G+ME: EMG Armband for Gamified Neurorehabilitation

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Problem & Scope

~100 million people affected by stroke globally

60% of stroke survivors experience **upper-limb impairment**, but **only 5-20%** of individuals regain full arm function

80% of stroke-related deaths and disability occur in in **low to middle-income countries (LMICs)**

- Meaningful recovery depends on **frequent, structured therapy** with high-intensity, task-oriented training
- Current rehabilitation options like robotic devices, functional electrical stimulation, and clinic-based therapy are effective but **expensive and difficult to access**, especially in low to middle-income countries
- This results in **preventable, long-term disability** on a global scale

Objectives

- Design a **low-cost, sEMG (surface electromyography)** armband that enables stroke patients to engage in **upper-limb rehabilitation** outside of clinical settings
- Inform design decisons based on **patient interviews**
- **Expand access** for frequent, structured therapy for underserved population in low to middle income countries

Professional Network

- Formed relationships with **neurorehabilitation experts** in multiple different disciplines, including clinical management and biomedical engineering
- Established **network** composed of mentors, rehabilitation facilities, and physical medicine and rehabilitation (PM&R) clinicians

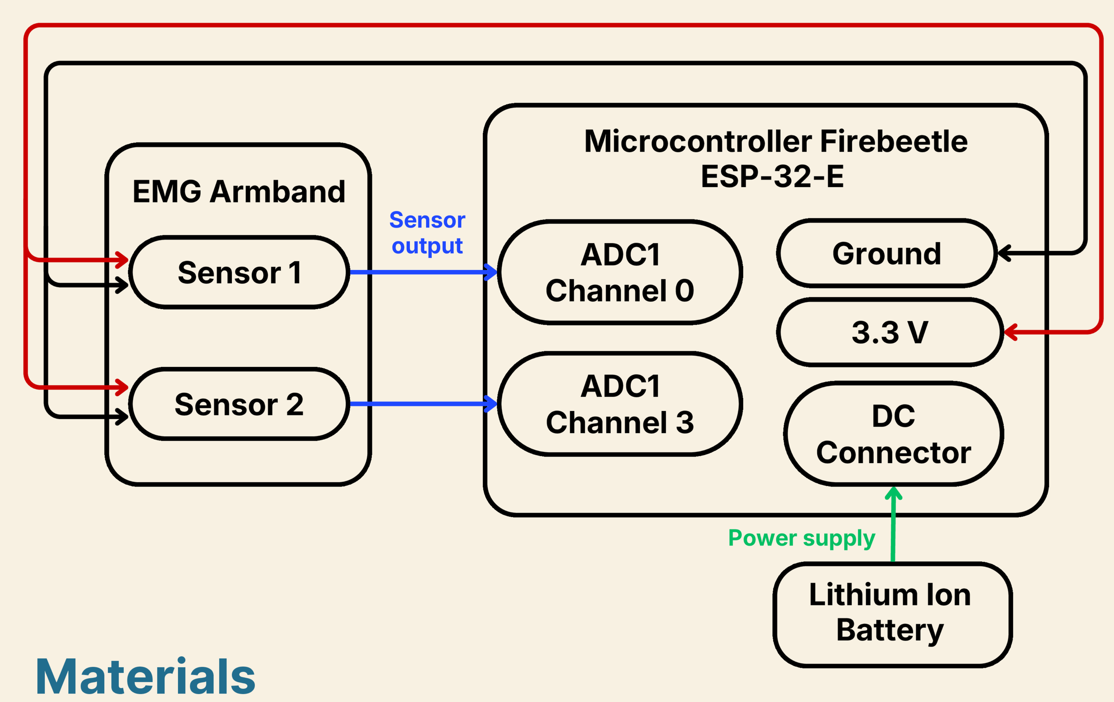
Pathway to Impact

- Secure **IRB approval** for a **clinical study** with patients from Johns Hopkins Medicine Rehabilitation Therapy Services
- Develop **music-based app** that evaluates amplitude of sEMG signals and provides feedback-driven motivation
- Continue **shadowing** in clinical settings & conducting stakeholder interviews
- Establish **partnership** in Baltimore and expand to lower-and-middle income countries

