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Torque Inducing Tremor Stabilizer

Brendan Chong, Clement Hii, Jacky Kam,
Umang Kapure, Samuel Krisetia, Gourang Kulkarni

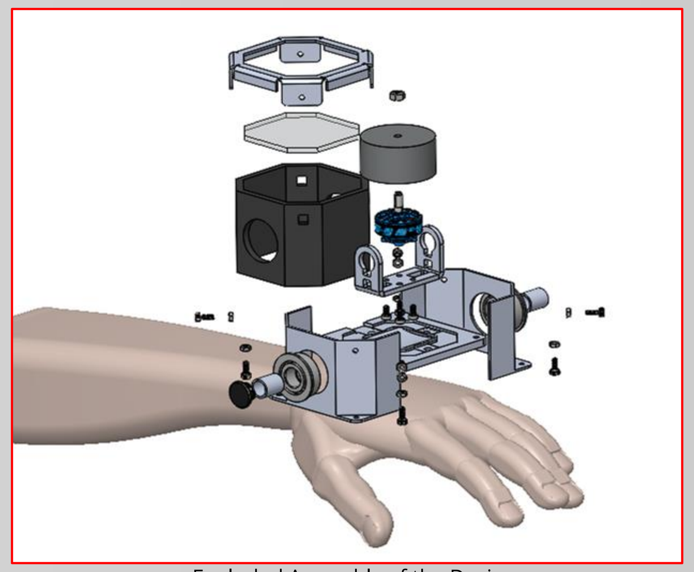
Integrated Engineering - University of British Columbia

INTEGRATED ENGINEERING

Mechanical

From non-newtonian fluid to satellite-grade reaction wheels, the team was inspired by many, creative solutions. The Final Design implements the following:

- A 45mm Diameter Steel Flywheel to induce a stabilizing torque to the patient. Compact, light and cost effective are its main attributes
- An Octogonal Soundproof Chamber, dampening sound by 40%. Provides a blend of durability and aesthetic.
- A Tough Resin Mount allows Flywheel Precession and enables the device's stabilization
- Manufacturing was aided by a Tormach 1100 CNC Mill, Manual Lathe, Waterjet Cutter and 3D printers


