UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Screentime Habit Correction Headband

Team 89

Colin Moy, Jake Chen, Zhiyuan Chen

Project Overview

Objective

The Problem

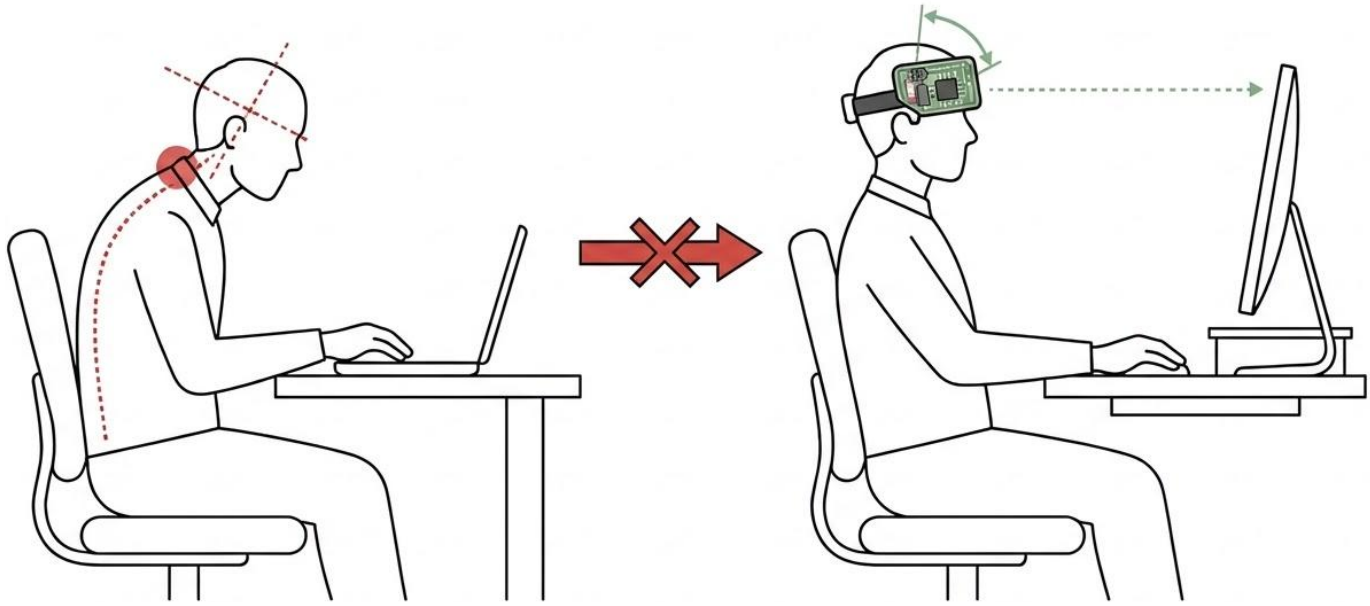
Subconscious leaning and forward head posture can cause digital eye strain and chronic back and neck pain.

