Bioinspired Exosuit

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Popovic Labs

WPI

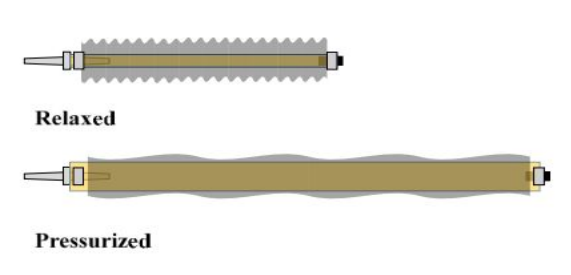
What is the Bioinspired Exosuit?

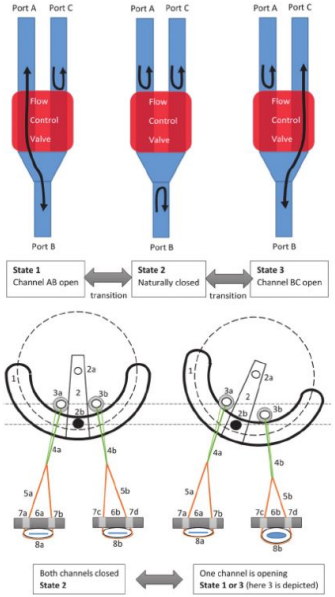
The Bioinspired Exosuit…

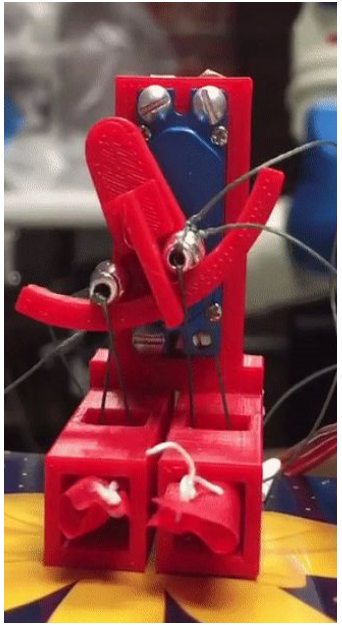
- Continues a multi-year effort.
- Utilizes Hydro Muscles, which are pneumatically-actuated artificial muscle.
- Uses neural network-based control informed by sensors.
- Adapts to the user’s specific gait cycle to provide optimal support.
- Lowers the user’s heart rate by providing assistive forces while walking over various speeds.

Hydro Muscle

- Pressurized to expand
- Depressurized to generate force





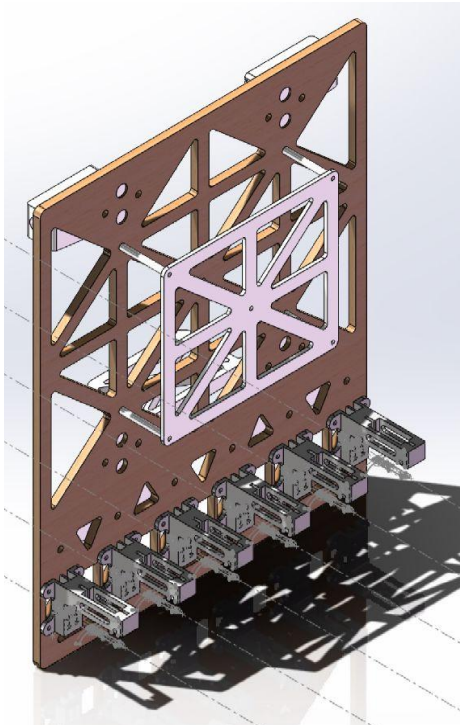


- Degree sensitive
- Discrete
- Continuous

CRFC Valve

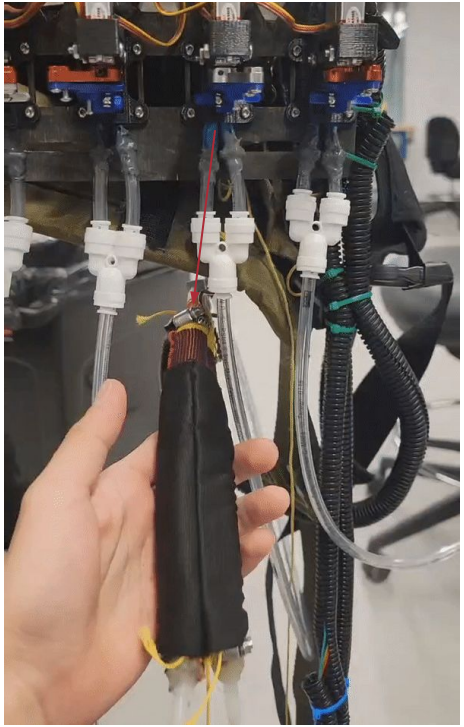
(Compact Robotic Flow Control Valve)

