PHOEBE LUO

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SKILLS

- Significant experience with **rapid prototyping** embedded systems over **5+ hackathons** using the following:
  - **CAD/Machining:** Solidworks, Inventor, 3D-printing, hand tools, drill press, lathes, CNC, Inventor CAM, GD&T
  - **Hardware:** Arduino, Raspberry Pi, ESP-32, soldering, oscilloscope, sensors, motors
  - **Software:** C++, C, Python, Java, Git, Linux, OpenCV, FreeRTOS, Jupyter Notebook
  - **Communication Protocols:** UART, I2C, SPI, CAN

EXPERIENCE

Robotics Research Assistant | *The Hospital for Sick Children (SickKids)* May 2022 - Aug 2022

- Designed, prototyped, and iterated a new mechanism for an MRI-compatible robot to manipulate mock human tissue under strict design constraints using **Solidworks**, incorporating **DFM** and **DFA** principles
- Wrote **soft real time Python code** to develop a novel **beam steering** feature to correct for motion during MRI guided high-intensity focused ultrasound (HIFU) cancer treatments, achieving a final steering accuracy of ±2 mm

Robot Designer & Programmer | *FIRST Robotics Competition Team 1241* Nov 2018 - Apr 2021

- Designed **gearboxes** from scratch, including **calculating gear ratios** to achieve design requirements like top speed, sourcing appropriate **motors, bearings**, etc, and using **Inventor CAD** to model custom gearbox plates
- Utilized **Inventor CAD** to create a **parametric model** of the robot drivetrain and gearboxes to validate the geometry, and used **Inventor CAM** to generate **g-code** for **CNC** manufacturing
- Integrated **SPI/I2C/CAN** based sensors through middleware to interface with third party drivers, and performed maintenance/debugging of components using **LabView** and **CAN analyzing** software to reduce cycle times by 25%

PROJECTS

Braille-iant | *C++, Inventor, 3D Printing, Embedded Systems*

- Created a low-cost braille printer by **rapidly prototyping** linear actuators and other mechanisms with Inventor **CAD** and **3D printing**, which was awarded best hardware hack at TOHacks 2021 out of 700+ participants
- Followed an **iterative design process** to innovate a robust paper piercing mechanism with a final success rate of 99%
- Developed **C++** code for an **Arduino** microcontroller, using **UART protocol** to run stepper and servo motors based on user input from a **Python GUI** to print braille letters

copy-cast | *Solidworks, C++, 3D Printing, Integration*

- Prototyped a **wearable exoskeleton** to enable external control of the wearer's hands through **CV** and live **gesture tracking** with **ML**, winning best medical project at MIT's annual hackathon out of 1000+ participants
- Designed exoskeleton ligaments and adjustable finger attachments using **Solidworks**, verifying assembly range of motion and checking for interferences that enabled easy integration with **off-the-shelf** parts (motors, fasteners, etc)
- Interfaced ML data about hand position with **C++** motor control code on an **ESP-32** through **wifi** communication

Anti Anti-Masker Mask | *OpenCV, C++, Rapid Prototyping*

- Developed wearable solution to deter anti-maskers from the user's vicinity by using **OpenCV libraries** for face detection and a flywheel propelled dart shooter, winning 2nd place at MakeUofT out of 180+ participants
- Wrote implementation firmware in **C++** for the **Raspberry Pi GPIO** pins, including **PWM** control of BLDC motors, sensor polling through **I2C** protocol with a **TOF** range finder, and interfacing components through **serial** communication

Dumpling Dynamics | *C++, Solidworks, Rapid Prototyping, Machining*

- Invented a robot to automate the dumpling-making process from concept to prototype, using **Solidworks**, **3D printing**, and **machining** to prototype clamping mechanisms, and won out of 477 teams at HTN, Canada's biggest hackathon

EDUCATION

University of Waterloo | *Candidate for Mechatronics Engineering, BASc - 3.9 GPA* Sep 2021 - Apr 2026 (expected)

INTERESTS

- Birds/Dogs
- Hackathons
- Anything Boston Dynamics does
- Food Reviewing and Cooking
- Minecraft

