

Design and Development of a Quasi-Passive Biarticular Exoskeleton to Increase Ankle Power during Walking

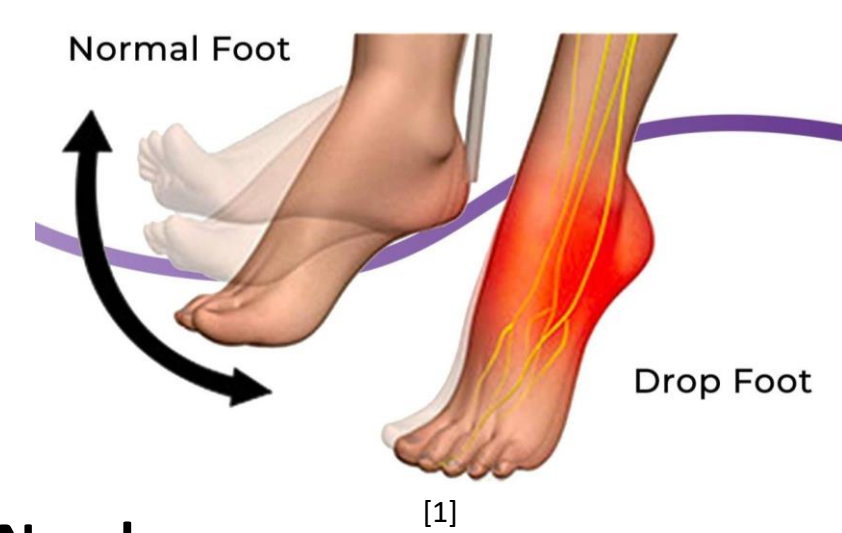
Sponsor: Emily Rogers-Bradley: Adaptive Bionics Lab

Team: Anjali Patadia, Alex Brownlee, Eden Guterman, Morgan Bresee, Youssef Eldeeb, Jesse Palamar



SCHULICH
School of Engineering

Objective



Market Need:

Currently, the market mainly offers solutions for knee injuries, with limited options for alleviating ankle joint load or conditions like drop foot.

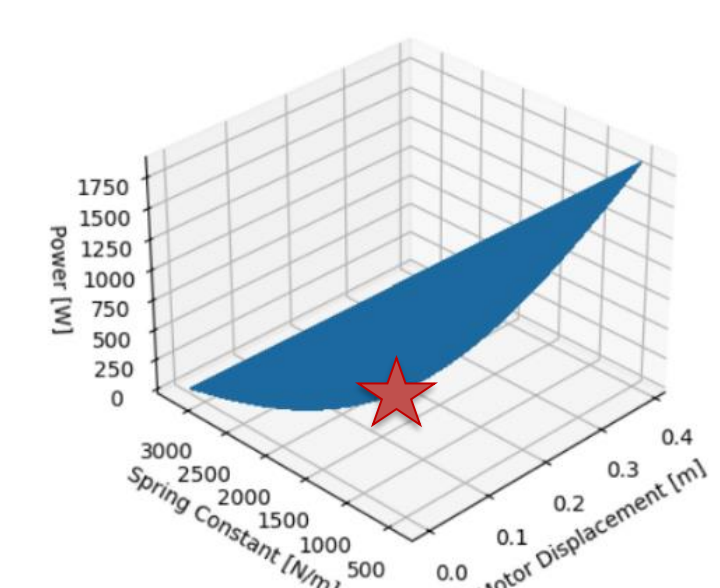
There is a need for a quasi-passive system to:

- Minimize metabolic cost
- Minimize weight

Device Specifications:

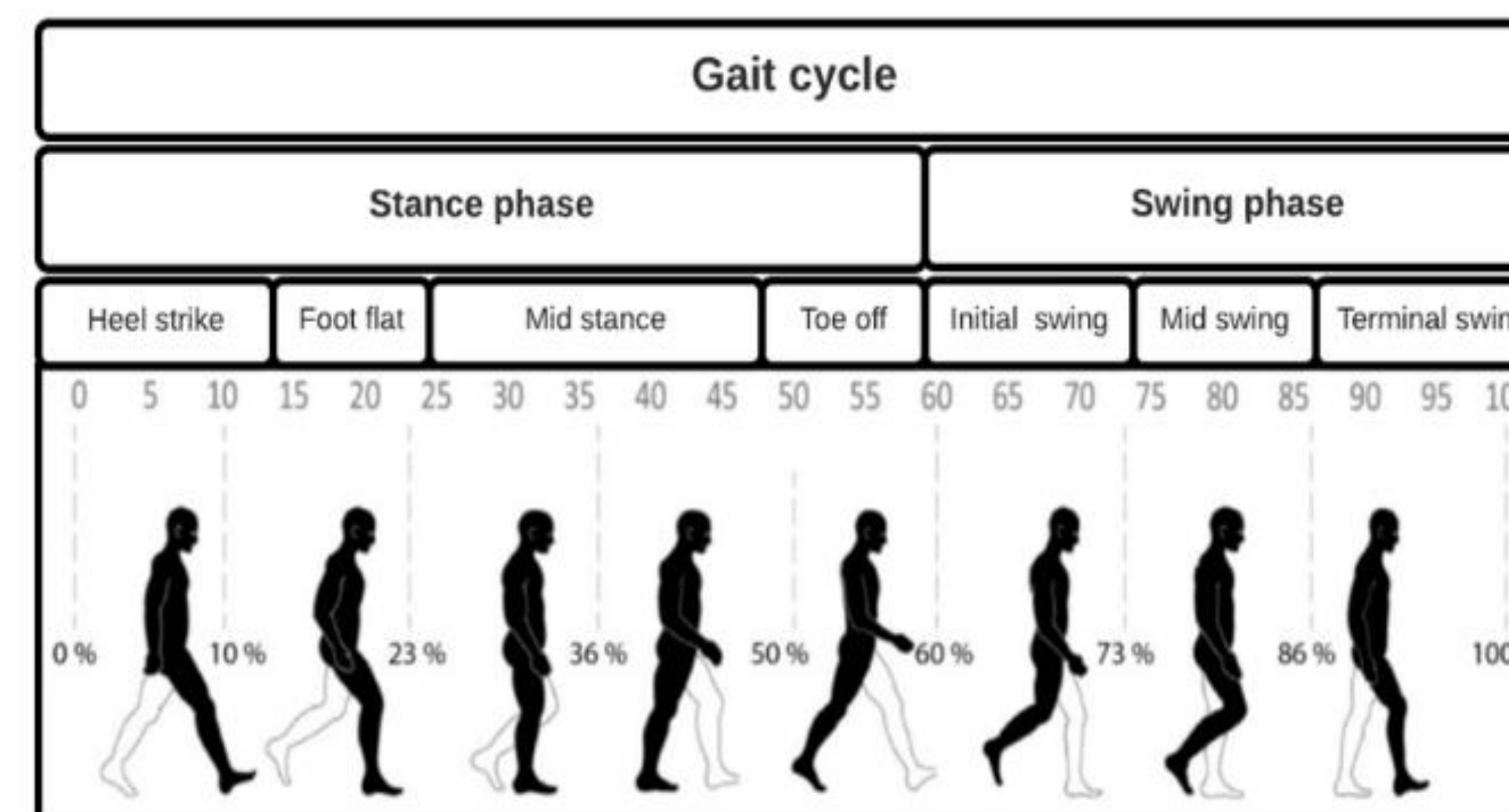
- Utilizes knee energy to increase ankle power
- Device Output: >30% of ankle torque - 28.81 Nm
- Weight Limit: <1.175 kg
- Power: <30 W