Mechanical Designs

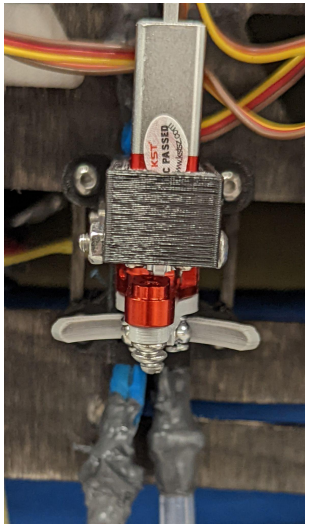


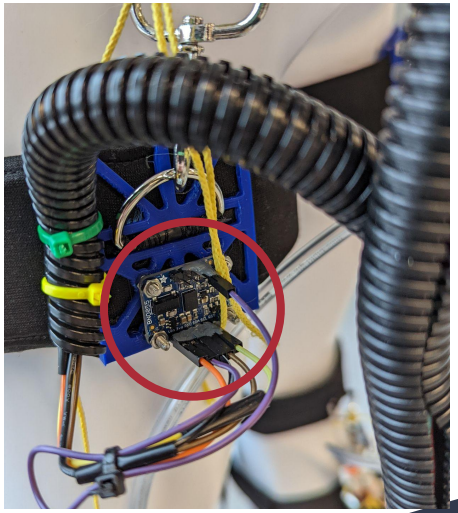
←Backboard Design

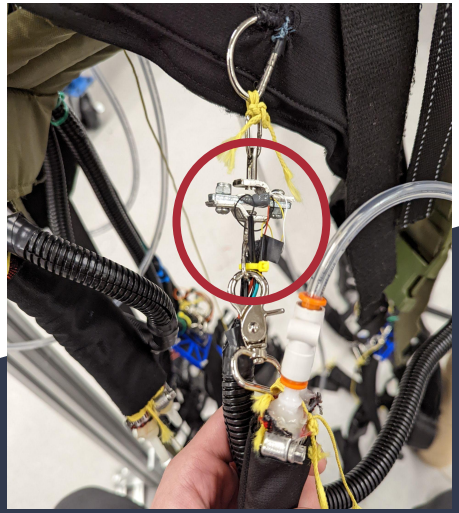
Actuator→

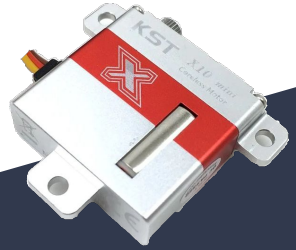