The Goal

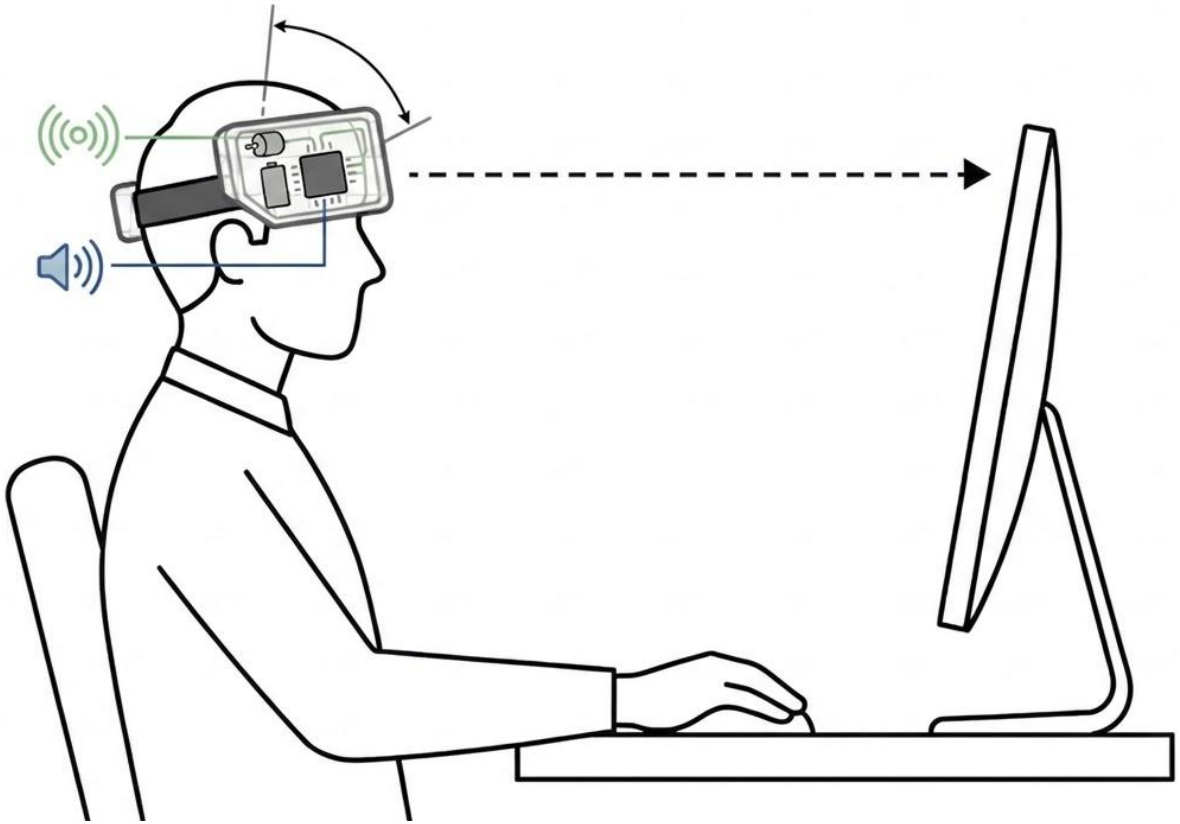
Build better long-term ergonomic habits through immediate physical intervention rather than post-session data tracking

Target Audience

Office workers, students, and competitive gamers



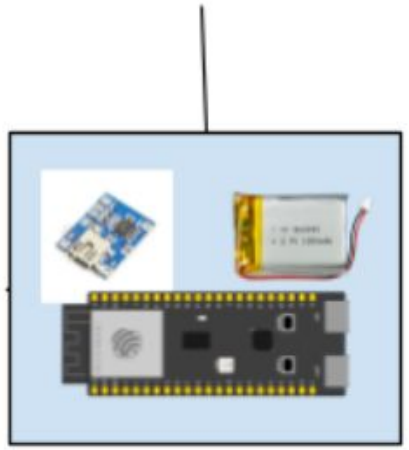
Project Introduction



- **Active Monitoring:** The wearable device tracks user posture using a ToF sensor for screen distance and an IMU for head tilt angle
- **Real-time Feedback:** Immediate physical alerts through haptic vibration and audio cues helps users correct poor positioning and prevent fatigue
- **Integrated Ecosystem:** A custom-routed PCB and 3D-printed enclosure pair with a mobile companion app to enable long-term habit tracking

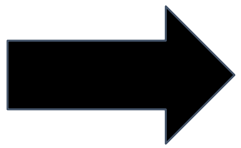
Original Design and Changes

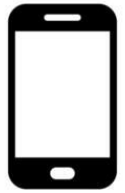
Headband with Sensors and Feedback Subsystems