Design Overview

1. EMG Sensor System

Electronics Schematic:



Materials

- Firebeetle ESP32-E microcontroller
- Gravity: Analog EMG sensor
- Lithium ion battery

2. Signal Acquisition & Transmission

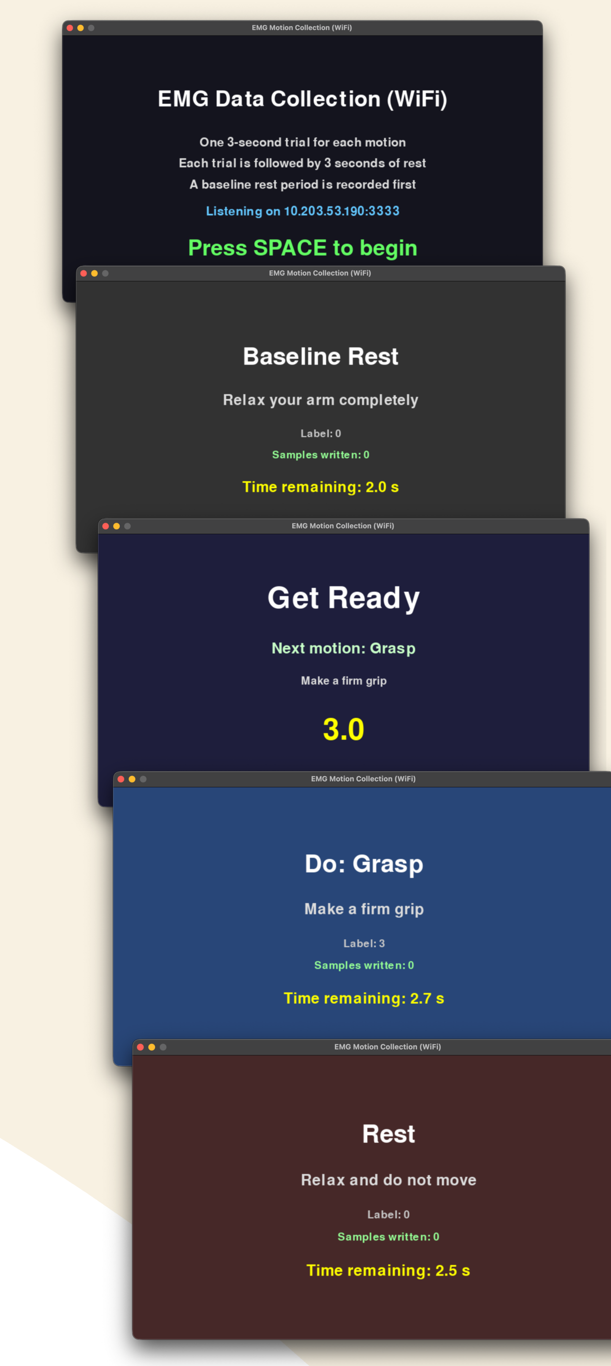
Arduino

Connects ESP 32 to Wi-Fi to initiate user datagram protocol (UDP) communication → Samples 2 EMG signals from analog input pins (A0, A3) at 1000 Hz → Batches 10 samples per packet & sends each batch via UDP

Python

Opens UDP socket to listen for EMG data sent via WiFi → Parses samples and records time, channel 1, channel 2 & motion in CSV file → Uses Pygame GUI to guide participant during data collection

Calibration Pygame GUI



3. Results

- Records **real-time muscle signals** and transmits them to a computer via WiFi
- Classifies **four different motions** from 1-2 sEMG channel signals: (1) flexion, (2) extension, (3) grasping, (4) ulnar deviation
- Analyzes and stores muscle signals during rest and each of the four motions to calibrate **comparison threshold**
- Evaluates **amplitude** of user motion to determine **strength** of action