PORTFOLIO

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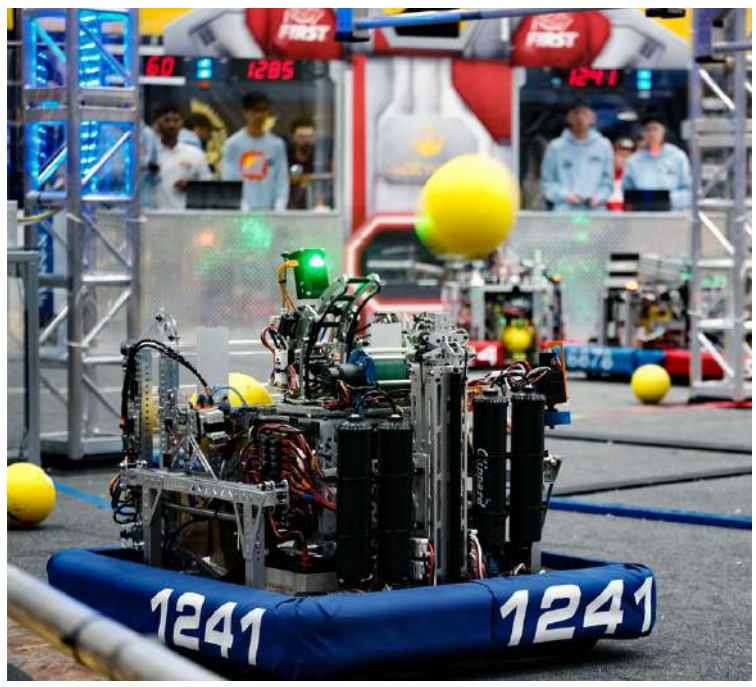
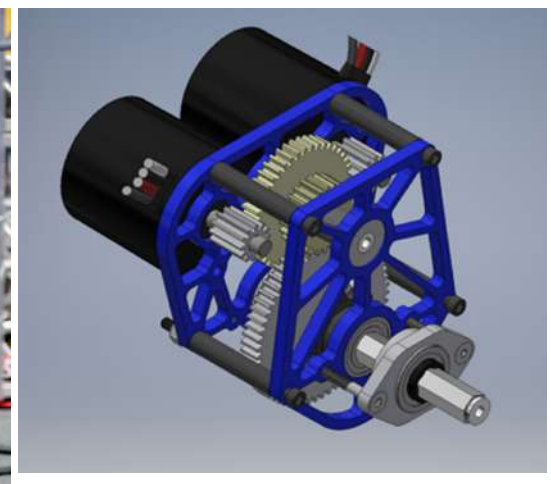
FIRST Robotics Competition





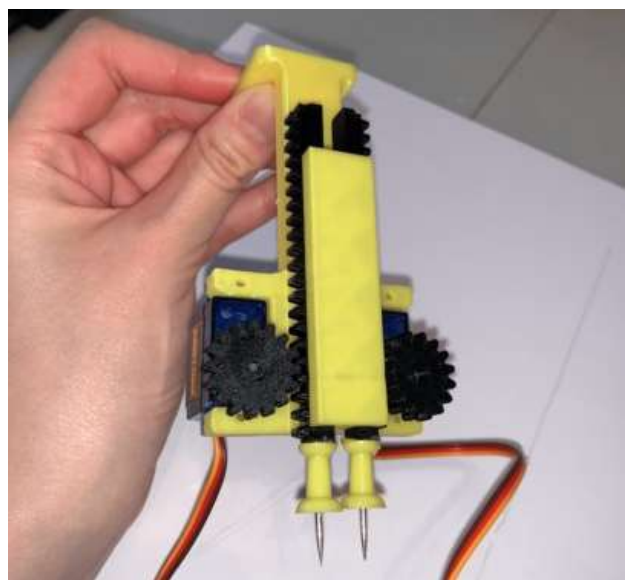
(Above) Gearbox CAD assembly, and the gearboxes in real life

(Left) Picture of the full robot shooting. The camera is actively tracking the target (the green light) and has shot the yellow ball.

