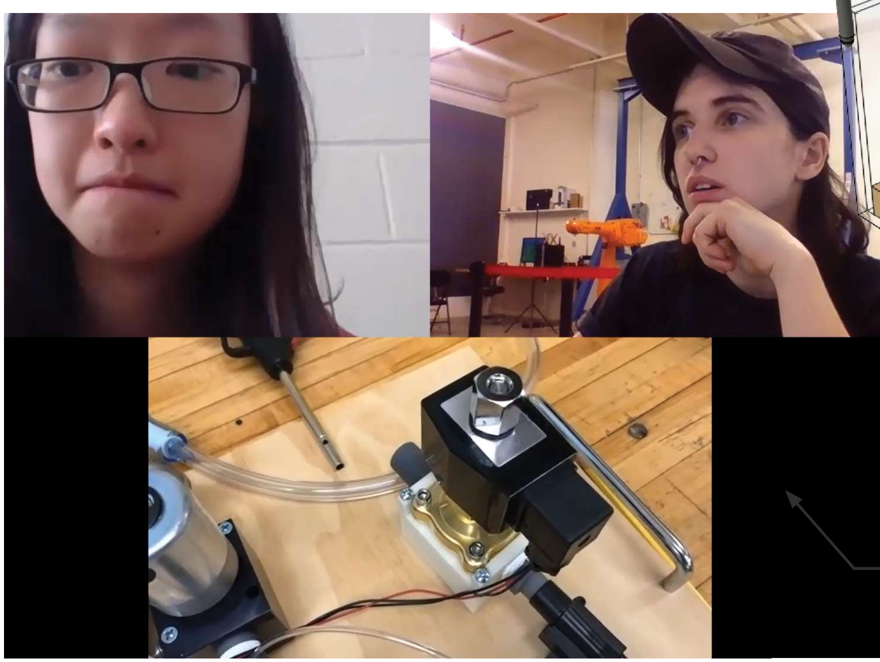


The final bench-test prototype was built by a small group of team members local to the Smith College campus. However, remote team members were critical for the sucess of the prototyping effort - lending their individual expertise to the local team on tasks such as soldering, electrical wiring, mechanical assembly, part fabrication and component installation.

By the end of the second round, a working, breathing ventilator, together with validated testing, supporting documentation and a design package, was submitted to the judges resulting in the SmithVent team winning the challenge.




A simplified bench version of the ventilator was designed for testing and validation.

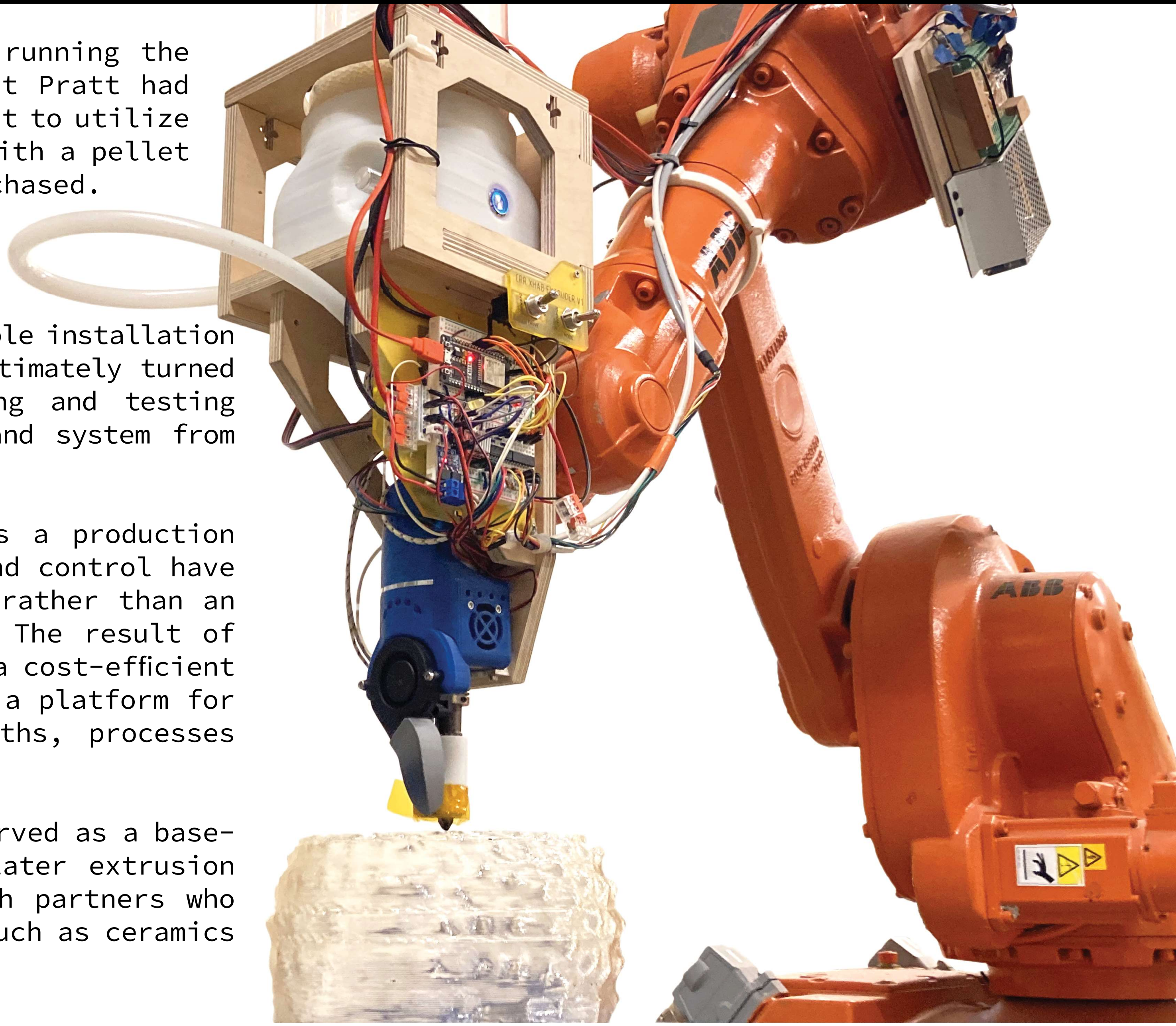


Remote teammates including myself assisted in protoyping through Zoom.

# Robotic Extrusion

CRR PROJECT
SOLE DEVELOPER
01.2021- 03.2021
+ONGOING

In January 2021, faculty running the NASA XHAB Design Studio at Pratt had approached me with a project to utilize the IRB 1600 robotic arm with a pellet extruder kit they had purchased.