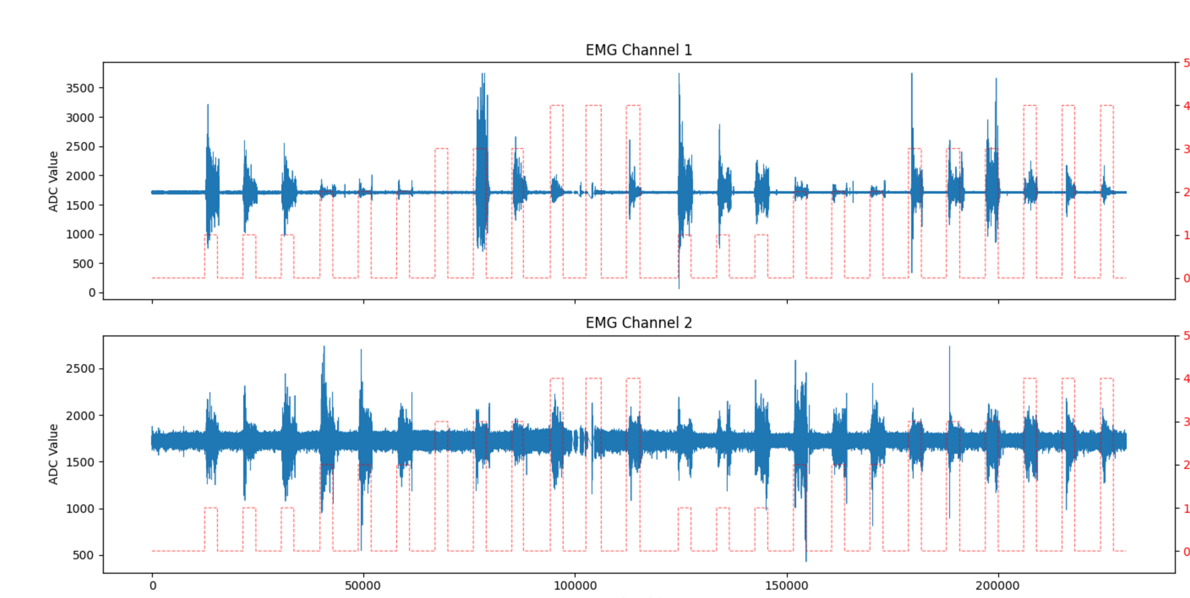


Figure 1. Example signals from two EMG channels

4. User Interaction

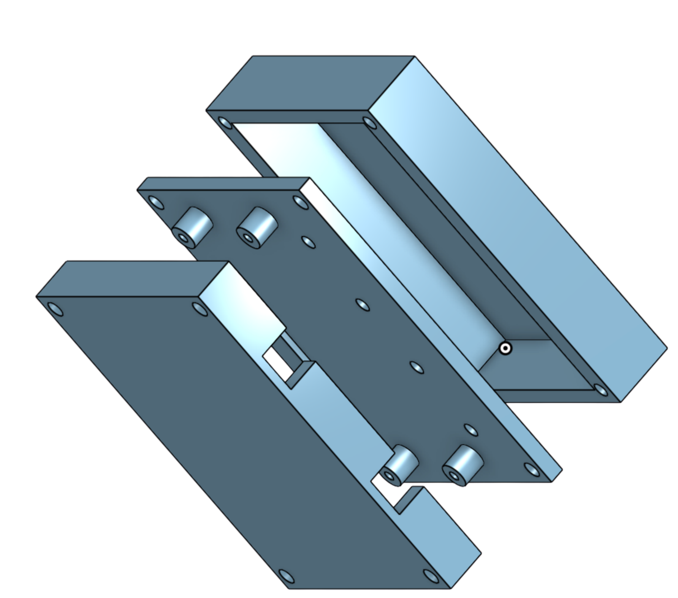


Figure 2. Three-dimensional layout of CAD objects enclosing sensor components