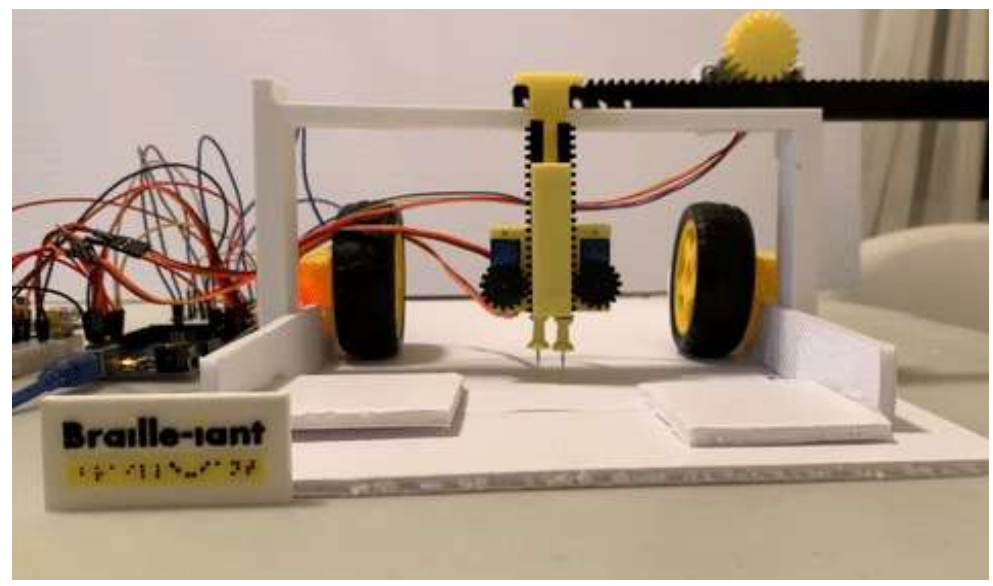
- As a designer and manufacturer on the team:
  - Used **Inventor** to design the chassis of the robot and the gearbox plates, performing **parametric modelling** to ensure the validity of my design and that it met requirements, and calculated gearbox ratios to source appropriate gears
  - Generated g-code using Inventor CAM software for CNC part fabrication, selecting settings that optimized time
  - Manufactured and assembled **10+** robot parts using **machine shop tools** including lathes, mills, and hand tools

- As the lead robot software developer:
  - Worked with **communication protocols (SPI, I2C, CAN)** to interface components (encoders, gyro, etc) with robot movements, and used **CAN analyzing** software for debugging problems throughout the competition season
  - Developed control software for the robot, for example designed and tuned **PID controllers** using **LabVIEW**, created **motion profiles** reduce shooting error, and wrote **autonomous routines** to ensure the robot scored the maximum number of points

Braille-iant



Close up of the final paper piercing mechanism design, which was designed, 3D printed, and assembled by me



Full image of Braille-iant midway through prinitng

- Built a low-cost world's cheapest braille printer for only $15 as a solution for making physical documents (receipts, contracts, doctors notes) more accessible to people who are visually impaired.
- **Rapidly prototyped** and **3D printed** the paper piercing mechanism in under 24 hours. The mechanism went through two iterations, the second design utilized 2 rack and pinion gears to convert a servo motor's rotational motion into linear motion
  - The paper piercing mechanism was designed in **Inventor** and I incorporated **DFM** and **DFA** principles to ensure feasibility
- Developed and integrated a **Python GUI** and **C++ Arduino** sketch to communicate via **UART** protocol, allowing the printer to receive user input and then drive stepper and servo motors to print the corresponding Braille output
- Used a breadboard to connect all the components, including servos, stepper motors, DC motors, and the motor controllers
- Braille-iant was awarded Best Hardware Hack out of 700+ participants and is seen working here