Relationship between Power, Displacement, Constant



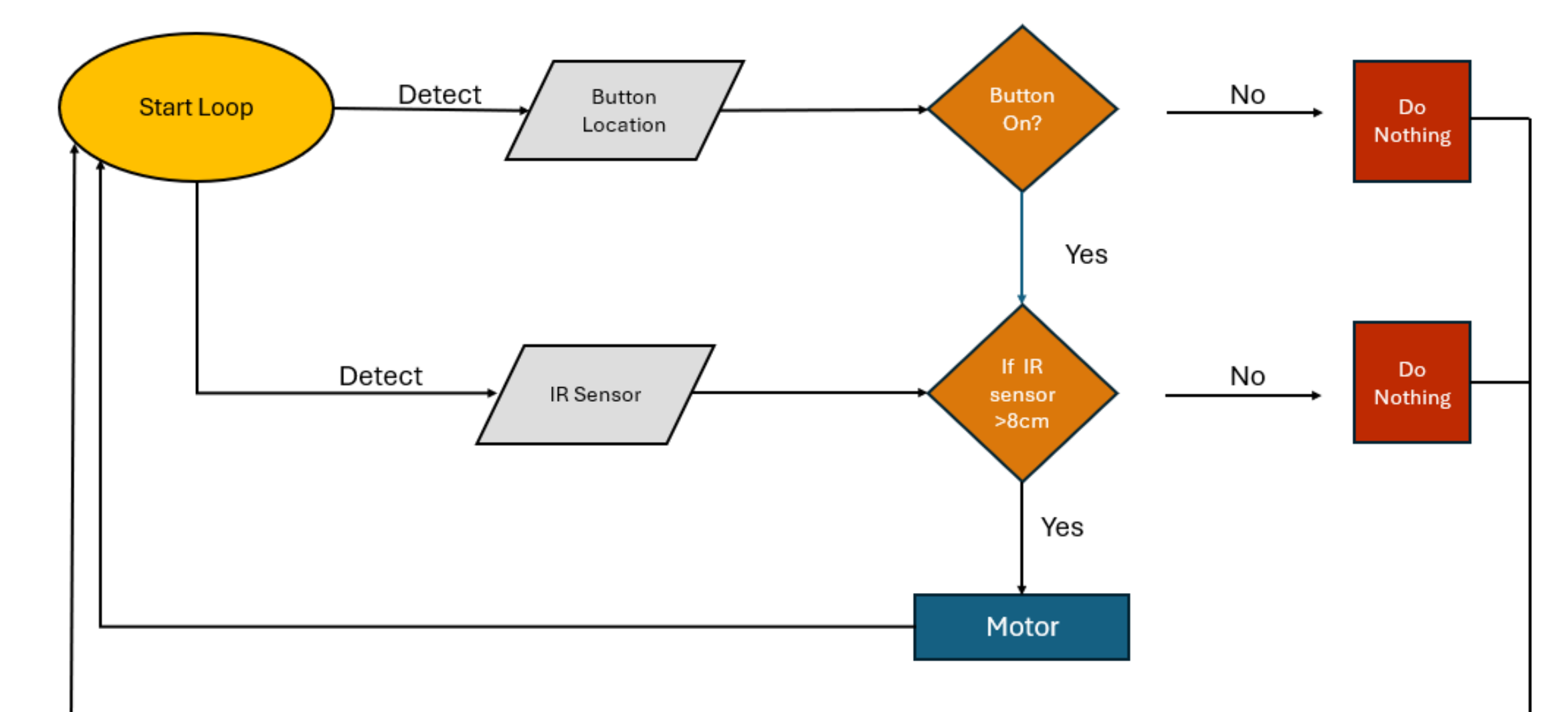
Theoretical Background

The device is designed to store knee energy during the swing phase and release energy during the stance phase.