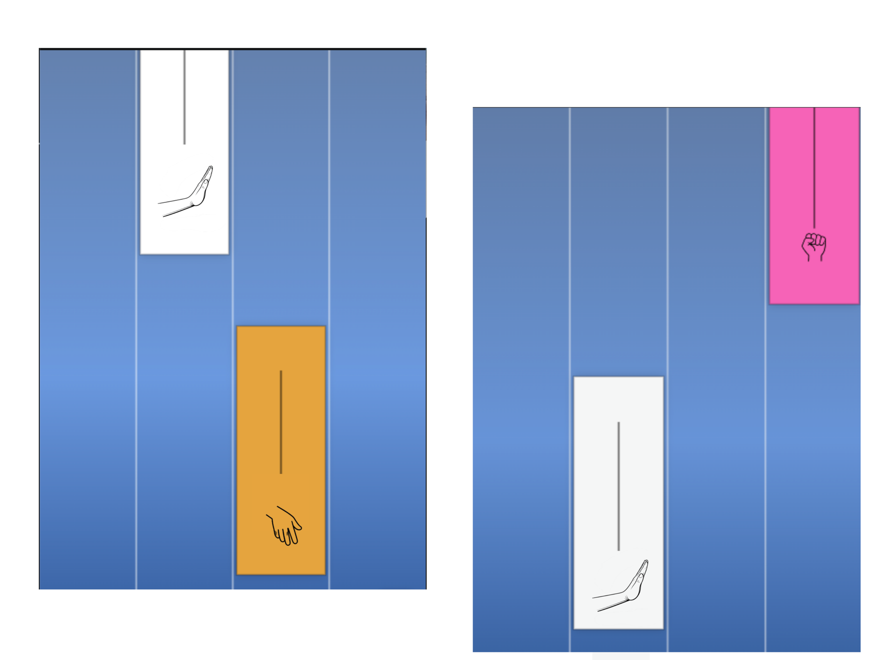


Figure 3. Graphical user interface design for music-based application

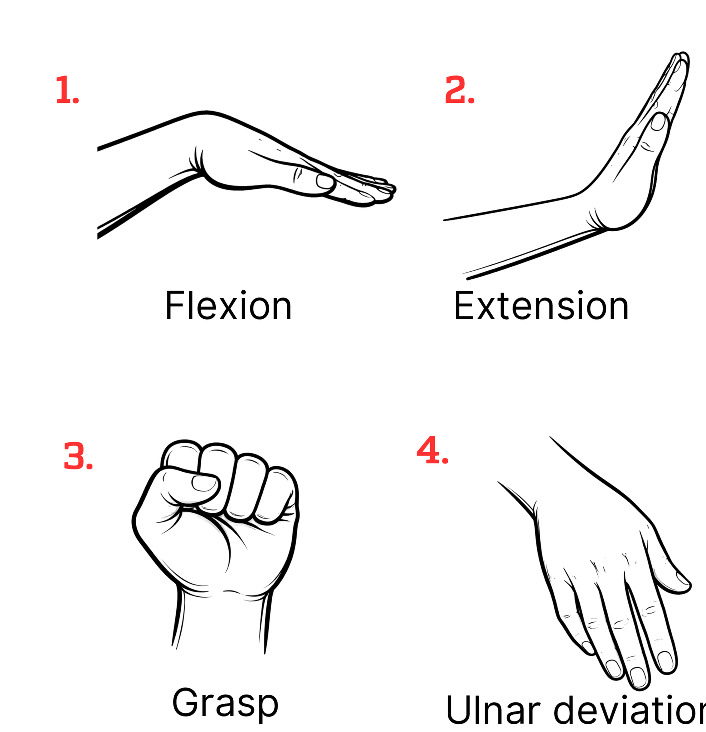


Figure 4. Four hand motions prompted by the GUI

References