PORTFOLIO

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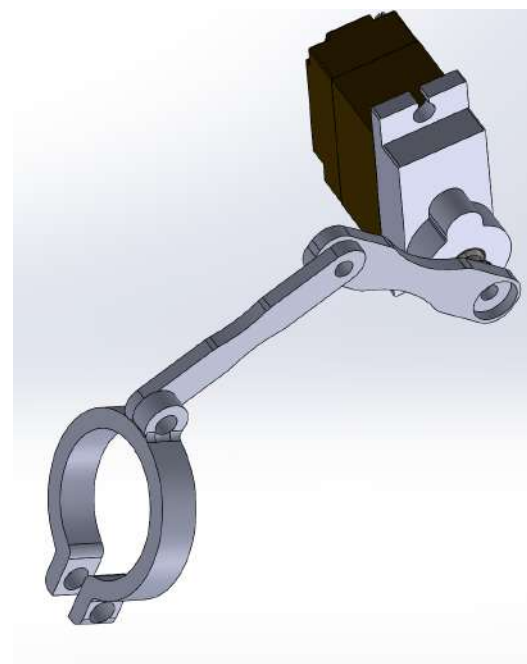
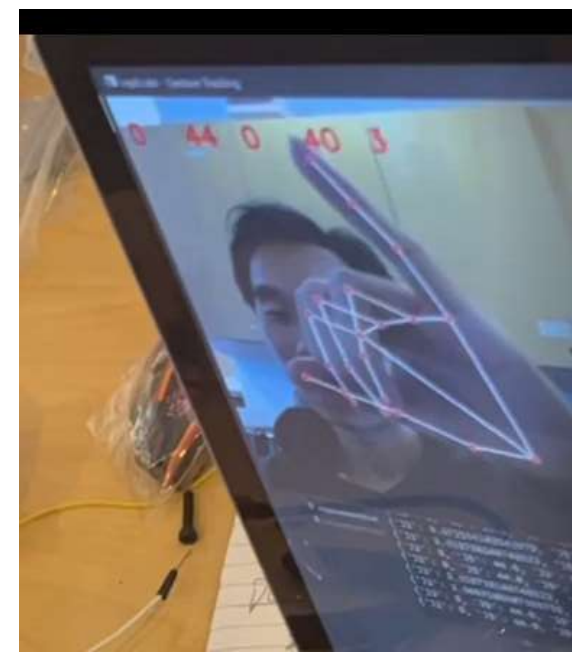
copy-cast





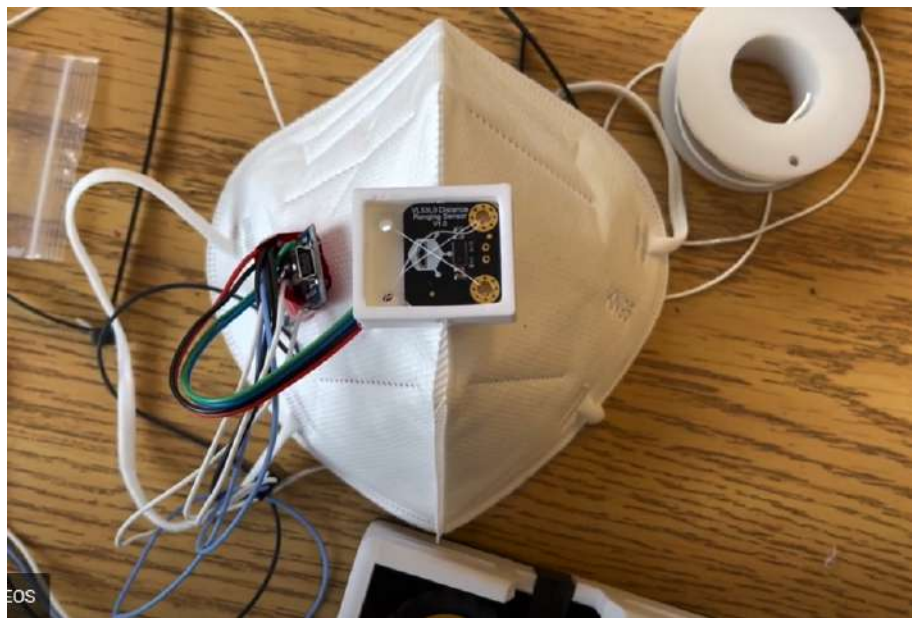
(Above) Closeup of copy-cast exoskeleton