Motor/Sensor Suite

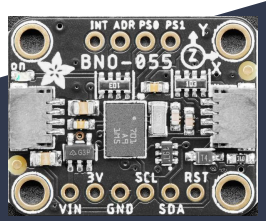






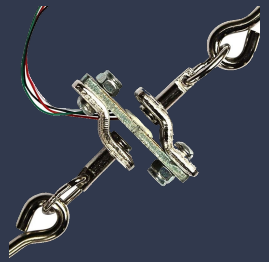


Servo Motor



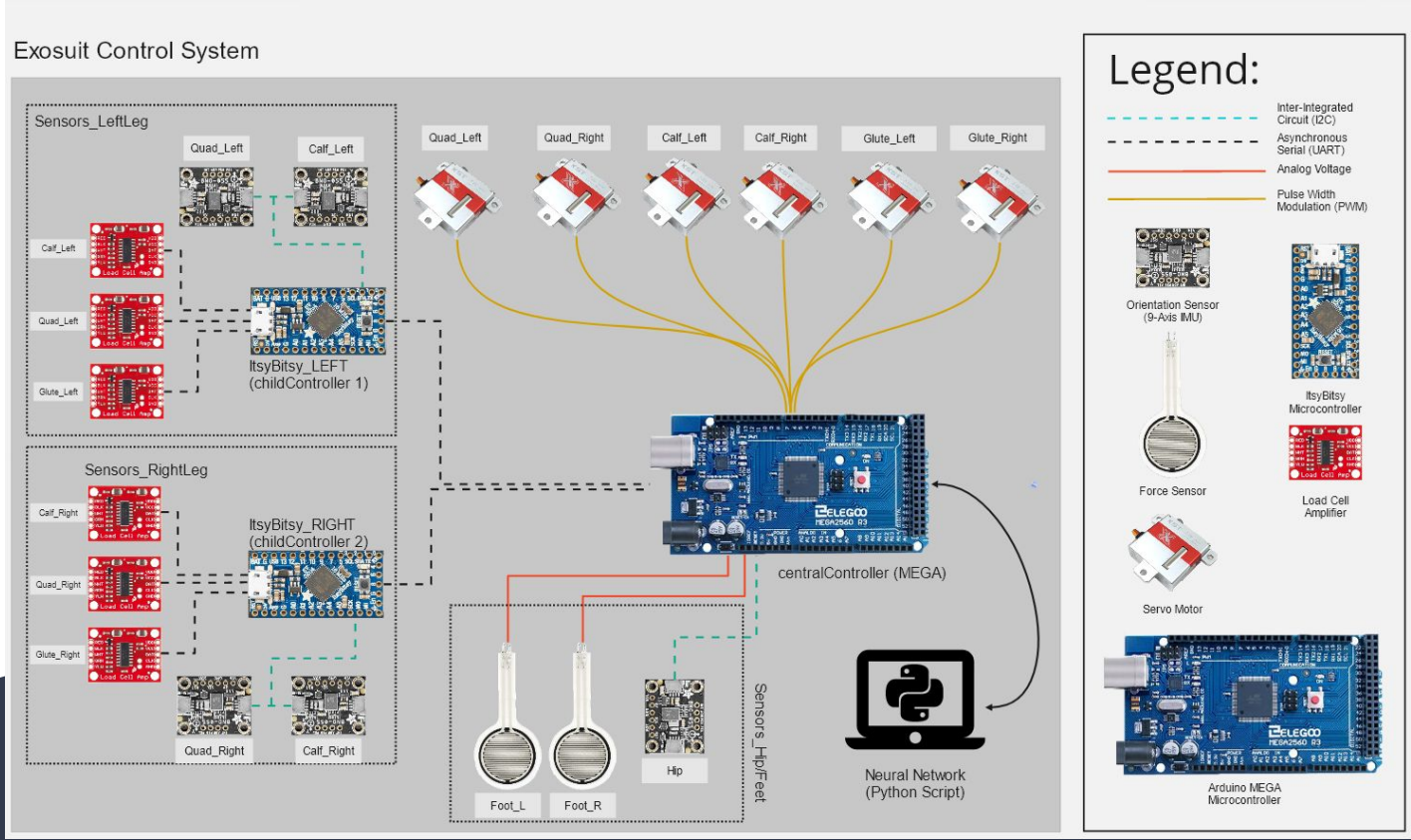
Orientation Sensor
(9-Axis IMU)