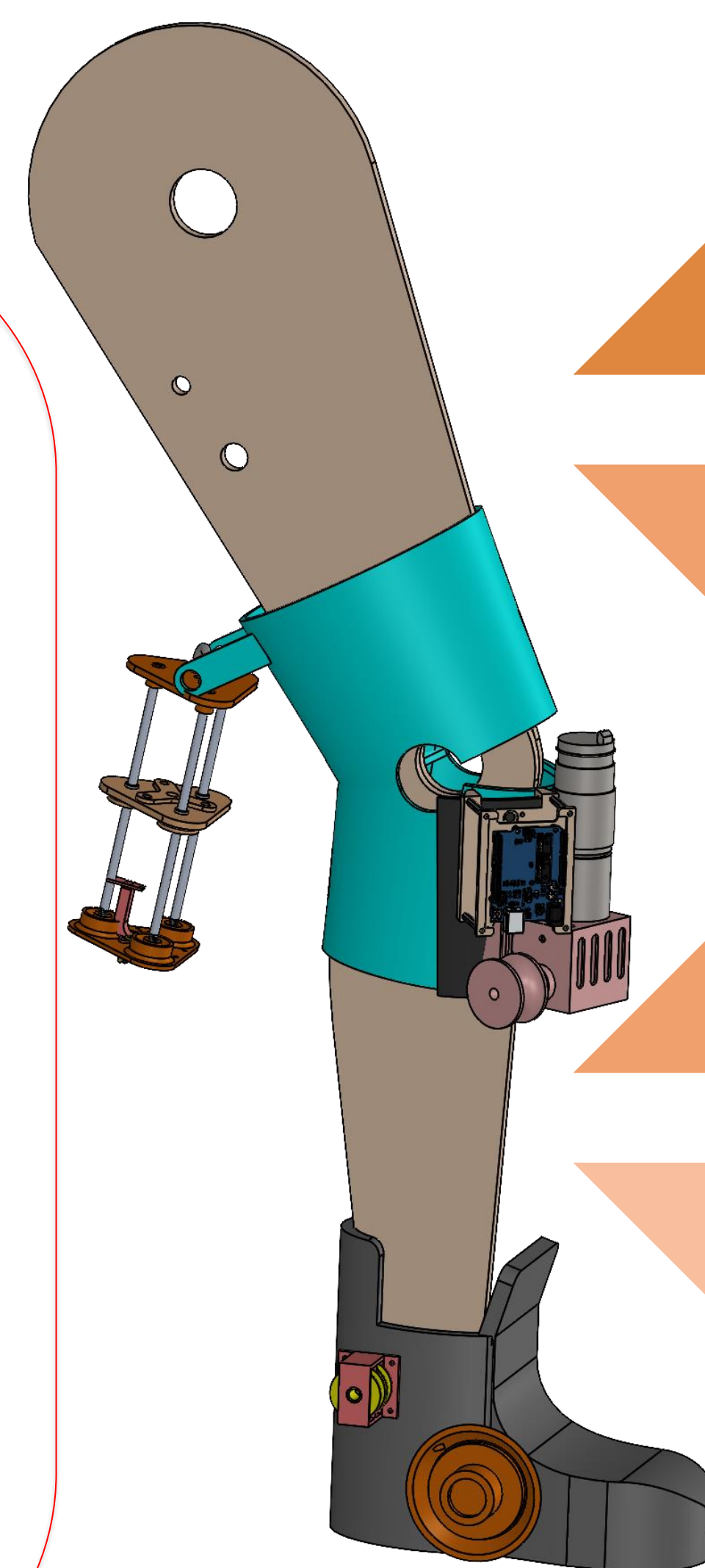
Control System

This is a logic diagram of how the system operates using an IR sensor and manual button to control the spring force in the system by actuating a DC motor.



Our Device - Spring Stride Assist

The Spring Stride Assist is a compact, wearable, powered walking aid. It consists of a comfortable thigh brace that attaches to driving components and routes cables to transfer energy to the ankle. By using three springs in parallel, it induces a constant moment around the user, which helps with ankle push-off, making walking easier and more comfortable.



Spring Assembly

Stores 138 N of energy through compression and transmits energy to the ankle during push off phase.

An IR sensor is placed on the assembly giving live feedback of the spring's displacement.

Tensioner System

Removes slack from the system to minimize energy loss from the spring assembly to the ankle.