Exploded Assembly of the Design

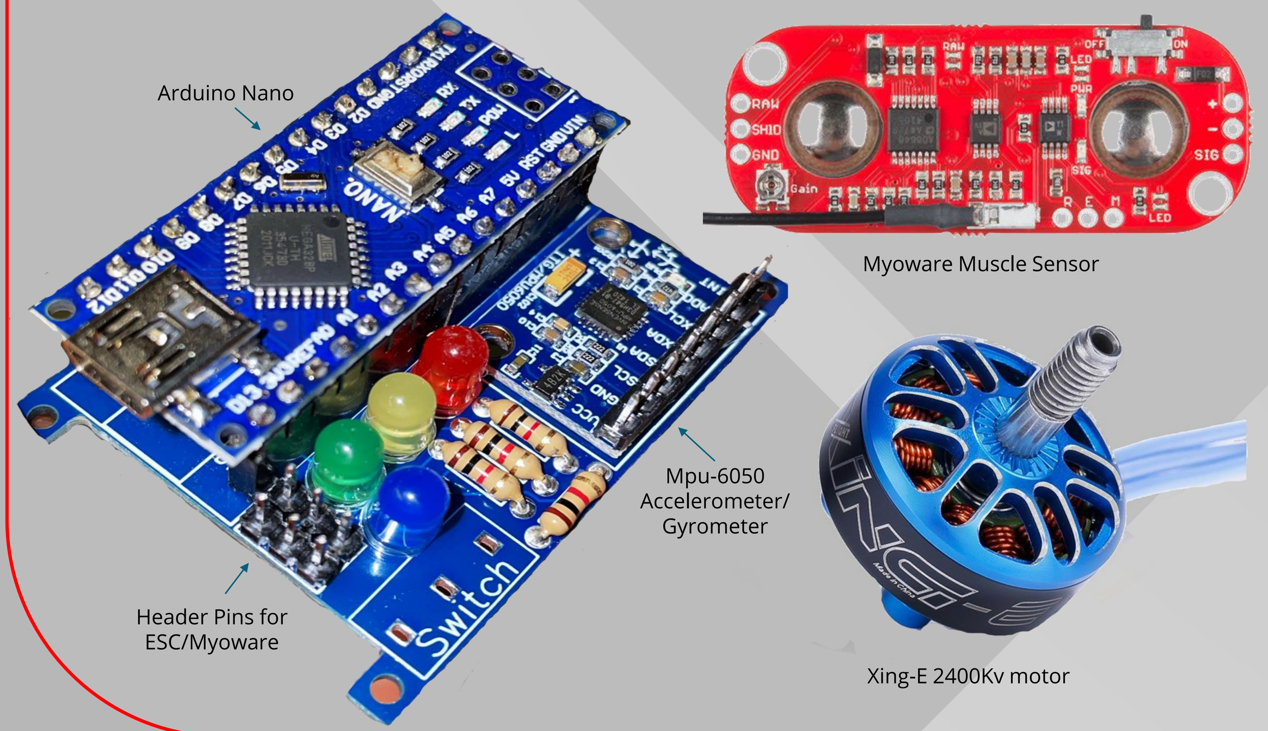

CNC milling of an iteration of the flywheel


Tough Resin Mount and Flywheel

Electrical

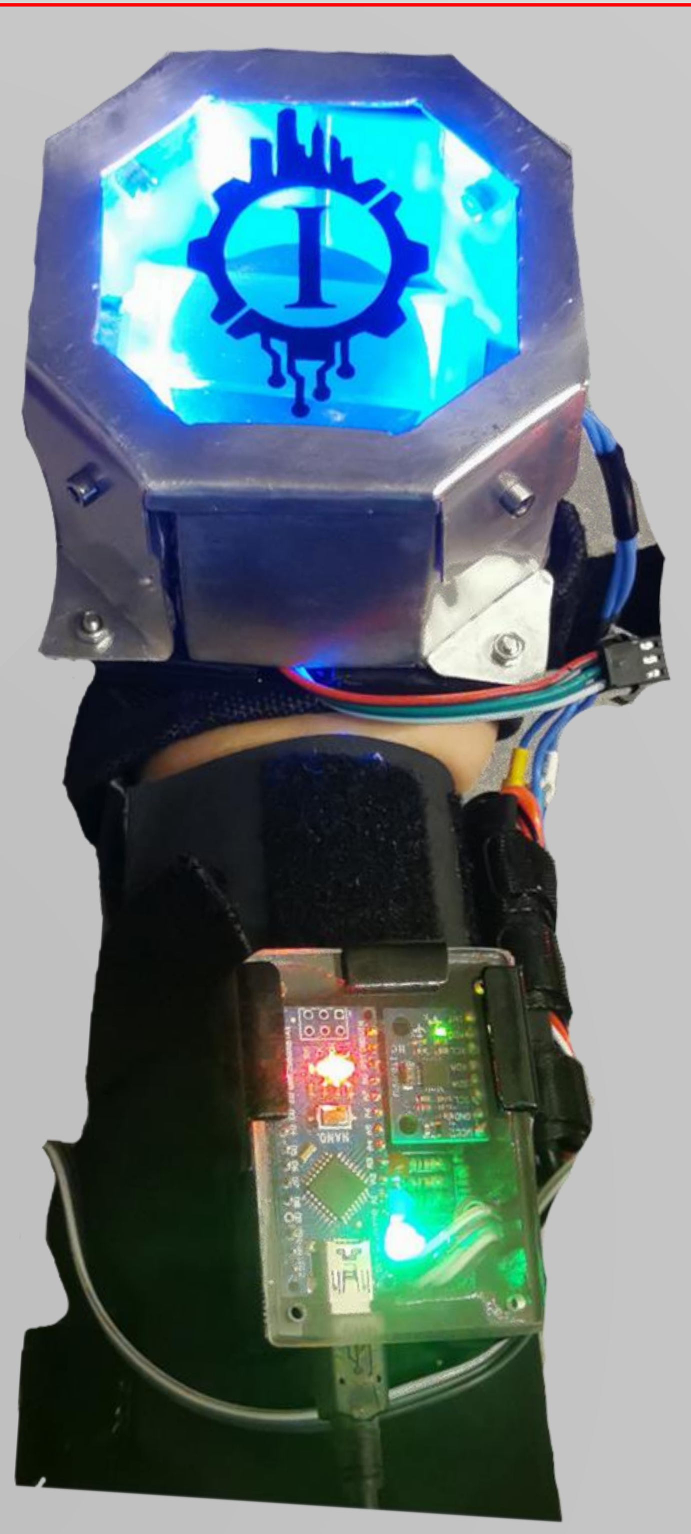
Engineered a PCB that integrates an Arduino Nano, mpu-6050, and LEDs with connections to a Myoware muscle sensor, and an Electronic Speed Controller (ESC) to connect all of the components.

- A 2S Lipo battery powers the PCB, while a 4S Lipo battery powers the ESC, which can power the glove for 40 minutes on a full charge.
- The motor specifications are as follows: a 2400KV brushless DC motor with a maximum RPM of 41000, operated by a 40A ESC.
- The motor housing has RGB light strips integrated in, which contributes to the glove's overall aesthetics.



