Threshold: Lifting Enhancer

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System Overview Document

Executive Summary

Threshold is an innovative wearable device designed to enhance workout performance by detecting muscle failure in real time using an EMG sensor. Equipped with LED indicators and a rest timer, Threshold provides instant feedback to help users optimize their training. By delivering precise, data-driven insights, the device notifies users when they reach their threshold, ensuring they maximize each set and fully utilize their muscle capacity. This results in more effective workouts, improved performance, and safer training sessions.

System Description

Threshold is a real-time muscle monitoring system that combines a Myoware 2.0 Muscle Sensor with multiple actuators to assist users in tracking muscle activation and recovery, which detects electrical activity in the muscles through the surface electrodes. The data is then sent through our software system, starting with the ADC module to allow for it to be read by the failure detection algorithm. Based on the failure detection algorithm, the LED Feedback system and/or Timer system may be invoked. The wireless communication and web application are synchronized as real-time data is sent through bluetooth, and the web app then displays a graph of the voltage levels over time.

Software

The software for Threshold will be responsible for monitoring muscle activity in real-time, processing EMG sensor data, providing feedback to the user via LEDs, a timer, and wireless communication to a web app. It will consist of the following key components:

Analog-to-Digital Conversion (ADC) Module: Continuously reads voltage levels from the EMG sensor to track muscle activity. Data is then passed down to the failure detection algorithm.

Failure Detection Algorithm: Identifies muscle failure by comparing real-time voltage levels to a predefined threshold (70% of peak muscle activation). Will alert the LED Feedback System and Timer System as well. Also sets the baseline voltage level and the predefined threshold.

LED Feedback System: Provides immediate visual feedback. The green LED will light for active contraction and red when failure is detected. Ensures that users receive immediate, intuitive feedback to maintain proper form and optimize training. Works in sync with the timer system and outputs red when rest occurs.

Timer System: Implements a rest timer to assist users in tracking recovery between sets. When failure is detected a minute long timer will be started and the light will remain red.

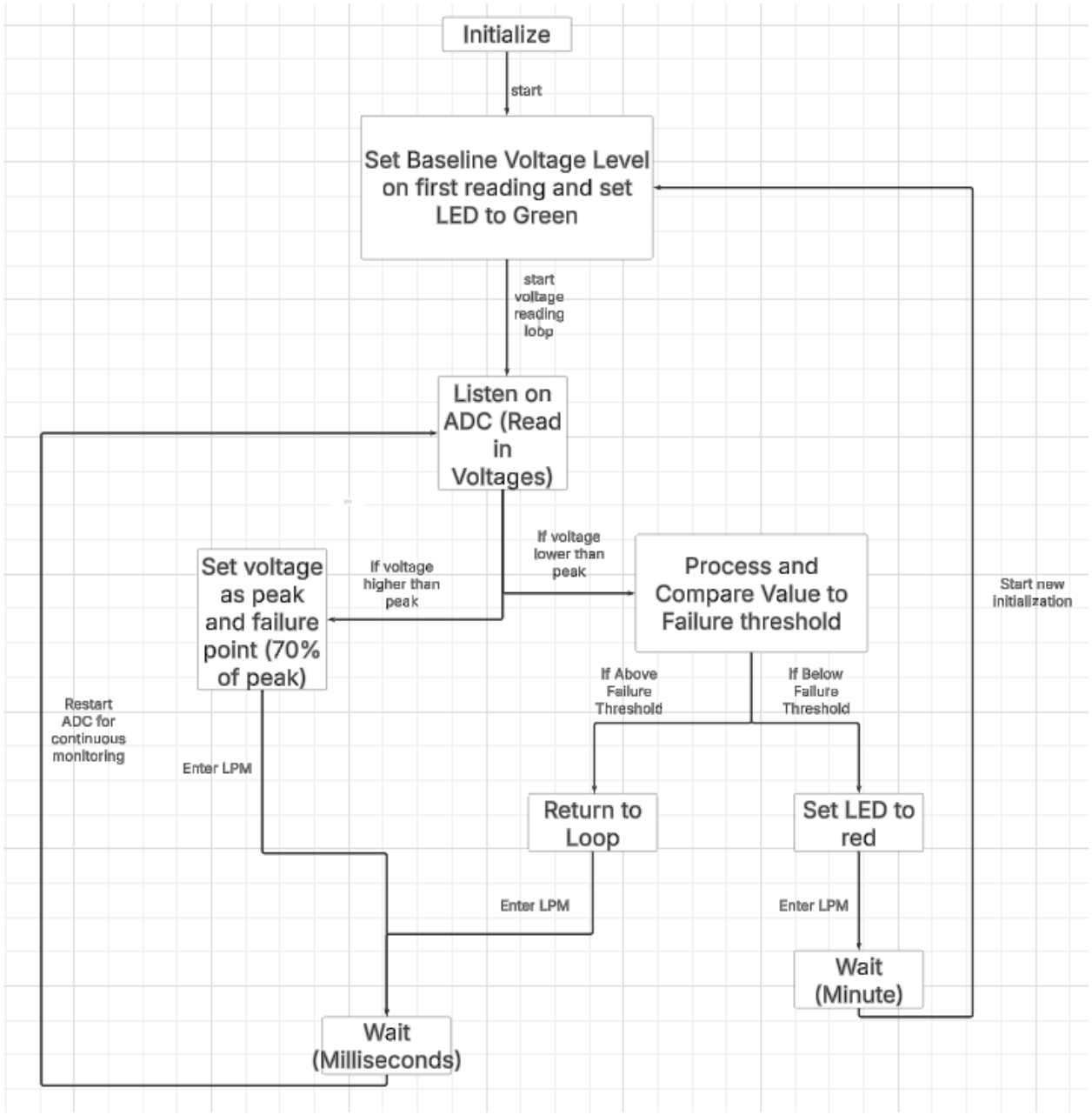
Wireless Communication: Uses the BLE module to transmit a time-series dataset of EMG voltage levels, enabling users to visualize performance trends. Uses UART hardware protocol in order to communicate between the device and web application.