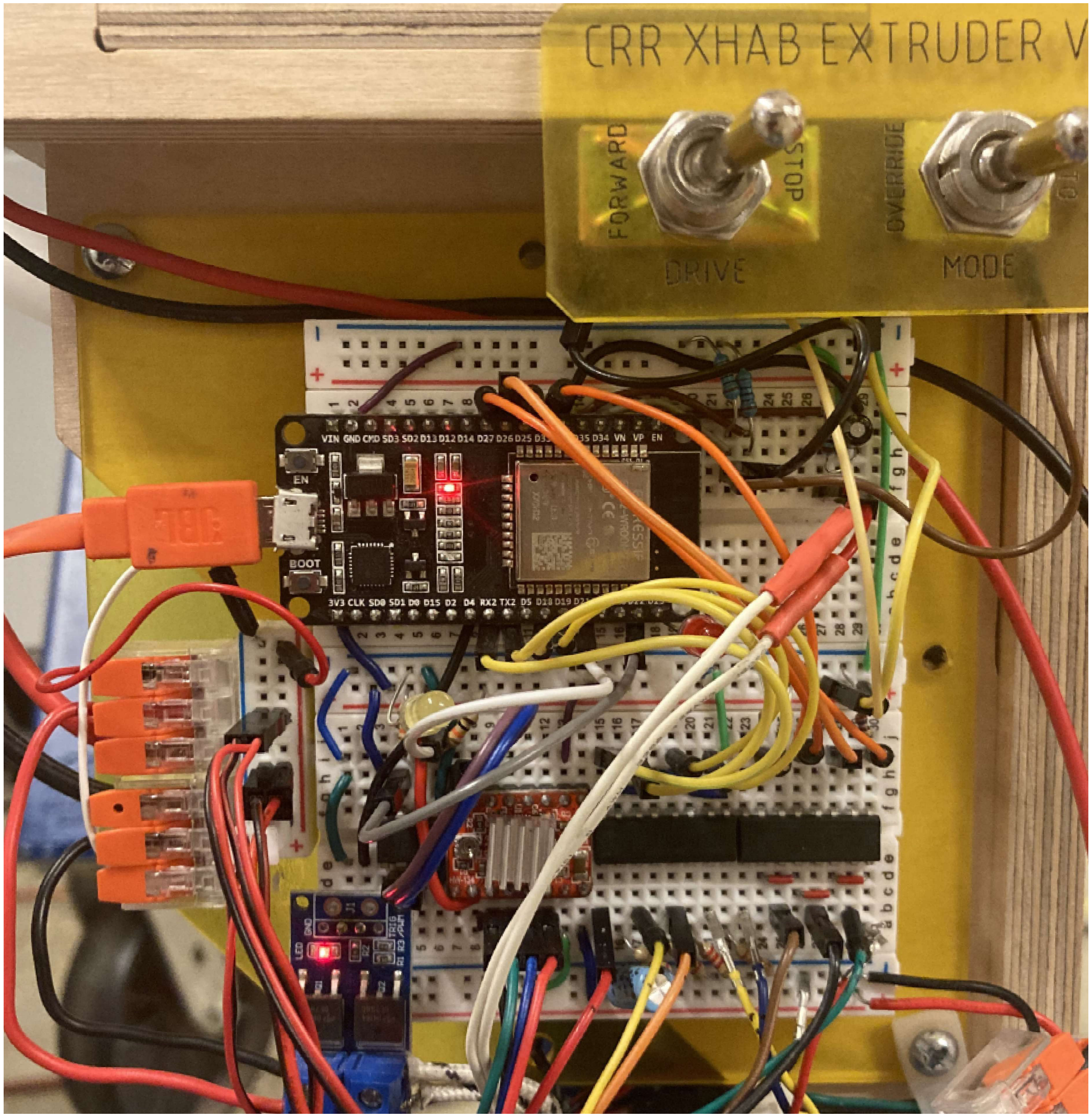


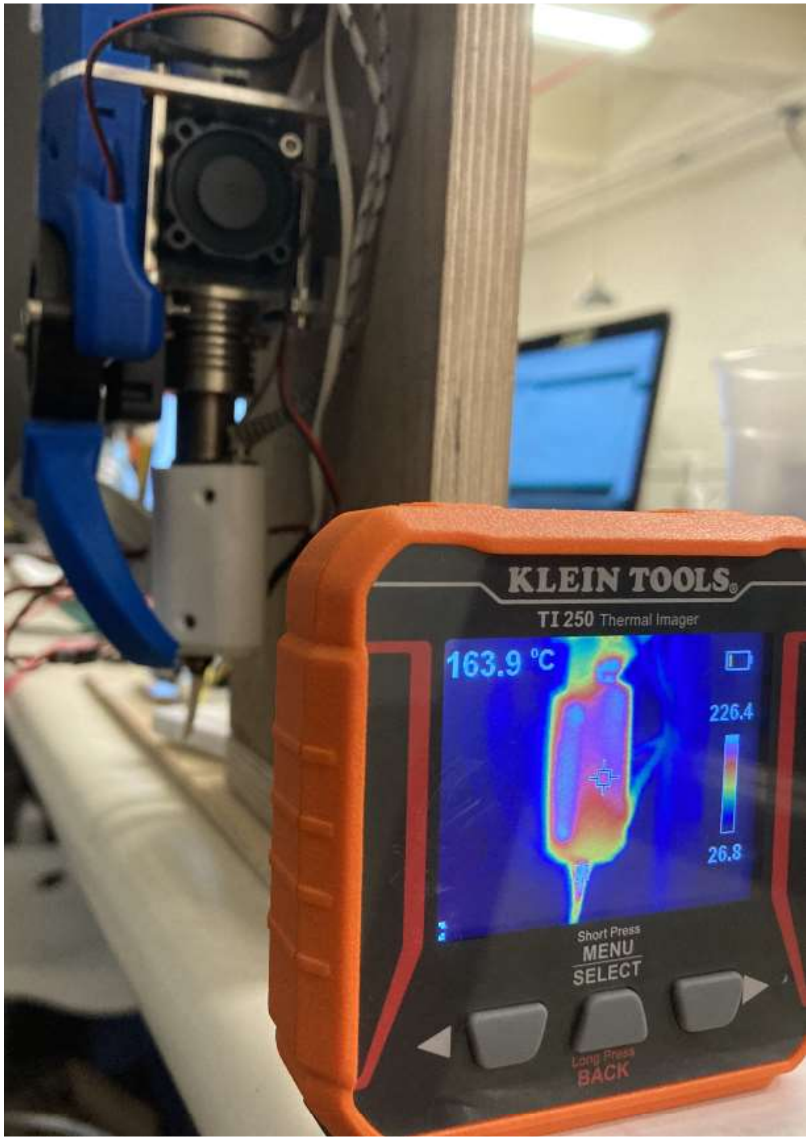

Initially scoped as the simple installation of a tool, this project ultimately turned into designing, programming and testing the extrusion controller and system from the ground up.

As 3D printing matures as a production technology, the tooling and control have become a means to an end rather than an area for experimentation. The result of this project was not just a cost-efficient robotic extruder but also a platform for devloping additive toolpaths, processes and tooling.

The controller has also served as a base-line for development in later extrusion projects with CRR research partners who are working in materials such as ceramics and cellulose paste.

The extruder purchased by the XHAB group was selected due to its description as “plug and play”; however, this referred specifically to installation onto an existing 3D printer. To utilize this with the robot, I determined the best course of action was to build the extruder from scratch on a programmable microcontroller. This would have the advantage of allowing communication with the robot for synchronized extrusion and the flexibility for future development compared to using an existing, G-code-based 3D printer controller.



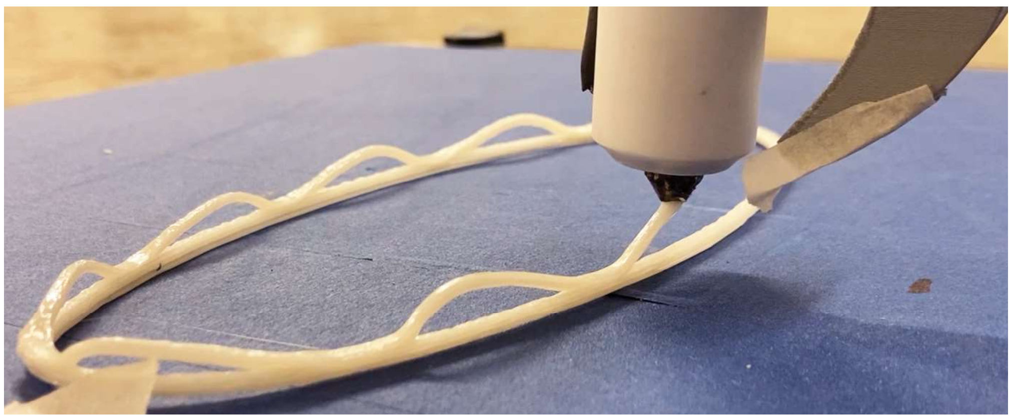




Manufacturer documentation of the extruder kit was sparse if available at all. Thus, everything from the stepper wiring order, rotation and gear ratio to the thermistor Steinhart coefficients and PID values needed to be determined through a combination of research, experimentation and contacting individual component manufacturers. Throughout the buildout, I maintained a thorough development log documenting my progress and decisions so the information wasn’t lost for other CRR researchers or myself in the future.