Problem Statement

Essential Tremor (ET), is a common neurological disease resulting in uncontrollable shaking, primarily in the hands. It affects nearly 4 in every 1000 people worldwide, has a 50% chance of being passed down genetically, and worsens with age, with the potential of developing into Parkinson's Disease. ET causes difficulty in many daily activities such as writing, eating, or drinking. Current solutions utilize gyroscopic stabilization, but are heavy and run at a constant speed.

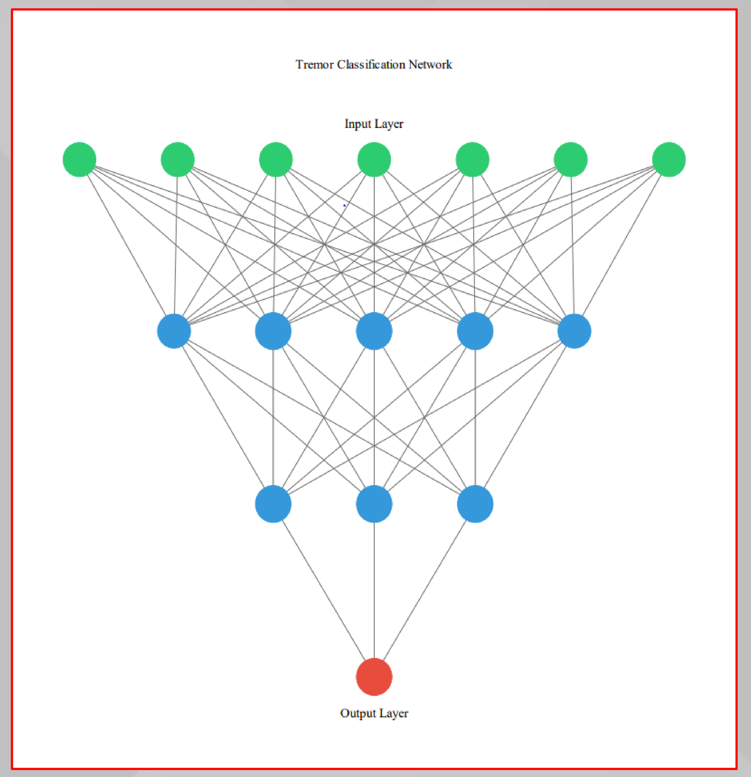


Our Solution

Combine gyroscopic stabilization with a neural network to adjust motor speeds during high-intensity tremors and user movement, to increase accessibility and ease of use

- 450g net weight, with 150g steel flywheel
- Composite walls of aluminum & rubber for enclosure
- Neoprene Sleeve for comfortable and tight conformity to the arm