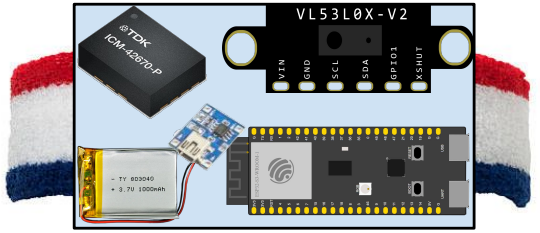
Phone Application Using Bluetooth

Housing with Power and Processing Subsystems





Phone Application Using Wifi

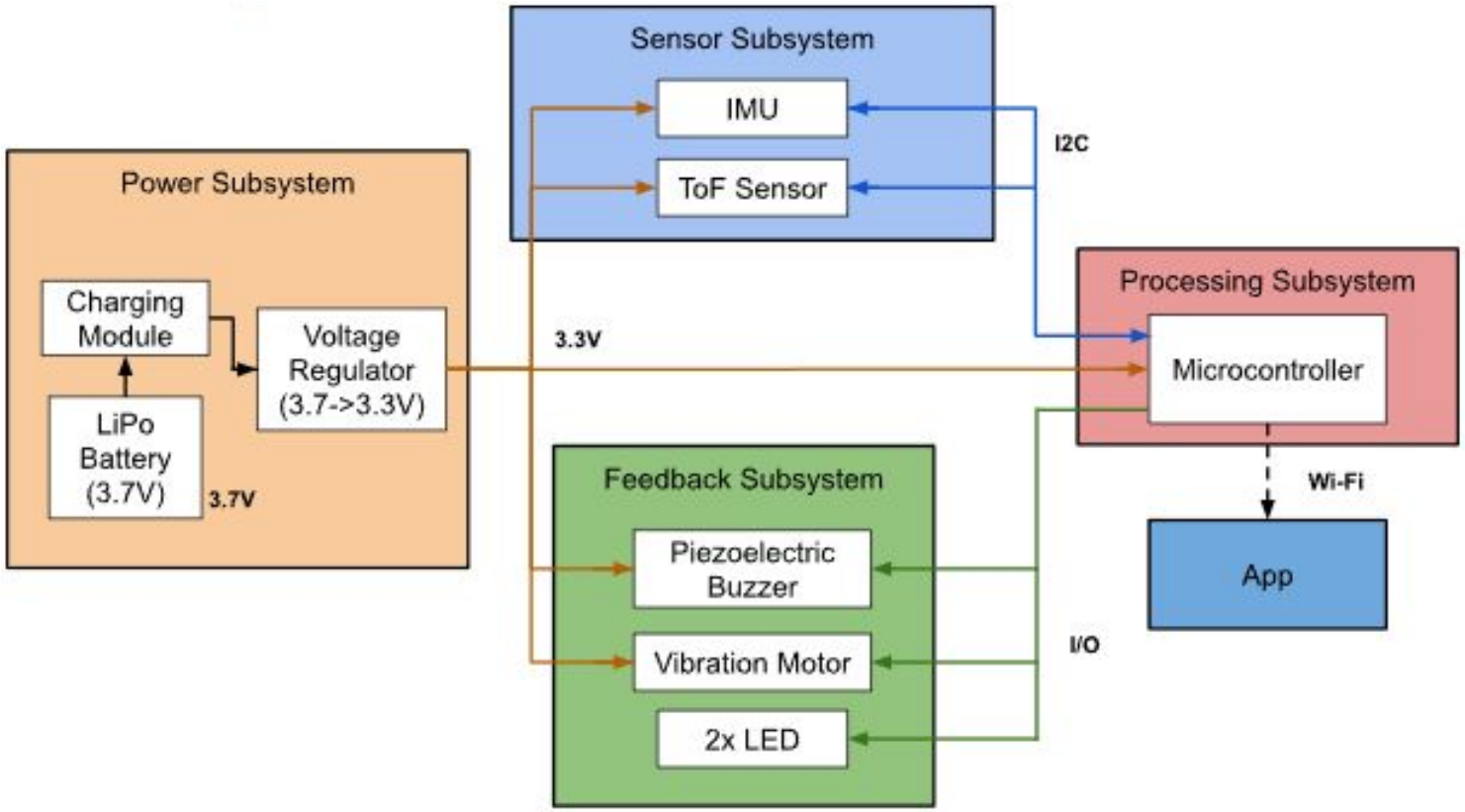


Headband with Power, Sensors, Processing, and Feedback Subsystems

Hardware Subsystems

Design Overview

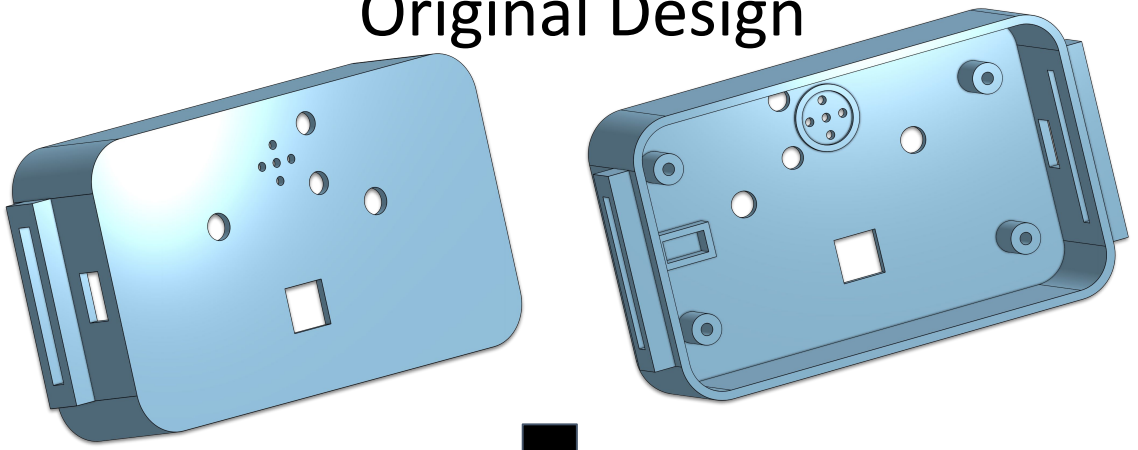
- **Core Subsystems:** Power, Sensors, Processing, Feedback, and App
- **Wearable Design:** The headband prioritizes a lightweight, compact layout that is comfortable for hours of continuous use