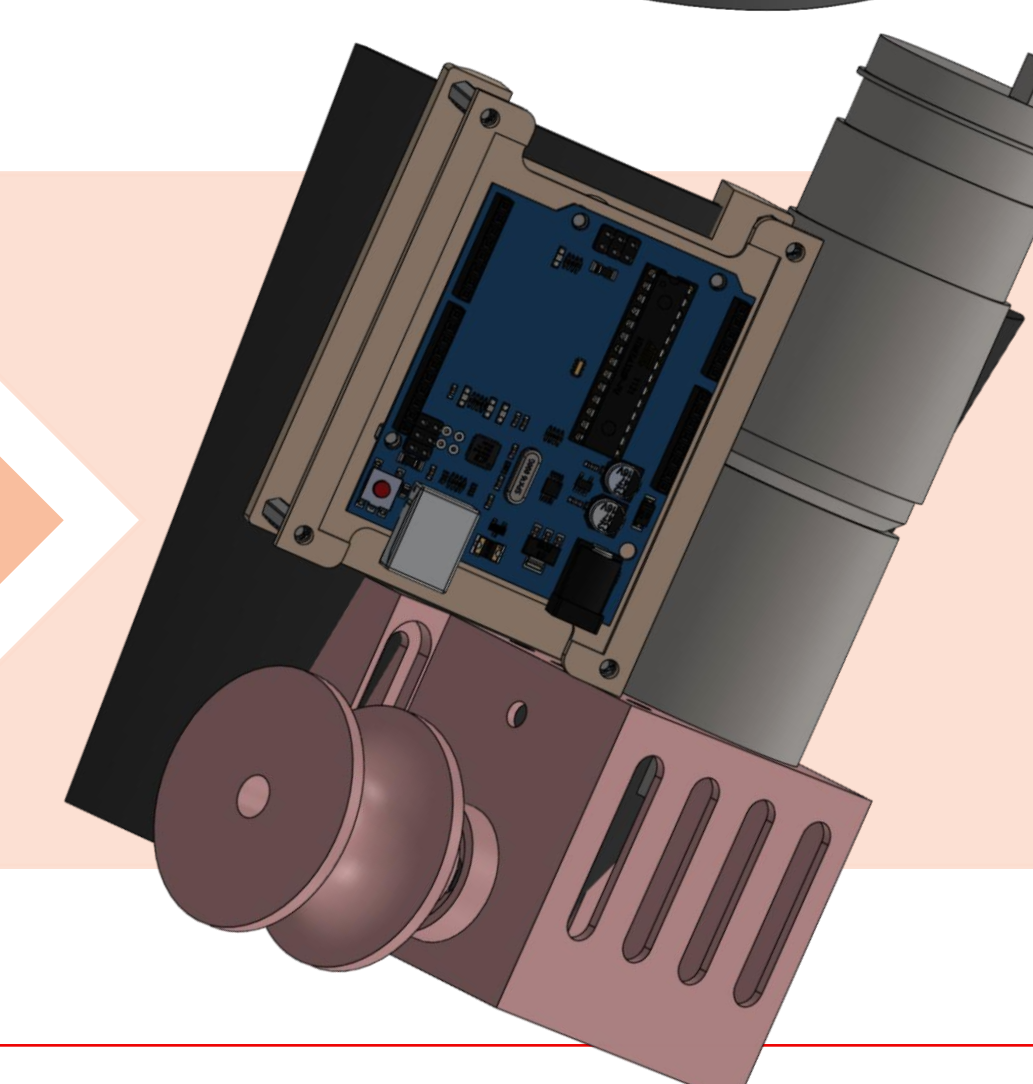
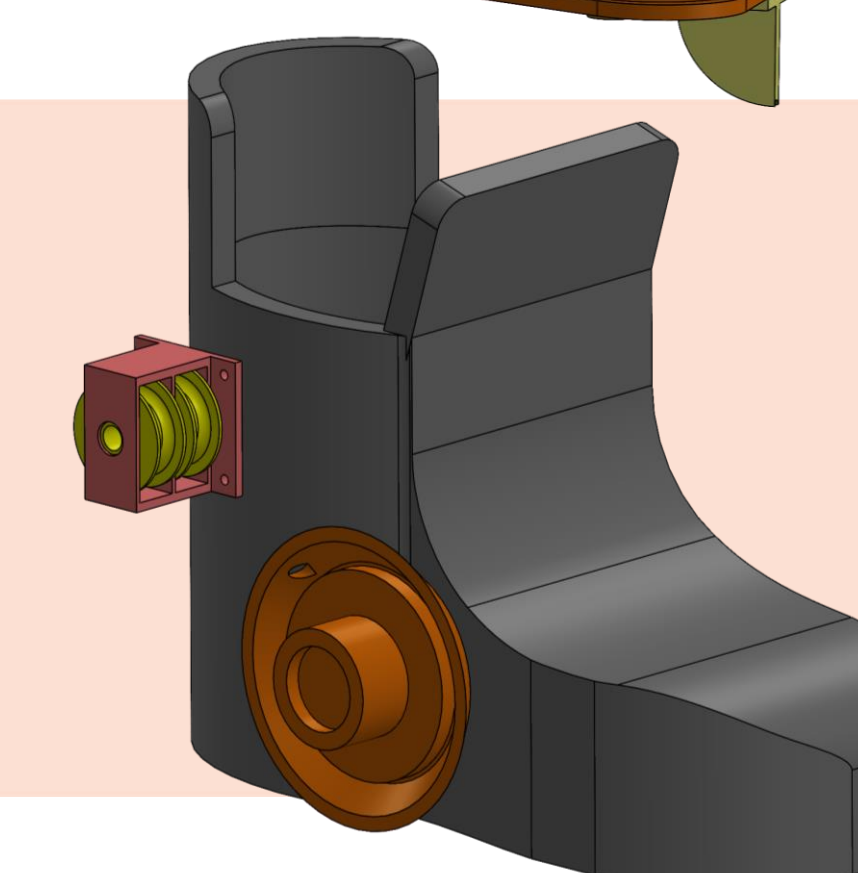