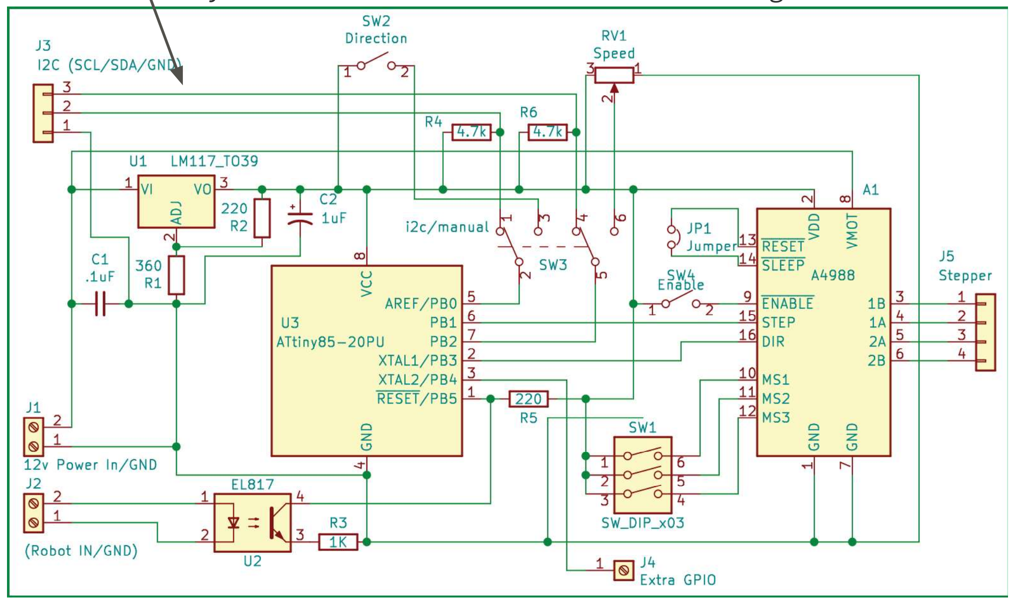
As the robot is not capable of controlling the heating and motor function of the extruder directly, I deisgned the extruder controller to operate either independently or as a peripheral unit to the robot.

I selected the ESP32 platform for its high processing speed, wifi + communication features plus consistency with boards built in the R/OSE project. I programmed an attiny85 chip as a dedicated I2C motor controller, freeing up the loop on the main board.

This gives the controller more freedom to perform other functions such as communicating with the robot, monitoring the temperature PID control, connecting with web/ NodeRed/ physical interfaces as well as flexibility for adding additional functionality and peripheral devices in the future.

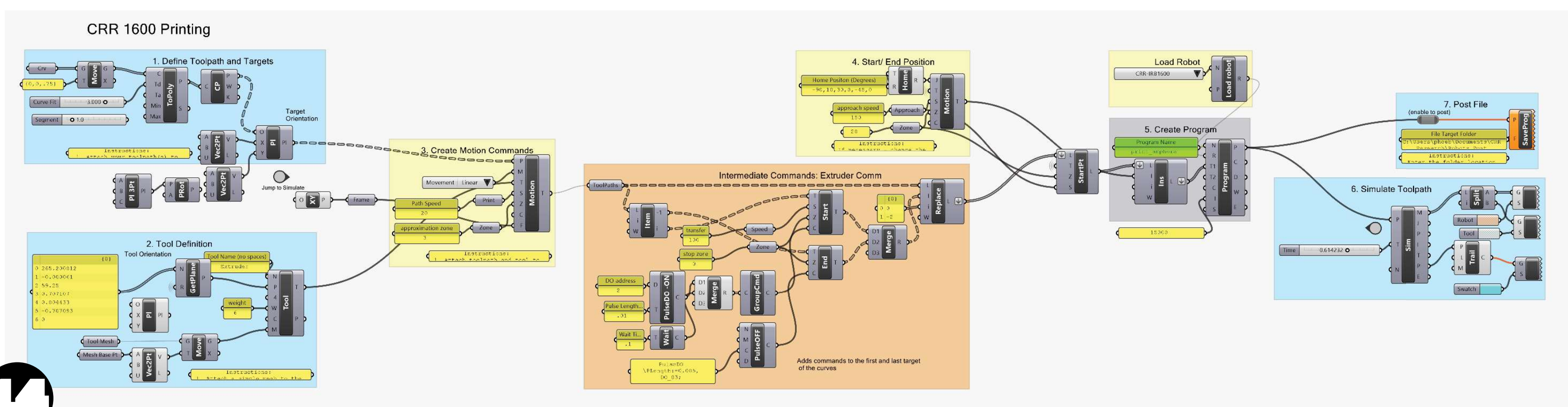


Schematic for a stand-alone stepper control board that has switchable manual and I2C inputs and can synchronize with the robot via a single IO.




Toolpaths and robotic programming are primarily carried out in Grasshopper. The actual robotic program is created from a series of targets using the open-source plugin “Robots”. This workflow is intuitive for many CRR research partners and offers great functionality in customizing toolpath parameters and creating communication signals between the robot and extruder.

The robot primarily communicates through pulsing IOs for specific intervals corresponding to extruder function such as extrusion direction and speed. This method of communication requires only one wire connection from the robot to the controller through an optocoupler and is easy to program via Grasshopper.




Extruder Github

Printed Vessel Extrusion Tests:
For these pieces, I used scanned 3D models of ancient ceramic artifacts sourced from online museum resources. All objects were sourced from institutions in the same country or region from which the object was originally recovered, as a consideration to modern and historical concepts of ownership and art.

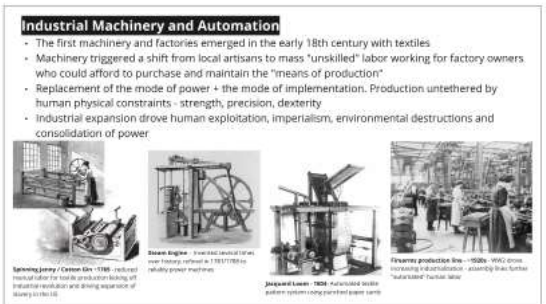
Clockwise from right: Amphora, Greece- deformed by heat. Moon Idol - Halstatt culture, Hungary. Soursop Bottle - Peru.

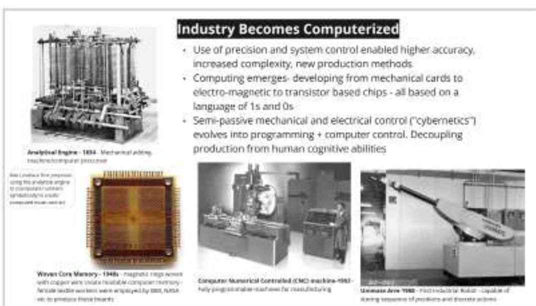
# PIC 369

*A Line / A Robot*

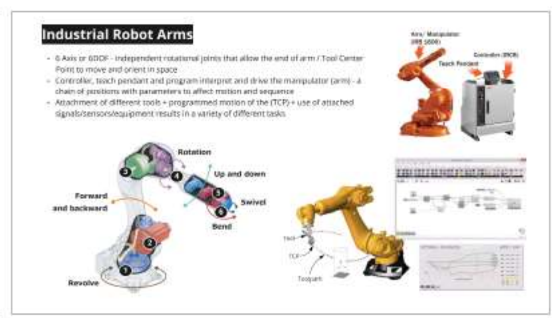
*Industrial Robotics as a Creative Medium*

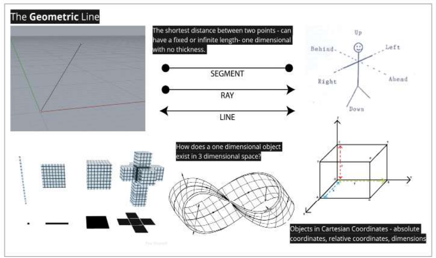
UNDERGRADUATE COURSE
INTRUCTOR
09.2021-12.2021