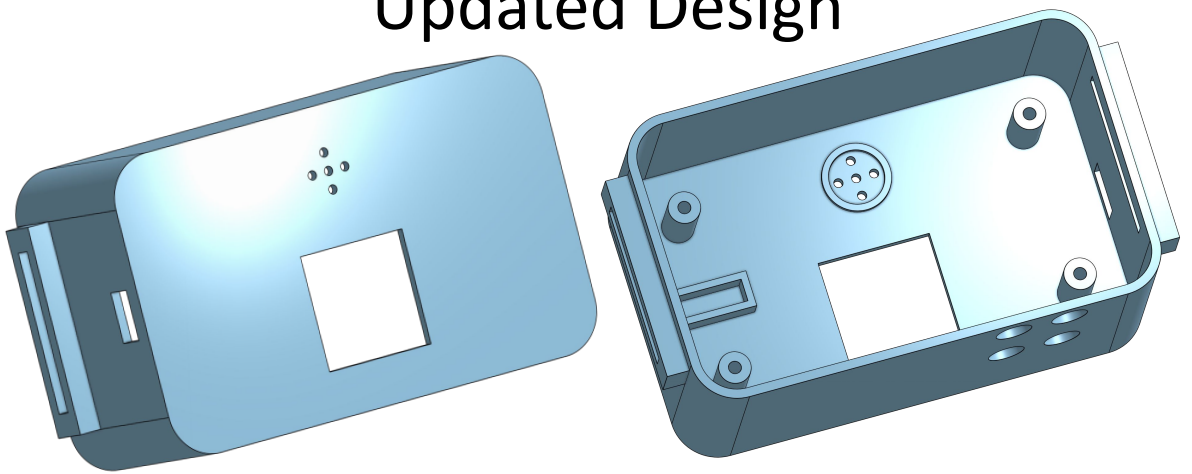
Physical Design

- **Enclosure:** Custom 3D-printed chassis designed to safely enclose the hardware while remaining comfortable for extended wear
- **External Interface:** Forward-facing, hardware-mapped ports precisely align the ToF sensor window and status LEDs
- **Internal Architecture:** Features 10mm standoffs for secure PCB mounting, an acoustic speaker grill, and a dedicated motor cradle