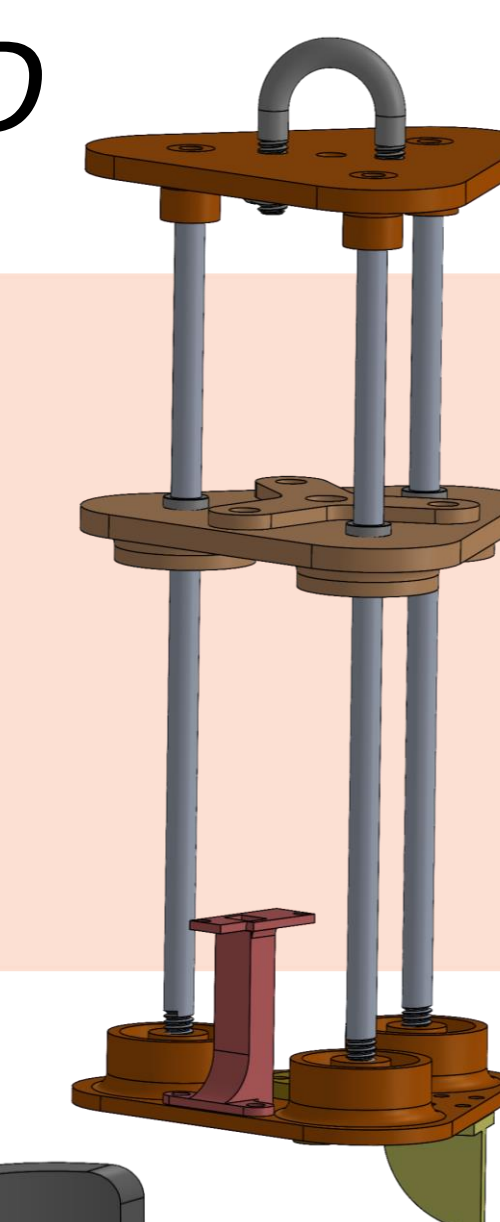
System routes cables from the driving motor to the spring assembly.

