WPI Popovic Labs

Abstract

The Bioinspired Exosuit utilizes pneumatically-actuated artificial muscle (“Hydro Muscles”) to provide assistive forces while walking. This project continues a multi-year effort to utilize Hydro Muscles for this purpose. The Exosuit uses neural network-based control, informed by a comprehensive suite of sensors used to determine the state of the suit. This neural network-based control allows for the adaption to the user’s specific gait cycle and provides optimized support to decrease the energy consumed while walking.

Objectives

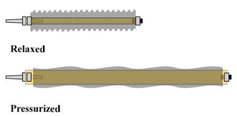
- To autonomously operate the exosuit by designing a novel control system.
- Reduce the heart rate of the user while walking under changing speeds.
- Package all the electronic components within a footprint that will remain under 8 lbs and at a small size.

Background

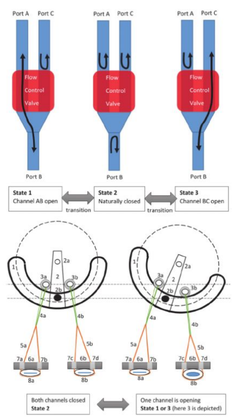
- Hydro Muscles are fluid elastic actuators that can be pressurized to charge and depressurized to generate loaded force to aid the bio-muscle force.[1]
- This is controlled by a degree sensitive, discrete and continuous fine flow control valve. (CRFC Valve)
- The Hydro Muscles are actuated corresponding to the timing of muscle contractions and motion of the subject during the gait cycle.

When the Exosuit is tuned to a specific person, it is proven to assist the user to a certain degree. However, since the gait cycle is constantly changing, a better method of control is required.

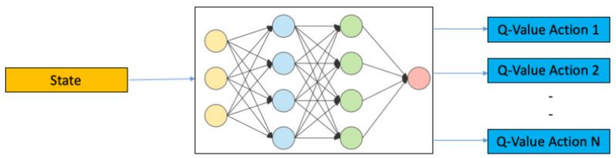
Hydro Muscle



CRFC Valve



Deep Q Learning



Machine learning is a method that uses a large amount of data to train a model to solve a task with many uncertain factors. Since each gait cycle is different, the machine learning method can be used to let the suit tune itself to adapt with different people.

Bioinspired Exo-suit

A wearable assistive walking device

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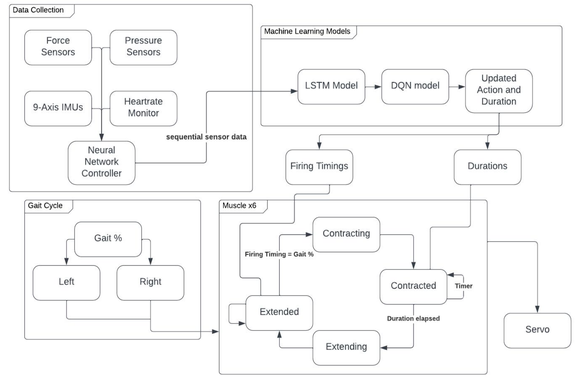
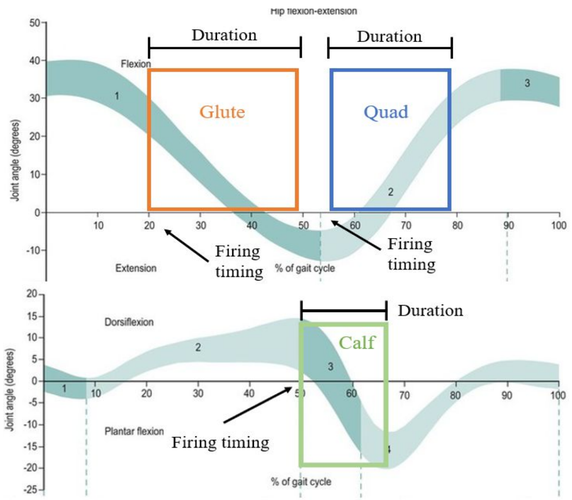
Scan for More Information

References: [1] Sridar, S., et al. (2016). “Hydro Muscle - a novel soft fluidic actuator,” 2016 IEEE International Conference on Robotics and Automation (ICRA), pp 4104-4021. Retrieved from http://users.wpi.edu

Machine Learning & Controls



Pressurization Timing



Results

Tests were performed on four subjects walking at three varying speeds for 4-minute intervals each. The neural network was trained with 100 datasets. The average heart rate was recorded for individuals walking with and without the suit:

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%

The data shows that the average heart rate was decreased for most of subjects. This reduction in heart rate shows that the exosuit positively affects the subjects. The subject who experiences an increase in heart rate may indicate that the exosuit has a poor performance in high speed, or simply the subject is being less familiar with exosuit.