Original Design

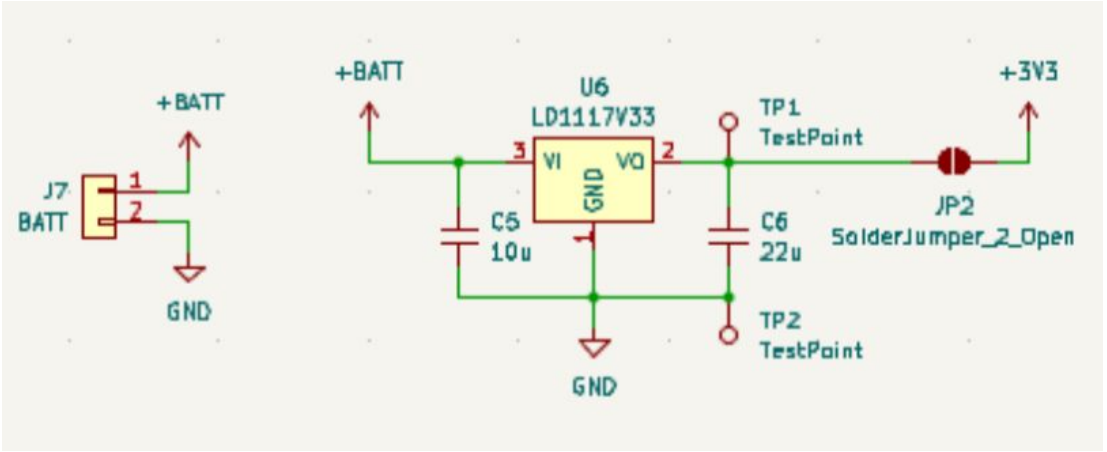


Updated Design



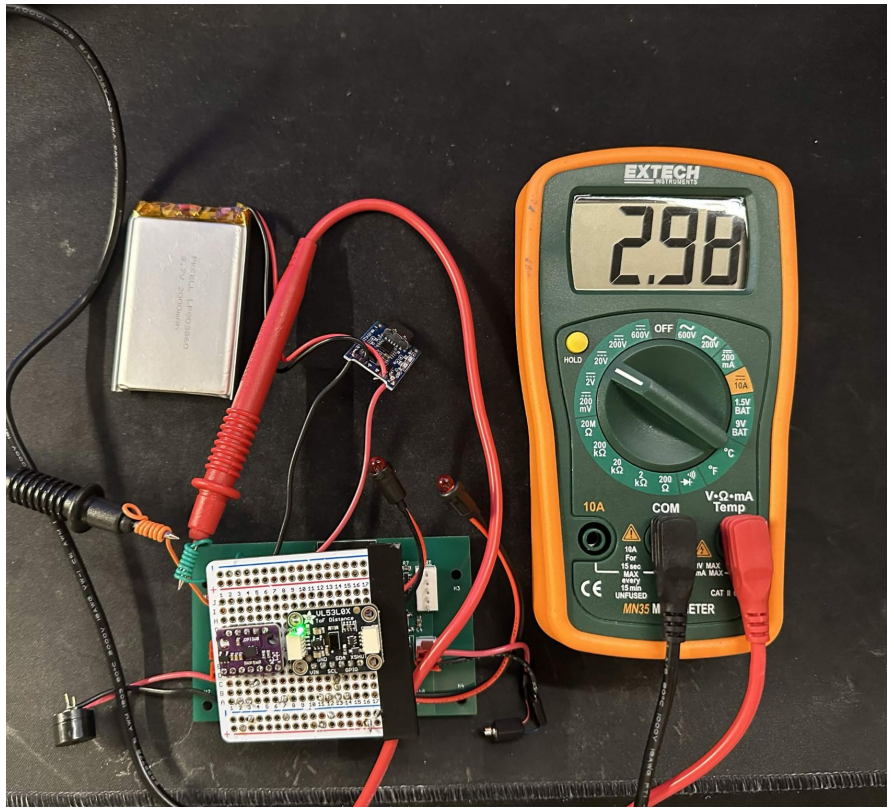
Power Subsystem

- **Battery life:** Battery has 2000mAh of charge, allowing for at least 2 hours of device usage with the 1A voltage regulator
- **Rechargeability:** Charging module with a USB-C port facilitates battery usage with built-in protection against overcharge, overdischarge, and overcurrent
- **Voltage Step-down:** 3.7V battery is stepped down to 3.3V using a voltage regulator, dissipating minimal power and powering the rest of the device



Power R&V

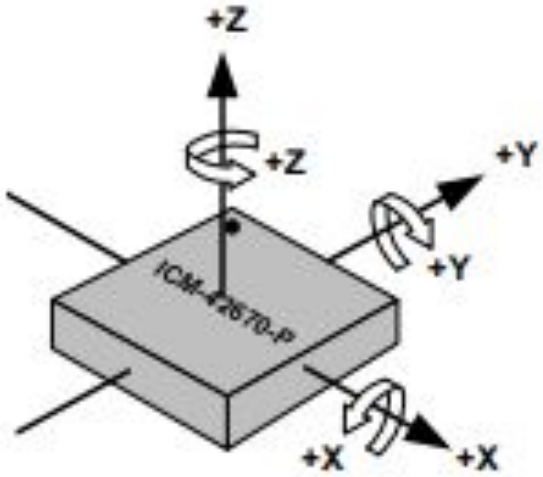
- The voltage regulator must step down the battery voltage to supply a stable 3.3V ± 0.1V to the sensors
- The 3.7V LiPo battery must power the device continuously for at least 120 minutes while maintaining a minimum output voltage of 3.3V under a standard operating load.