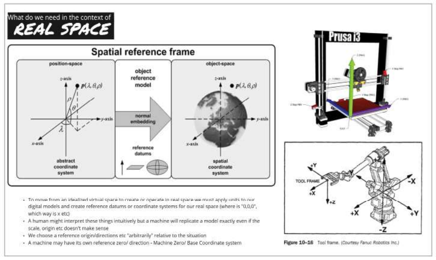



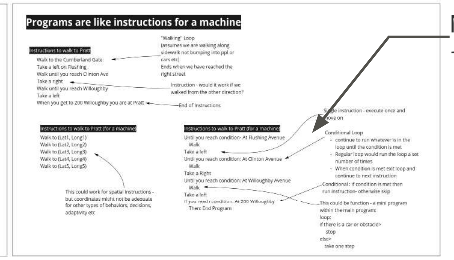




During the Fall 2021 semester, I took on instruction of the Pratt course “A Line, A Robot”, an interdisciplinary course on utilizing industrial robotics as a medium for motion, interaction and creative expression.

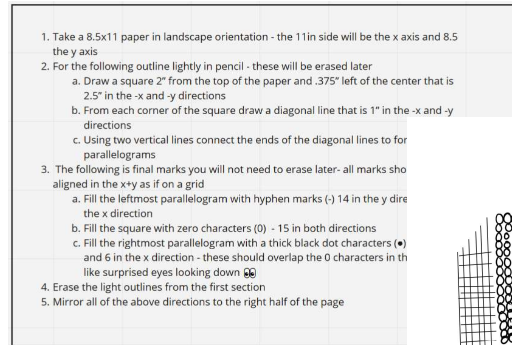



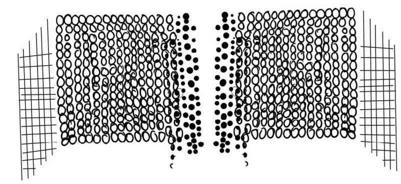

Miro was used as the primary platform for the class lecture content and interaction.

“Code for a Forgery” Homework Assignment
Students were asked to create a set of Sol Lewitte-style instructions to allow one of their peers to recreate an artwork.
(artwork from Ruth Wolf-Rehfeldt)

The class is open to students from all majors with no required prerequisites. The content of the course introduced students to using robotics without needing technical expertise, instead focusing on broader concepts of digital and real space, motion, programmatic thinking and the engineering design process.

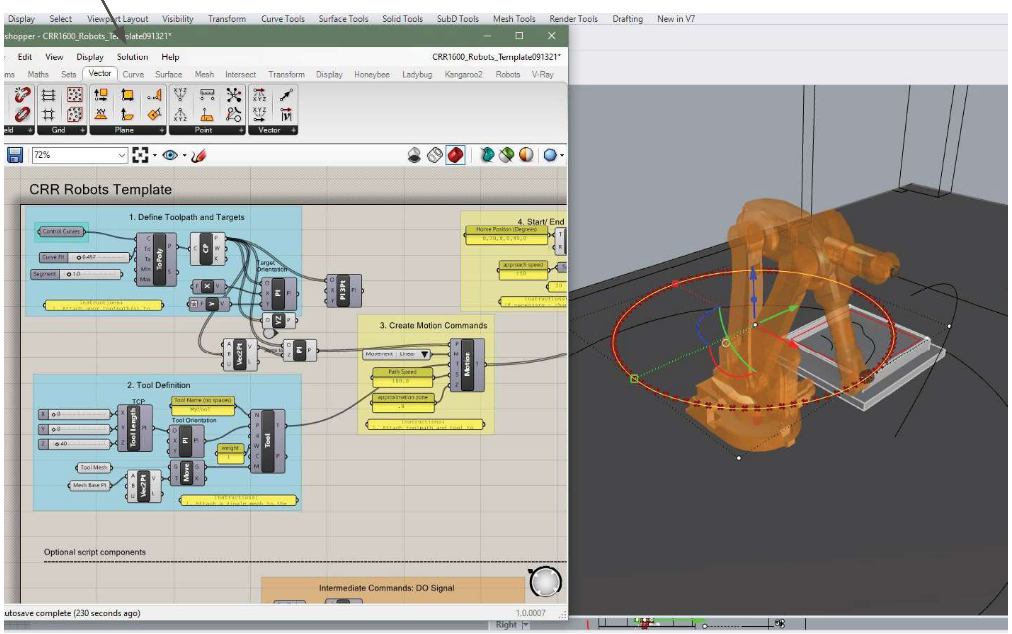


1. Take a 8.5x11 paper in landscape orientation - the 11in side will be the x axis and 8.5 the y axis
2. For the following outline lightly in pencil - these will be erased later
    a. Draw a square 2" from the top of the paper and .375" left of the center that is 2.5" in the -x and -y directions
    b. From each corner of the square draw a diagonal line that is 1" in the -x and -y directions
    c. Using two vertical lines connect the ends of the diagonal lines to for parallelograms
3. The following is final marks you will not need to erase later- all marks sho aligned in the x+y as if on a grid
    a. Fill the leftmost parallelogram with hyphen marks (-) 14 in the y dire the x direction
    b. Fill the square with zero characters (0) - 15 in both directions
    c. Fill the rightmost parallelogram with a thick black dot characters (•) and 6 in the x direction - these should overlap the 0 characters in th like surprised eyes looking down 👀
4. Erase the light outlines from the first section
5. Mirror all of the above directions to the right half of the page