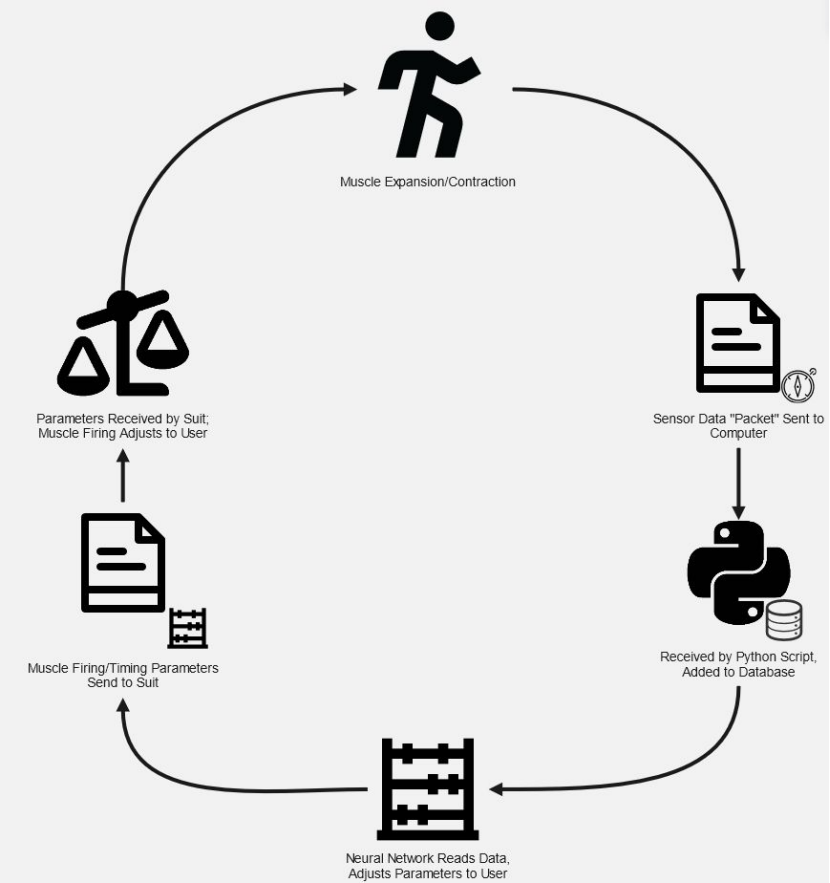
Force Variable
Resistor



Load Cell

High-Level Electronics Architecture



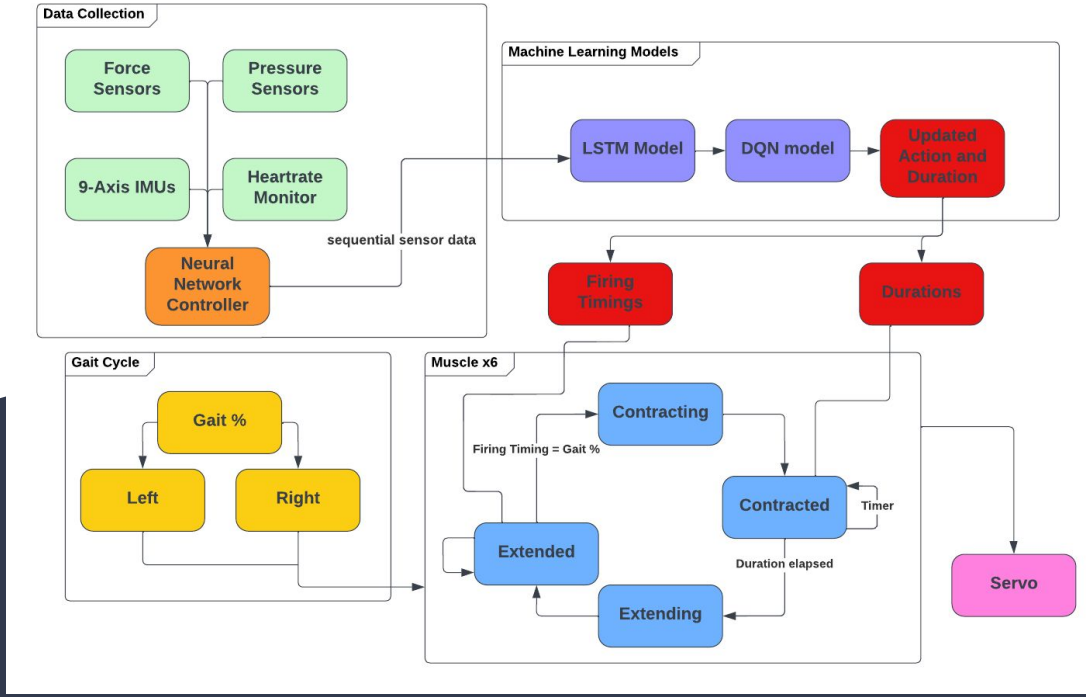


- Custom libraries built for inter-microcontroller networking
- “Suit-side” computation spread between ItsyBitsy and MEGA microcontrollers
- High-frequency sensor data collection for rapid adjustment
- **Result**: Suit dynamically supports user, matches their movement speed and monitors their level of exertion