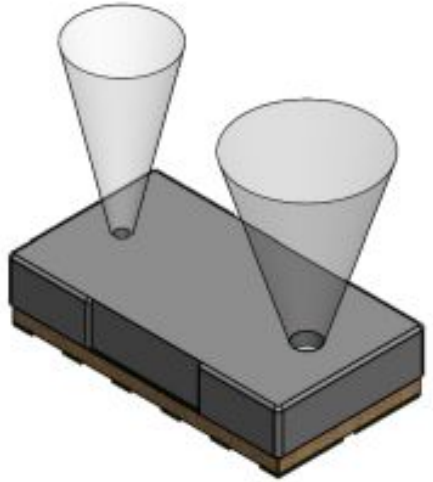


Battery reading: 3.95 V
Voltage regulator reading: 2.98 V

Sensor Subsystem

- **Position and Orientation Measurement:** 6-axis IMU combines an accelerometer and gyroscope to allow measurement of head position and orientation
- **Distance Measurement:** ToF sensor uses a near-infrared laser to measure the distance from the sensor to an obstacle up to 2m
- **I2C Compatibility:** Both sensors can use the I2C communication bus to communicate measurements to the microcontroller

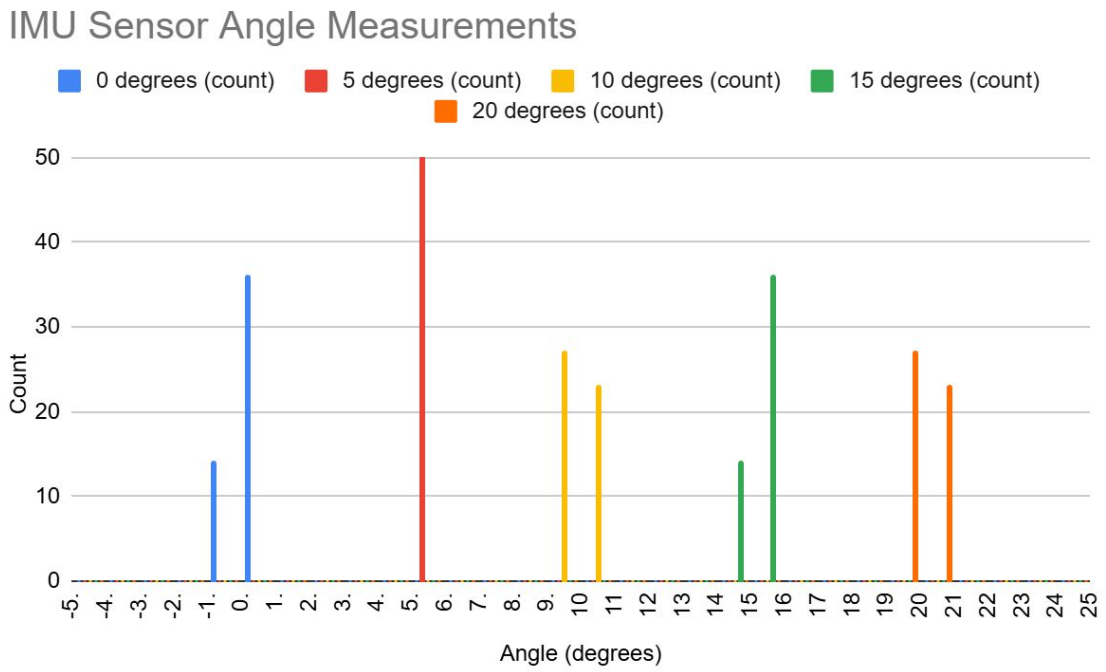




Sensor R&V

- The ToF sensor must measure the user's screen distance with an accuracy of ±5 mm for distances ranging from 0 to 500mm.

- The IMU must detect head pitch angles with an accuracy of ±2 degrees for angles up to 20 degrees from the calibrated baseline.