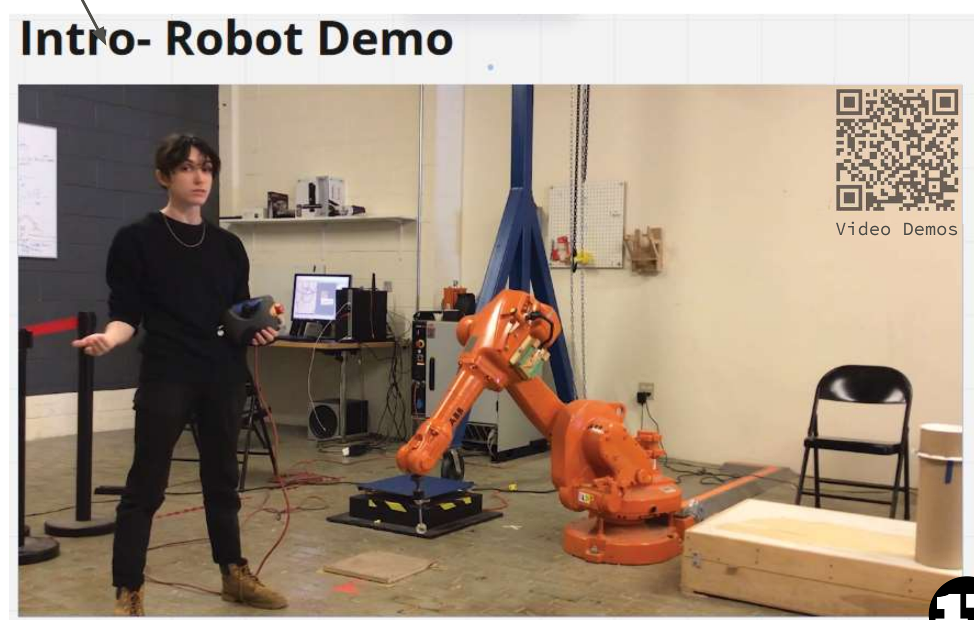


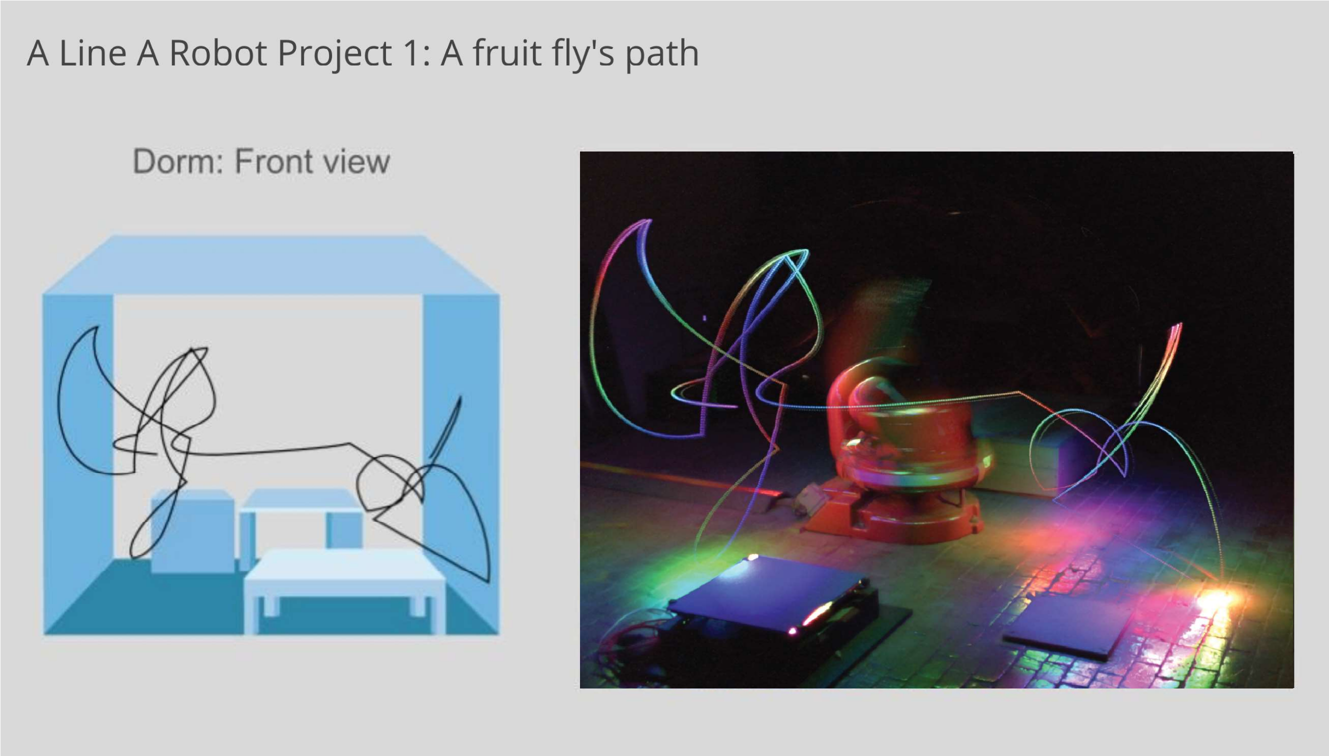
Students were taught how to use Rhino and Grasshopper to turn lines and curves into robotic motion and then how to leverage parameters such as spatial orientation, kinematics and tool definitions to alter the motion into more dynamic outcomes.

I supplied students with a Grasshopper template script that simplified robotic programing without hiding away all the internal function.




Video demonstrations supplemented the in-person classes allowing students with different experience to follow at their own pace.

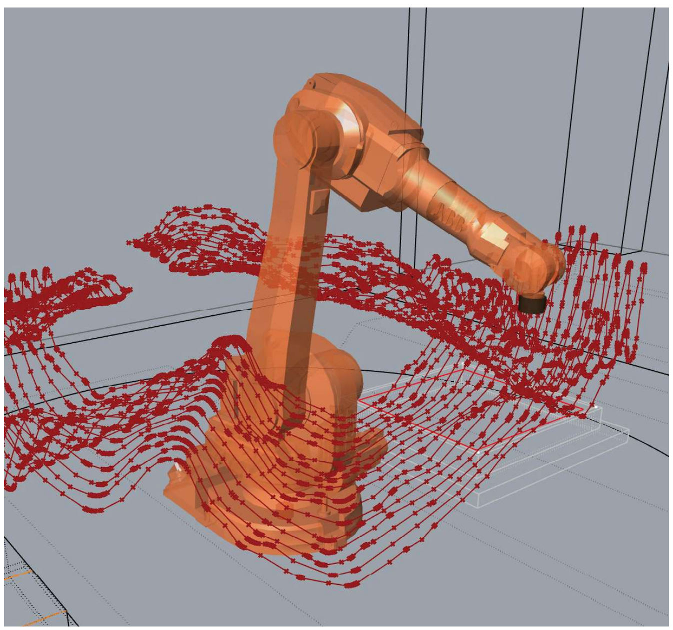




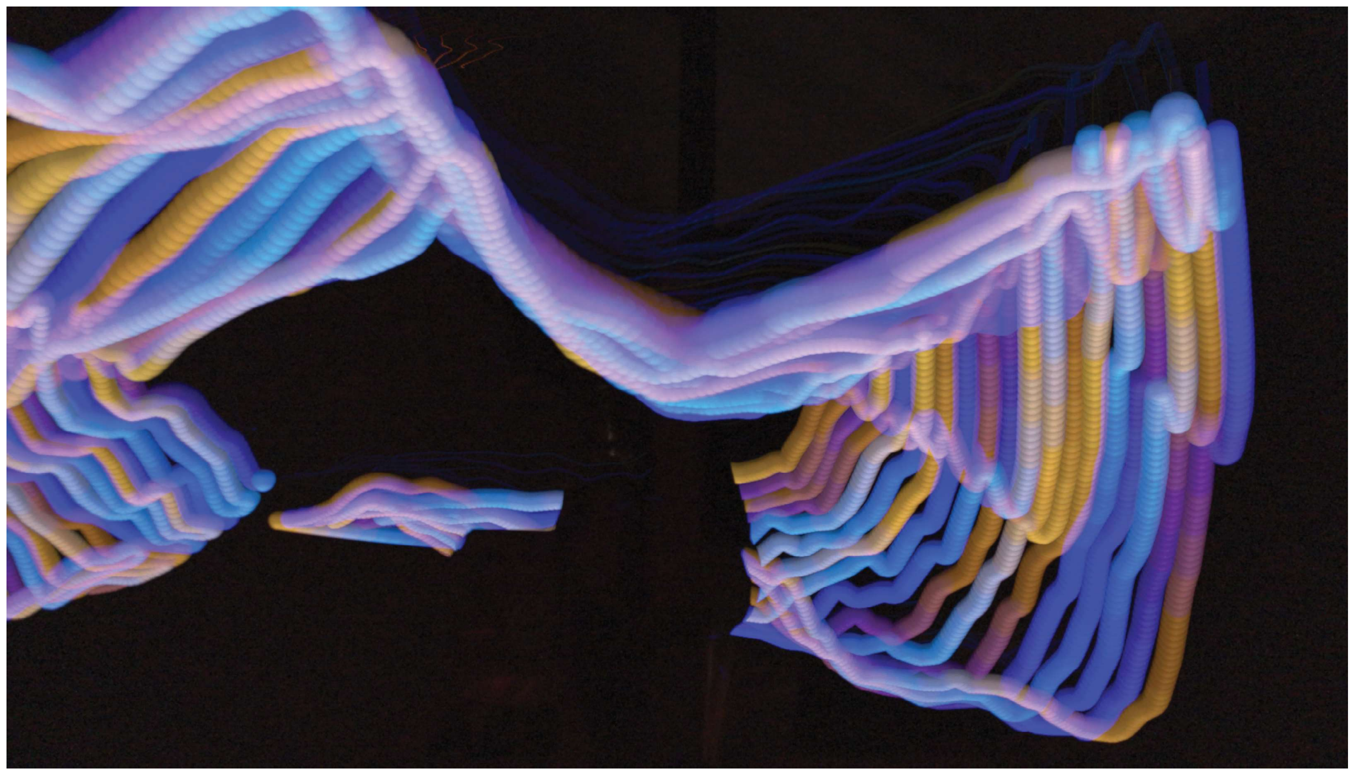

For the students’ midterm project they used what they had learned about robotic motion and building programs in Grasshopper to transform a single contour into a long exposure light painting executed by the IRB 1600 robot arm.