Controls & Sensing

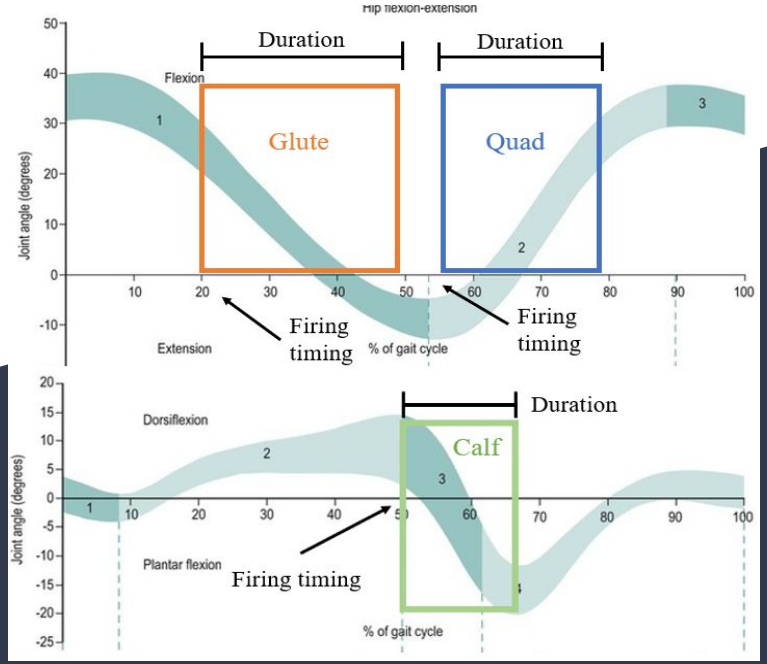
Controls & Sensing

- Adaptive Speed Control
- Hierarchical State Machine
- Servo/Valve Control

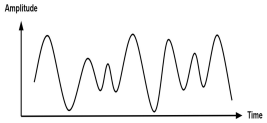


Controls & Sensing

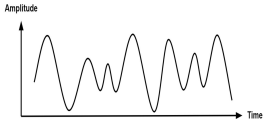
- Pressurization Timing
- Adjustable Parameters
- Mechanical Motion vs. EMG data



Neural Network Structure



x(1, 1), x(1, 2), … , x(1, m)



x(2, 1), x(2, 2), … , x(2, m)

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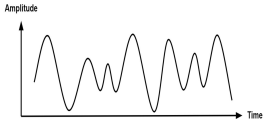


x(n, 1), x(n, 2), … , x(n, m)

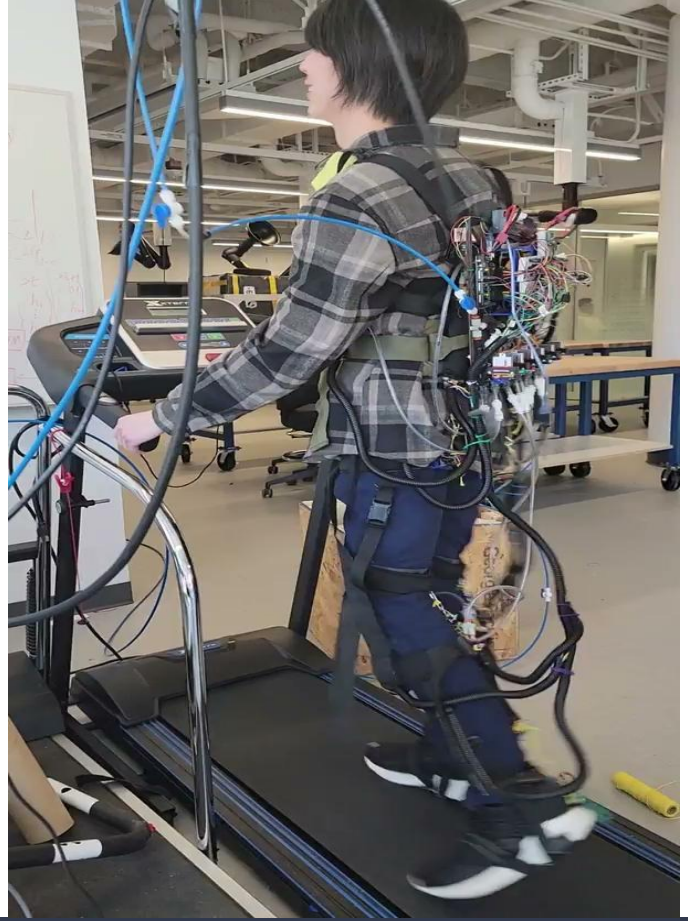
→ Long Short Term Memory → Deep Q Network → New timing and duration for muscles

h1,
h2,
…
h3

[a1, a2, a3, a4, a5, a6]

Result

Effect of Exo-suit on average heart rate (BPM)		
Subject	**Pace**	**Average heart rate changed in %**
1	2.1mph - 3.6mph - 2.4 mph	-2.71%
2	2.2mph - 3.3 mph - 3.9mph	+1.8%
3	2.8mph - 3.4mph - 2.2mph	-7.78%
4	2.3 mph - 3.5mph - 2.7mph	-8.84%



Video

Questions?