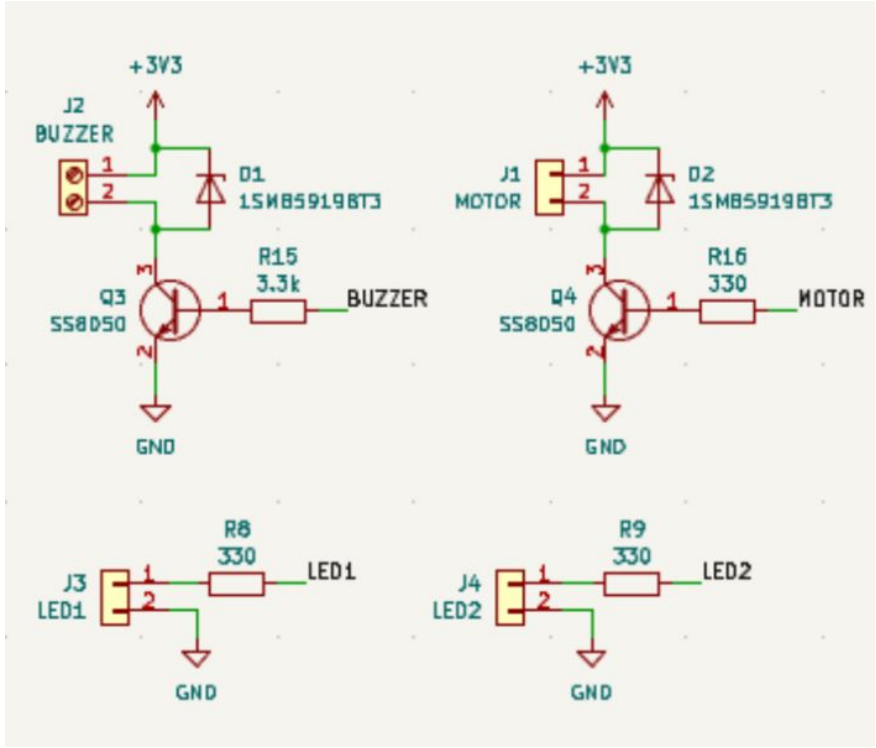


Feedback Subsystem

- **Feedback Variety:** Feedback subsystem comprises of a buzzer, vibration motor, and two LEDs in order to provide different forms of feedback when the microcontroller drives them
- **Gradual Feedback:** When initially driven, vibration intensity is at a medium level, and feedback level is linearly increased over 3 seconds until alarm state