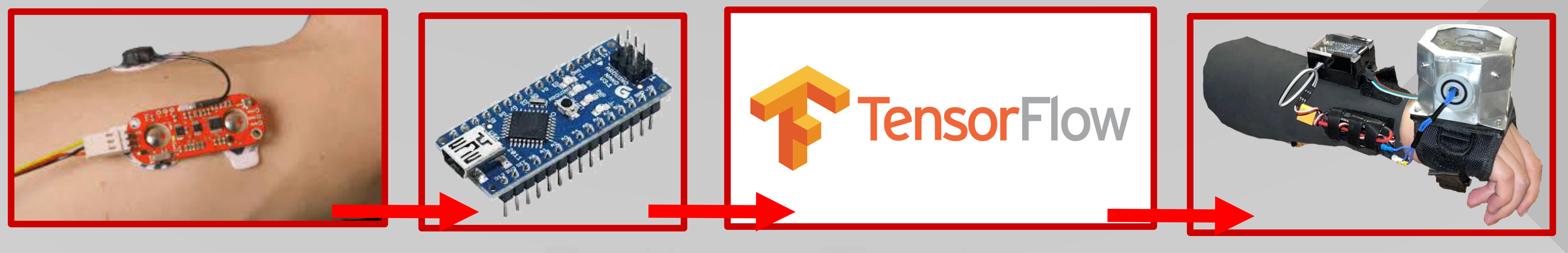
Software



Keras

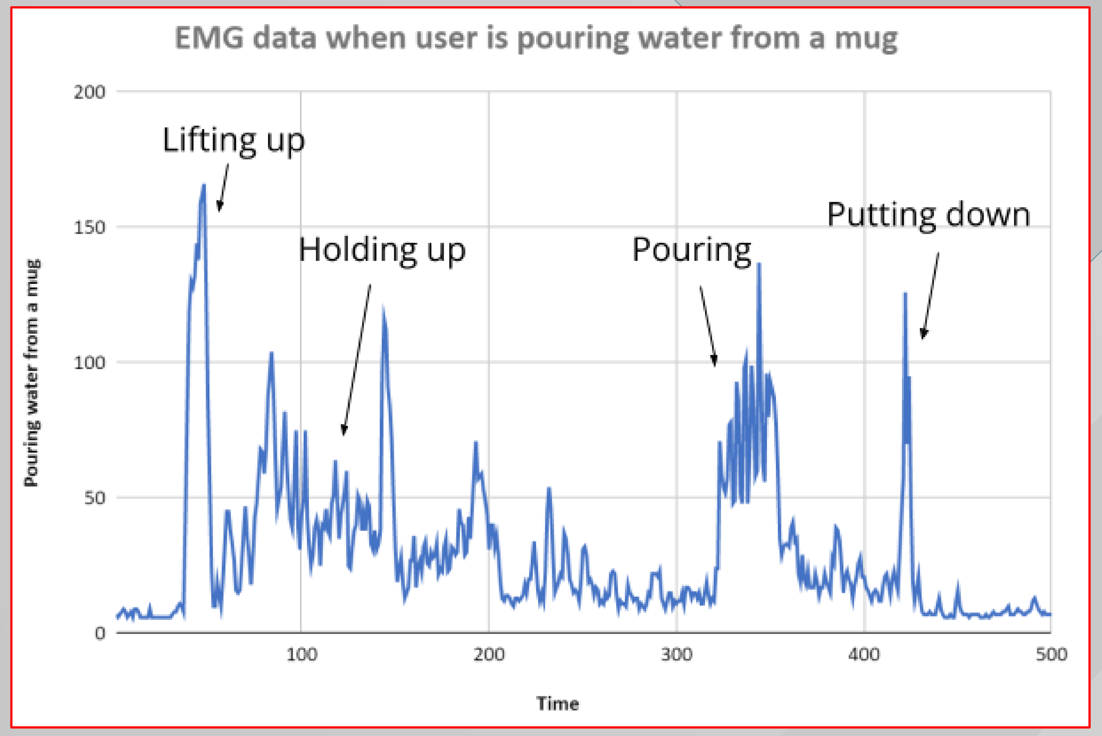
A neural net coded in Keras was used to aid in the dynamic adjustment of motor speed. Test data was acquired through extensive testing with stakeholders, which allowed us to train the network to:

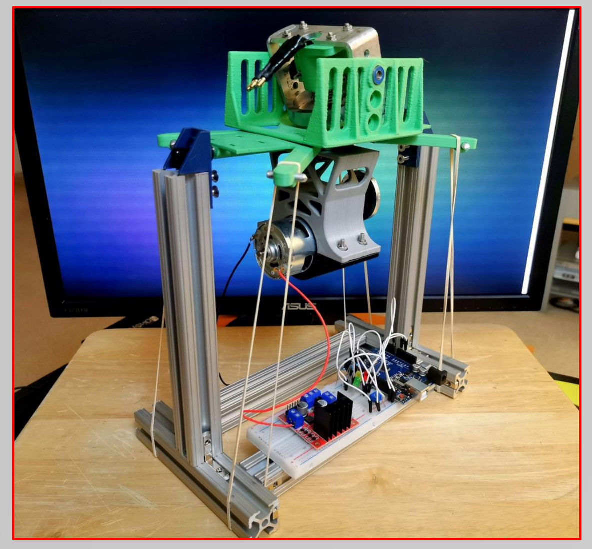
1) Detect: When the user is experiencing hand tremors as well as the general motion / orientation of the hand
   - Implemented with a single-output neural network classifier which takes the sensor values as its input
1) Determine: The intensity of tremor based on contextual movement and adjust motor speed to mitigate accordingly
   - Rather than using the direct sensor inputs, the change in sensor readings between two readings was used as the network input.
   - Actor-critic reinforcement learning was used to train against live data.
1) Decide: Use previous steps to run the motor at an appropriate speed.
   - The output of the motor speed network is constantly updated, with the tremor classifier being used to activate the motor.



User Testing/Results

Preliminary testing underwent several retrials in order to determine the optimal myoware placement that accurately reflects motions such as grasping or wrist rotation.





- A test stand was created to validate safety and to test the effects of gyroscopic precession
- It utilizes an offset mass to simulate the tremors while the top carries the swing to allow gyroscopic precession to occur

Current Limitations

- ESC is unable to drive motor in reverse, which introduces a delay when changing motor speeds due to the flywheel inertia.
- Due to the required inertia, the weight of the enclosure is heavier than desired (~450g gross weight). This is coupled with the necessary safety precautions (8mm thick enclosure walls, Polycarbonate)
- Due to the power draw of all components, the Lipo battery is unable to supply maximum voltage for extended periods of time

Future Iterations

- The size of the device will be optimized to lower the mass and bulkiness of the device.
- Further training on Machine Learning program to increase accuracy of tremor identification.
- Sound and vibration reduction in order to decrease impact of loud sounds