Web Application: Displays a graphical representation of voltage levels over time, allowing users to track muscle engagement patterns. Can store historical data for progress tracking and personalized performance analysis.

Hardware

The primary hardware component we will be integrating for this system is the MyoWare 2.0 Muscle Sensor. Once attached properly to a muscle belly using the disposable surface electrodes the sensor will provide a filtered analog signal from 0-3.3V. The MSP430FR5994 microcontroller will process the signals with its built-in ADC, utilizing the data within the designed algorithm to determine when muscle exhaustion has been achieved. Visual feedback for the device will be output using 3mm red and green LEDs. During rest states the green light will signal that the muscle is either at rest or currently in non-failure exercise. The red light will be lit upon failure and will stay lit until the set timer has run out. The timer will be displayed on a 16x2 LCD screen that will be connected to buttons on the MSP430 in order to set the time desired by the user. Additionally, we will be utilizing HM-10 bluetooth module to transmit workout data to a web app to help users track workout information. For the user interface, we will likely use a button as an on-off switch - potentially, it may be more practical to expand button functionality, using different lengths of time pressed, to begin the tracking of a set. BLE module used for wireless communication.

State Machine



Parts

Title	Part #	Supplier	$	Description
MyoWare 2.0 Muscle Sensor	DEV-21265	Sparkfun	39.95	EMG sensor with snap connectors, used to detect muscle activity. Outputs a rectified and amplified analog signal from 0-3.3V. This sensor will simplify the EMG signaling by filtering and conditioning output allowing for accurate detection of muscular activity.
Disposable Surface EMG/ECG/EKG Electrode 24mm	SEN-12969	Sparkfun	8.95	EMG electrode sensors. Features snap connectors compatible with the MyoWare2.0 Muscle Sensor, and latex-free gel for adherence to skin.
BOOST-CC2564MODA	296-46657-ND	Digikey	25	BLE LaunchPad expansion board. Other options for BLE are available, but due to the wearable nature of the design, physical bulk must be considered.
Lithium Ion Battery - 110mAh	PRT-13853	Sparkfun	5.50	Very small, lightweight battery for size considerations. With estimated power draw, it should last at least a couple hours.
LEDs	COM-00533, COM-09650	Sparkfun	0.45	Red, green LEDs
Basic 16x2 Character LCD	LCD-09053	Sparkfun	18.50	3.3V LCD display for text output. The LCED will display the countdown clock for time remaining in rest. It can will be connected to button to allow for changing of timer from 1-3 min intervals
LilyPad Button Board	DEV-08776	Sparkfun	2.10	A button board designed for wearables, if we wish to sew this into something.

Demo

Our demonstration will consist of a live use of the product. A participant, equipped with Threshold to their bicep, will demonstrate a dumbbell bicep curl. This will be performed until failure, and the web application's statistics/visualizations will be displayed concurrently. It is likely that the demo will consist of two or more participants total - we hope to show the functionality of the calibration between different individuals, but all show the same conclusion of muscular failure being reached with feedback from the device. Ideally, it is apparent that muscular failure truly *was* achieved by the demonstrator (through visible slowing of reps, reduced range of motion, etc), accompanied by the device's confirmation.

Resources

1. Product Showcase: MyoWare 2.0 (Product Showcase: MyoWare 2.0)
2. (PDF) Gym training muscle fatigue monitoring using EMG ...ResearchGatehttps://www.researchgate.net › ... › Muscle Fatigue
3. Measurement of Muscle Signals and their Processing ...Central European Researchers Journalhttps://ceres-journal.eu › download
4. Design an Electronics Project That Responds to Your Muscles ...www.youtube.com › watch