Control System & Driving Motor

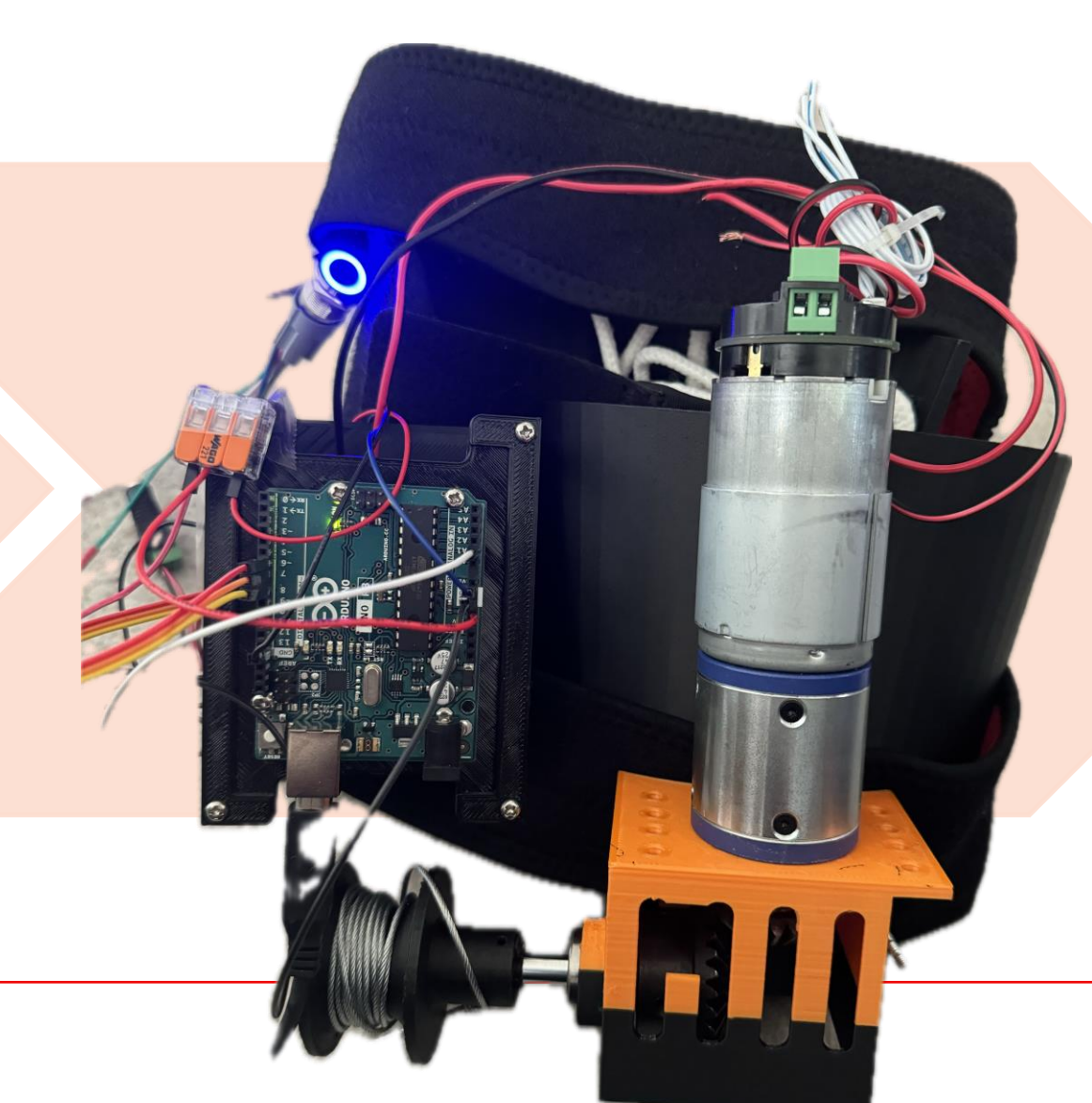
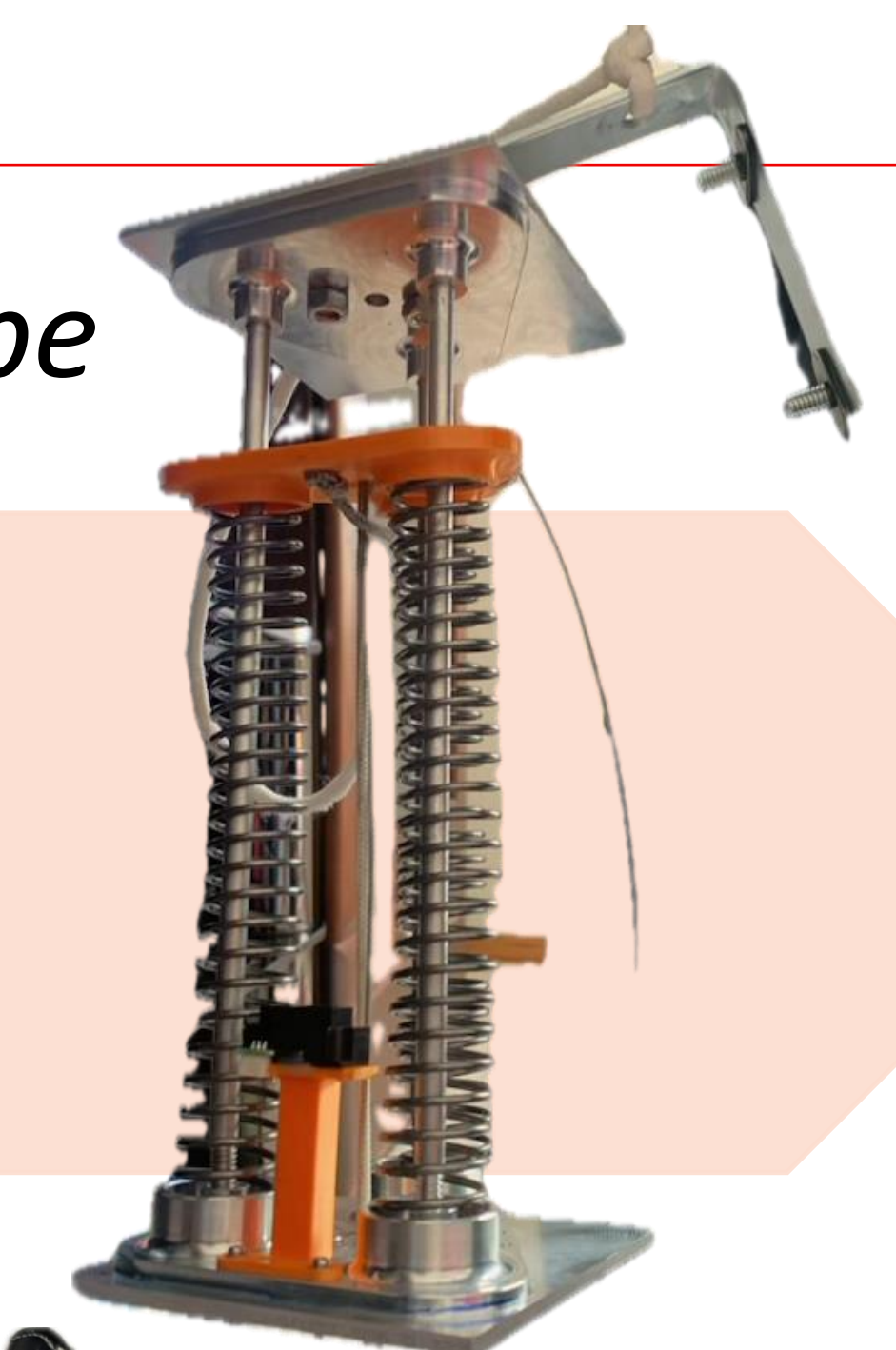
The control system takes inputs from the user (button) and the IR sensor to driver the motor storing energy to the required amount.

Driving motor converts rotational motion to linear motion through a right-angle gearbox.

CAD



Prototype



References

[1] The Feet People. "Symptoms We Treat: Foot Drop." 2024. <https://www.thefeetpeople.com.au/symptoms-we-treat/foot-drop/>
 [2] G. Smith et al., "Analysis of Human Gait Cycle With Body Equilibrium Based on Leg Orientation," ResearchGate, 2023. https://www.researchgate.net/publication/365480248_Analysis_of_Human_Gait_Cycle_With_Body_Equilibrium_Based_on_Leg_Orientation