Students were able to leverage not only the kinematics of the robot but also the staging, camera use and presentation materials to create compelling outcomes.

The class is still ongoing, with students working on aspects of tool design and program manipulation to transform a toolpath from a single line into an outcome of their choice.



Midterm project materials from student Sue Kim (above) and Jasper Anderson (above and left) printed with permission.



# Fabrication

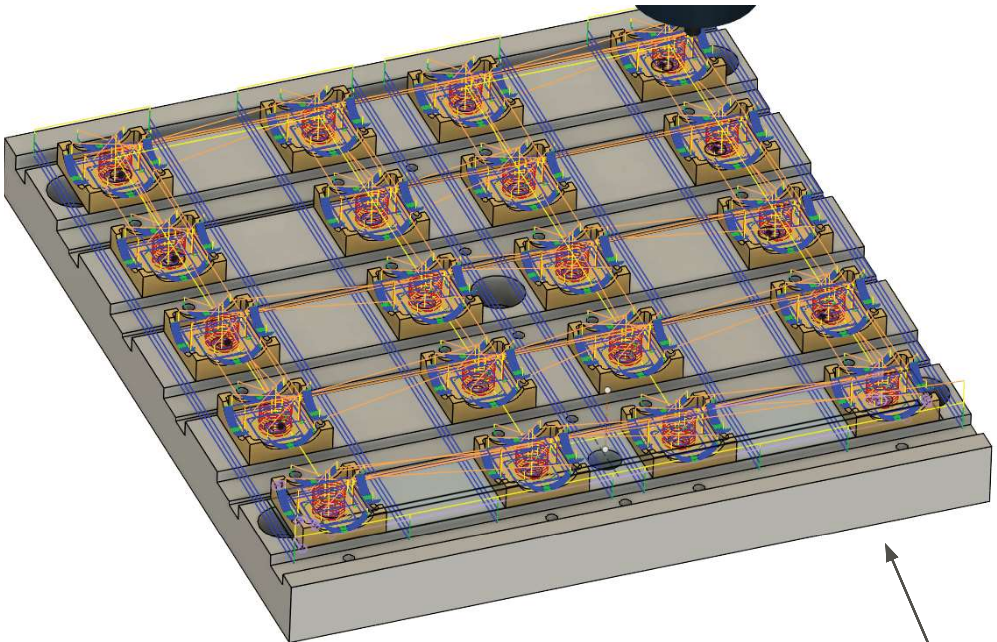


My work as a machinist at RUSHDesign called for working across a wide array of fields, fabrication techniques and materials. Projects covered design engineering, prototyping, art fabrication, small-volume production runs as well as the coordination and scaling of larger manufacturing efforts.

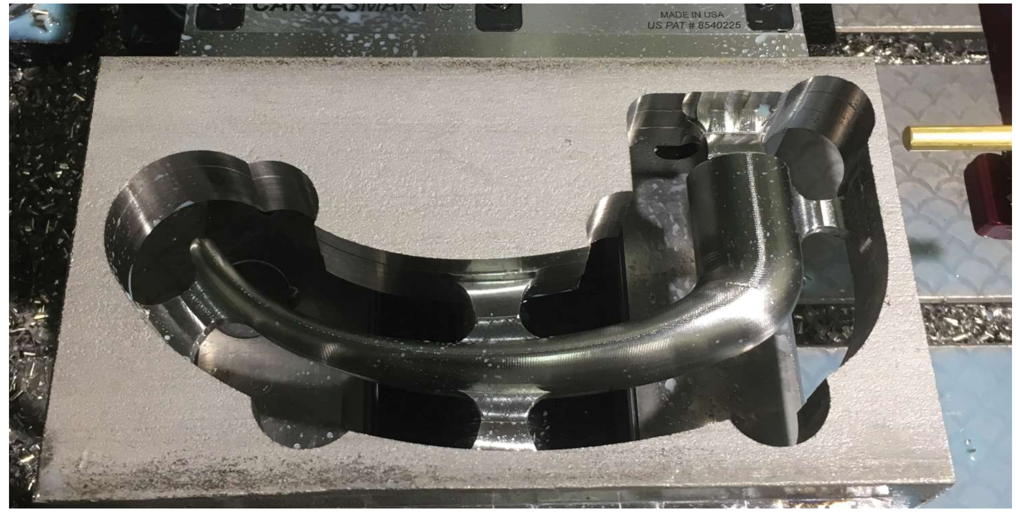
This custom LED fixture housed three lenses and control components in a water-tight enclosure allowing it to be installed in an outdoor 9/11 memorial in Hoboken. Design of the system and electronics were completed by the owners at RUSHdesign with prototyping, production and assembly by me.

This 16” trophy commissioned for BMW consisted of multiple fabrication steps and coordination of outside vendors all in just two and a half weeks. Laser cut acrylic sections were flame polished and then assembled on brass rods with knurled end caps to form the head. The stems were milled from billet aluminum on three sides then powdercoated and fastened to a steel base and the machined brass emblem.

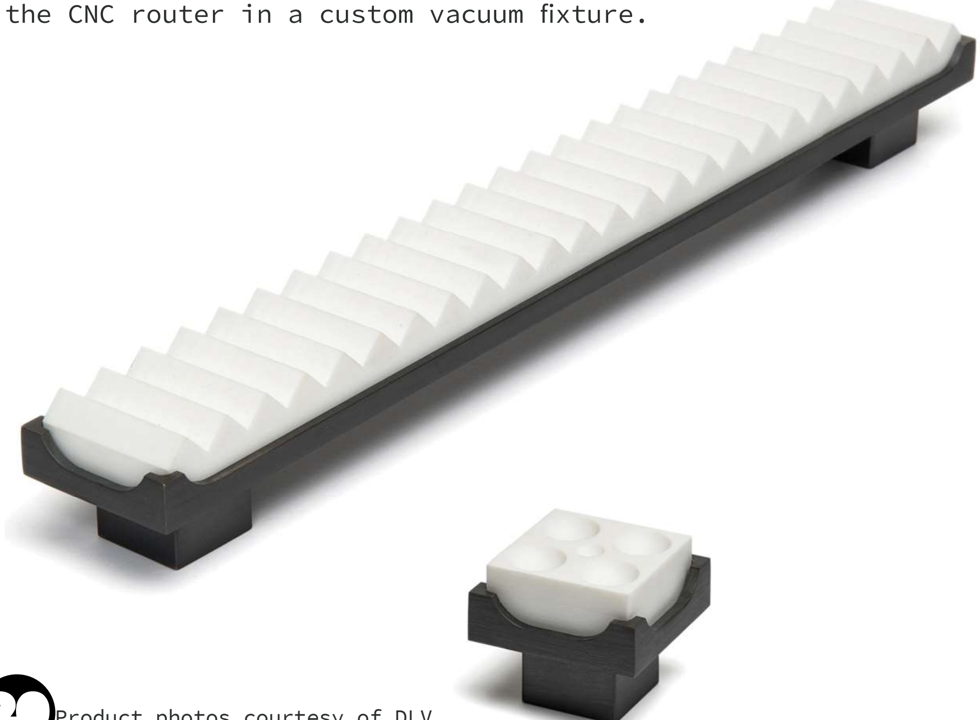

After completion, the client commissioned an additional pair of 50% scale trophies



Quantity production for DLV’s high end cabinet hardware required efficient production of a variety of custom-sized parts for each of their product lines. Aluminum fixture plates with low profile clamps and part stops were made for the metal parts whereas corian and wood parts were cut on the CNC router in a custom vacuum fixture.