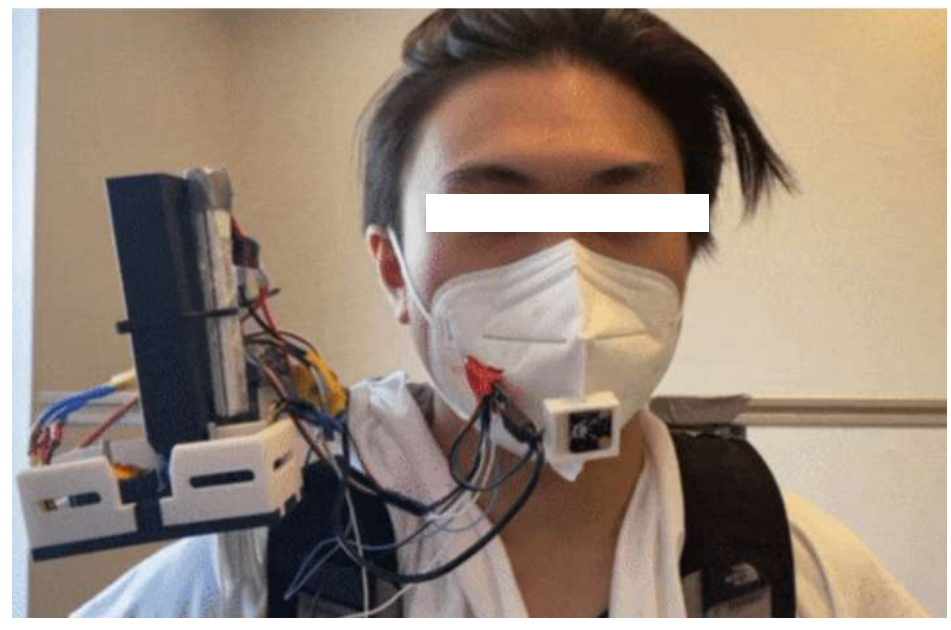
(Middle) CAD model of one finger attached to a micro servo for the exo skeleton

(Left) Live gesture tracking through OpenCV to determine hand position

- The copy-cast is an exoskeleton that controls the wearers hands based off another person's hand through computer vision and **live gesture tracking**, implemented with **OpenCV** and **MediaPipe**. The finger positions are determined and converted to angles that get sent to the servo motors that move the exoskeleton accordingly.
- Designed for applications such as physiotherapy and muscle-memory based learning of skills such as performing surgery
- Used **Solidworks** to design and validate the geometry of the exoskeleton, and used **DFA** principles to ensure that assembly could be done with the materials on hand (M2 and M3 nuts and bolts) and integrate easily with micro servo heads
- The adjustable finger attachment ring was inspired by a retaining ring clip and is tightened with an M2 nut and bolt.
- Wrote integration code between the live gesture tracking running on a desktop and the **ESP-32** microcontroller through wifi communication, and also wrote **C++ code** for the **GPIO** pins for servo motor control
- Collaborated with MITERS, MIT's oldest makerspace, to arrange for parts to be 3-D printed on a Prusa
- The copy-cast was recognized as a top medical hack at HackMIT 2022, out of 1000+ participants and a demo video is here

Anti Anti-Masker Mask





Mask close up - the 3D printed casing for the point lidar was sown on as well as the other electronics

Pictured is the mask and the dart shooter together. It is attached to the user with an aluminum extrusion on a vest.

- Designed wearable technology to deter anti-maskers from the user's vicinity by first detecting them with computer vision, and then shooting them with a custom designed flywheel dart shooter (with a custom magazine as well!)
- Wrote Python code with **OpenCV** libraries for facial detection to look for anti-maskers in the vicinity. If so, it then used **UART** communcation to notify the microcontroller that a target has been found.
- Interfaced facial detection code with **C++** firmware to first check with a TOF sensor via **I2C** protocol if the offender is within 6 feet, and if so, to run the shooter's DC motors using **PWM** control.
- Currently implementing this using **FreeRTOS** to allow for real time tracking (and shooting) of anti-maskers
- The Anti Anti-Masker Mask won 2nd place at MakeUofT, Canada's largest Make-a-thon, out of 180+ participants! See it working here