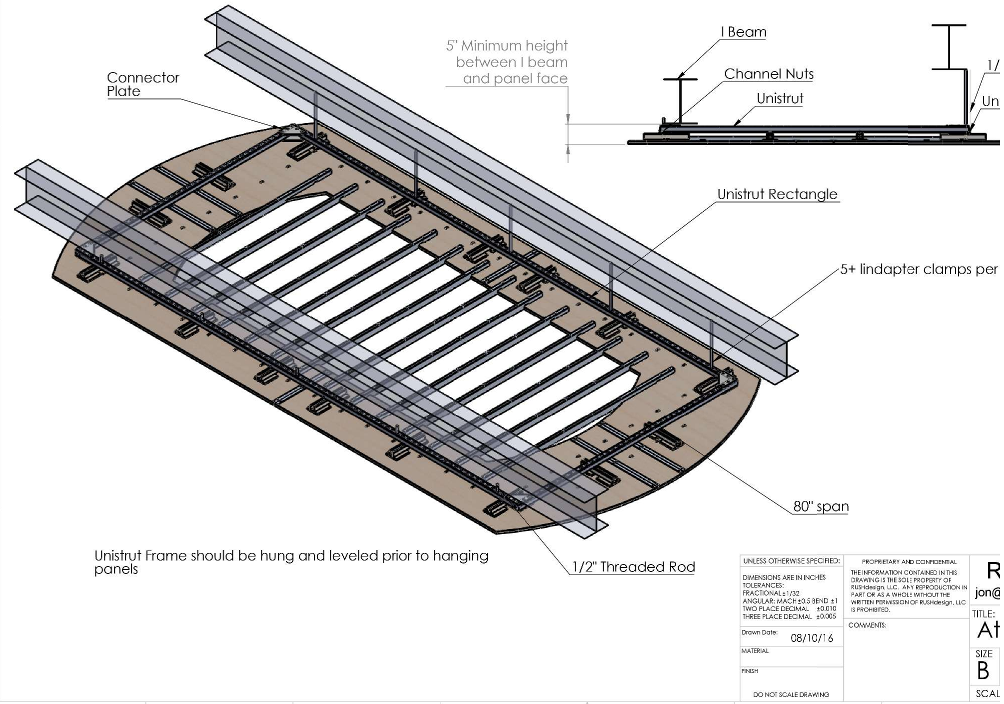
High-end architectural and interior design hardware required different approaches to materials, machining and finishing. Some parts such as those for DLV (left) were produced at high volumes in materials such as brass, corian, and wenge but required only a machined finish, leaving polish and patina to the designers. Whereas these custom 304 stainless-steel exterior handles (above/below) required machining, welding, finishing, patina and laquering before being delivered to the client.



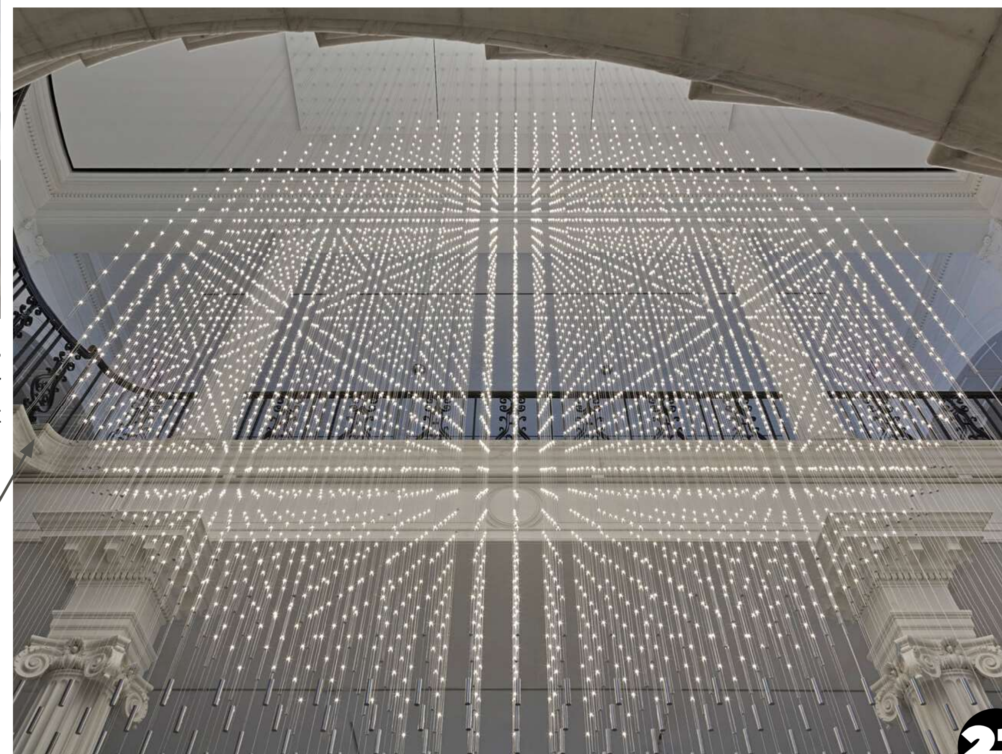


Product photos courtesy of DLV

The scope of my work on projects at RUSH differed from project to project. In some cases, I was given fully dimensioned drawings; only requiring that I program, setup and produce parts that met the client specifications. Other projects started with only vague client descriptions, requiring a collaborative approach to design and prototype components that met the client needs. Some projects covered a full scope of project management, coordination with vendors, production, logistics and installation.




Mirror assembly components for Columbia's astrophysics department required setup of precise soft-jaw fixtures for multiple machining operations to produce parts to tight specifications.



We frequently worked with Studio 1Thousand to produce custom lighting installations such as this chandelier for the Museum of the City of New York. Another team at RUSH wired the LED strands and control electronics with my team producing the machined panels, assembling electronic and structural elements and crating the chandeliers for shipment. I also frequently worked with the electronics team to debug components and do repairs in the field.

# Personal Work

ART + FABRICATION
SOLE DEVELOPER
ONGOING

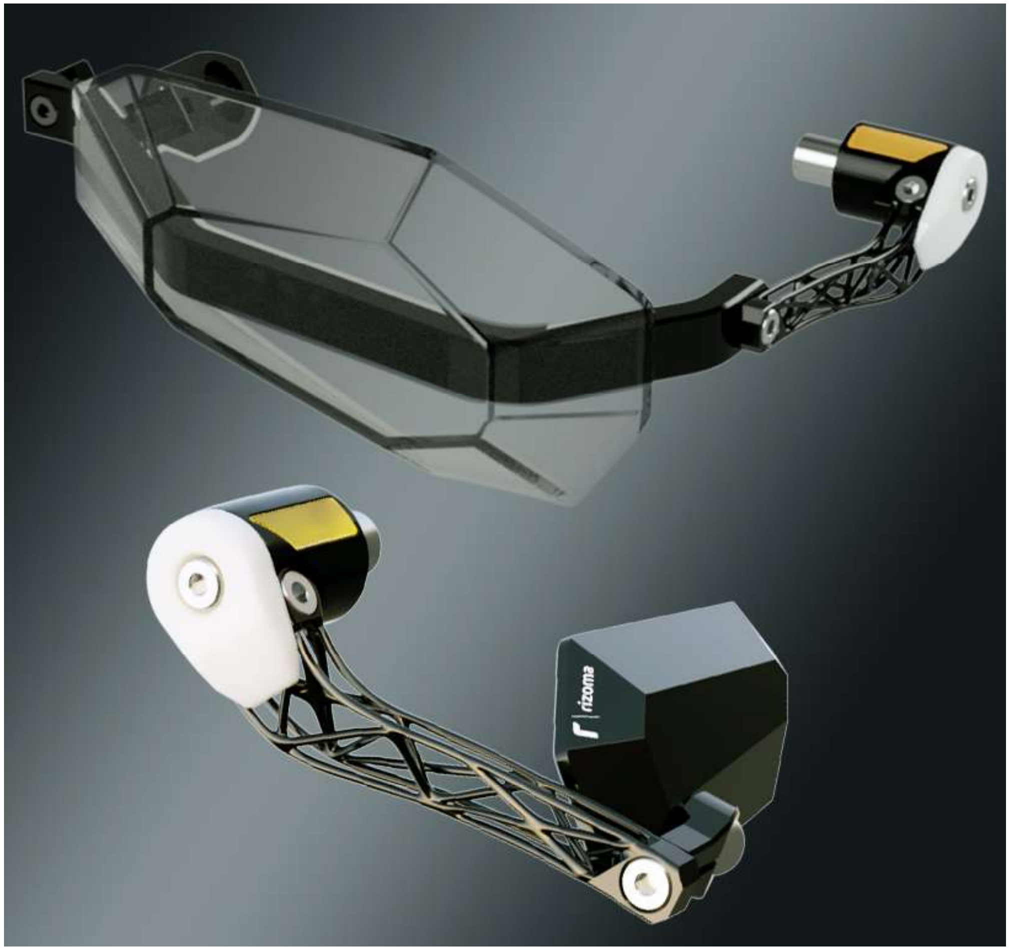
## Machined Objects

Clockwise from left: A hand-poke tattoo tool machined in 260 brass. An office table made from the baltic birch ply cutoffs from a commission. A series of ash trays machined from scrap 5052 aluminum plate then polished and hand-engraved.

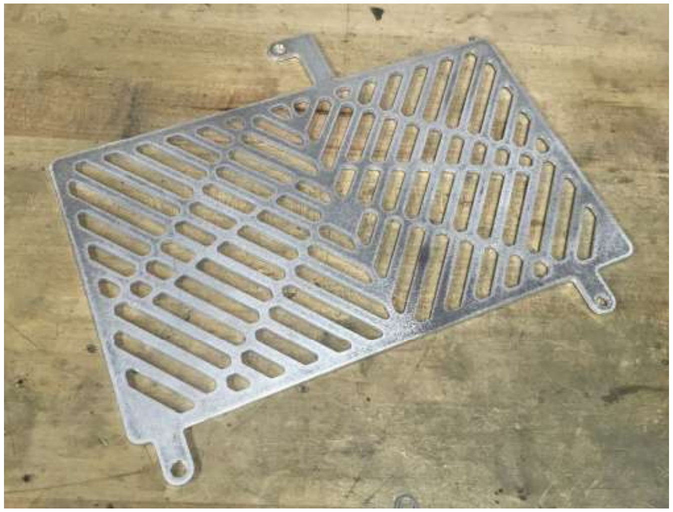
# Art/Sculpture

Clockwise from right: 1:4 scale ceramic excavator bucket. 5’x5’ painting CNC engraved in baltic birch plywood. Centipede ceramic planter.

# Bike Parts



Left: Concept bar-end motorcycle accessory line for a design challenge hosted by Rizoma in which I was a finalist. These were designed for modularity and use of digital manufacturing processes, diversifying the supply chain and allowing for user customization.

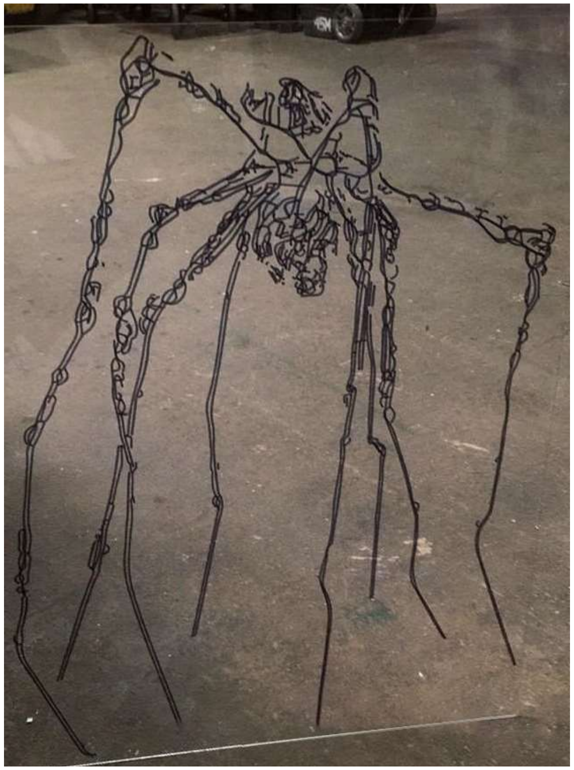


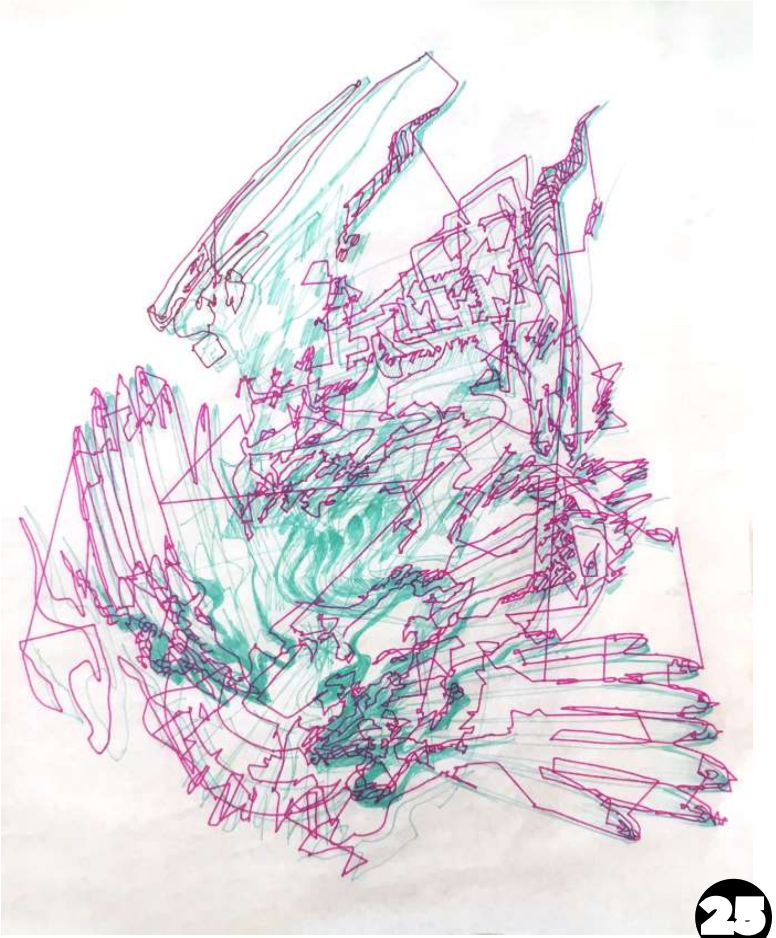
Above/ Left: Custom radiator guard, crash bars and footpegs built to protect my CB500x during off-road riding. Lacking any bending tools, the crash bars were built from square tube stock that was kerf-bent then brazed, tig welded and laquered. This allowed for easy modification of the bend angles and machining access prior to final fit up and welding. The crashbars and guard survived a 10,000 mile test run across the US.

# Automatic Drawings

"Automatic Drawing" is a practice of releasing conscious control over the art-making process. This method has been an important therapeutic technique in my personal struggle with mental illness. Ultilizing computer and machine collaboration, I wanted to explore these notions of autonomy and control.

I created the initial automatic drawings which were then photographed and mapped to line contours using different methods in Processing, Grasshopper and Adobe Illustrator. Using Processing, these contours were converted to Gcode where sections of code were randomly culled. The Gcode was executed over the initial drawing with a CNC router using a simple spring pen tool I had machined. Experimentation was also done in reversing the process- using processing to create generative contours that were then drawn over by particpants at the ITP Camp group show.






Thanks for reading!