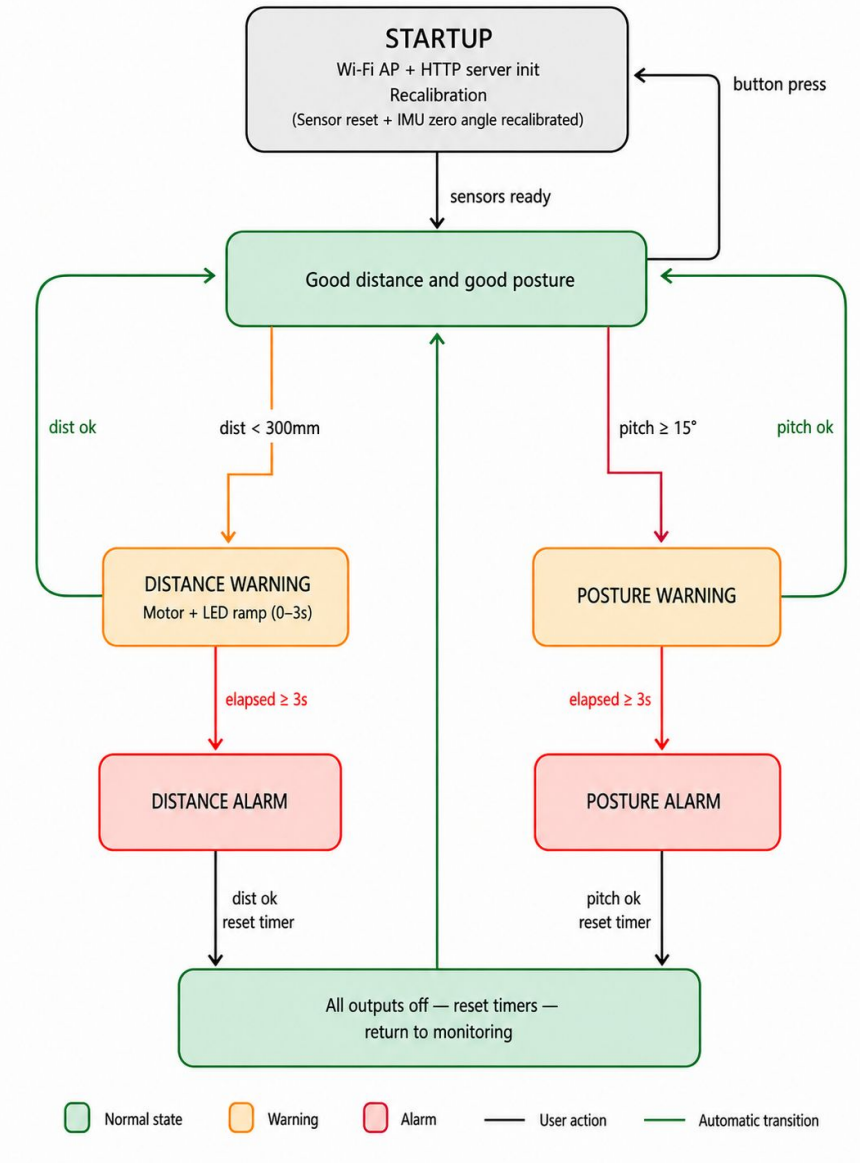
Feedback R&V

- One LED turns on after 3 seconds of head posture angle exceeding 15 degrees
- Other LED turns on after 3 seconds of screen distance less than 30 centimeters
- Motor and buzzer activate when head posture angle and screen distance alarms are both detected
- Feedback system turns off within a second of good position detected



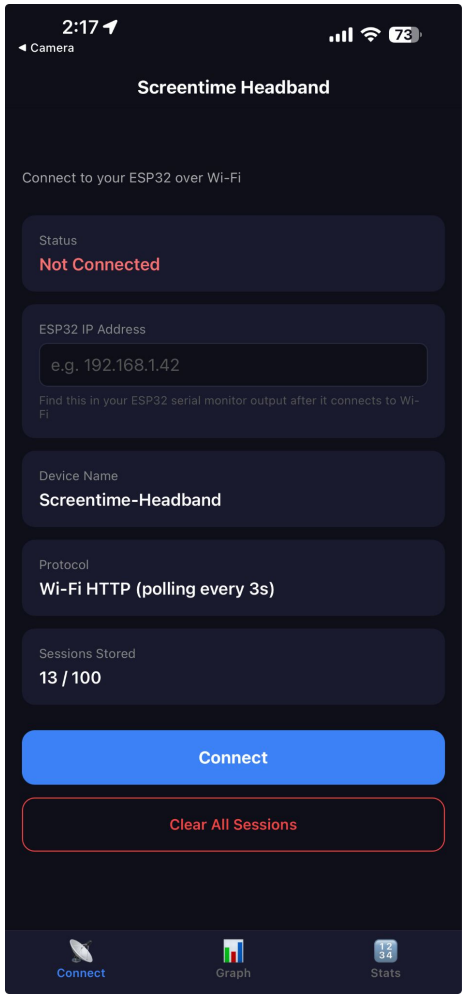
Processing Subsystem

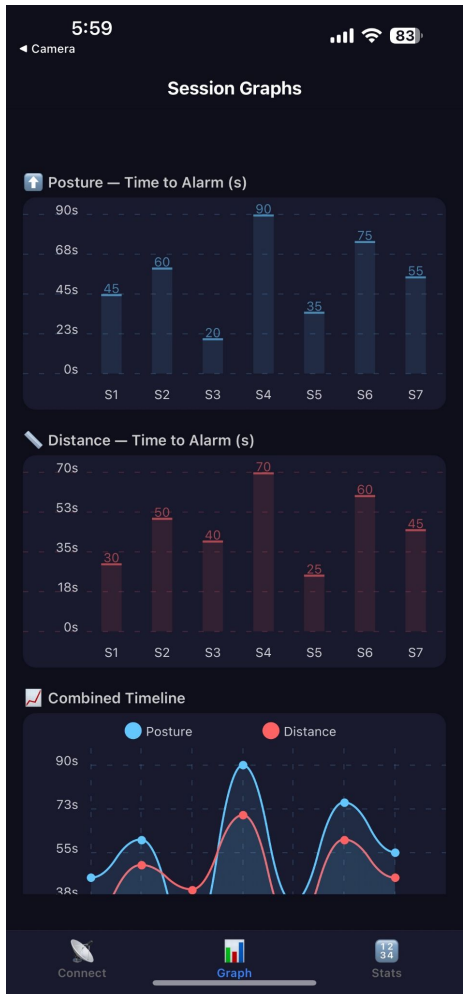
- **Real-time sensors:** Combines VL53L0X distance data with ICM-42670-P tilt measurements to detect poor posture in under 200 ms
- **Progressive Feedback:** Implements 3 second warning ramp (0%->50% intensity) for motor using PWM followed by full alarm state using vibration motor, buzzer, and LEDs
- **WiFi data logging:** Creates local access point serving as HTTP server for session data retrieval and mobile app integration

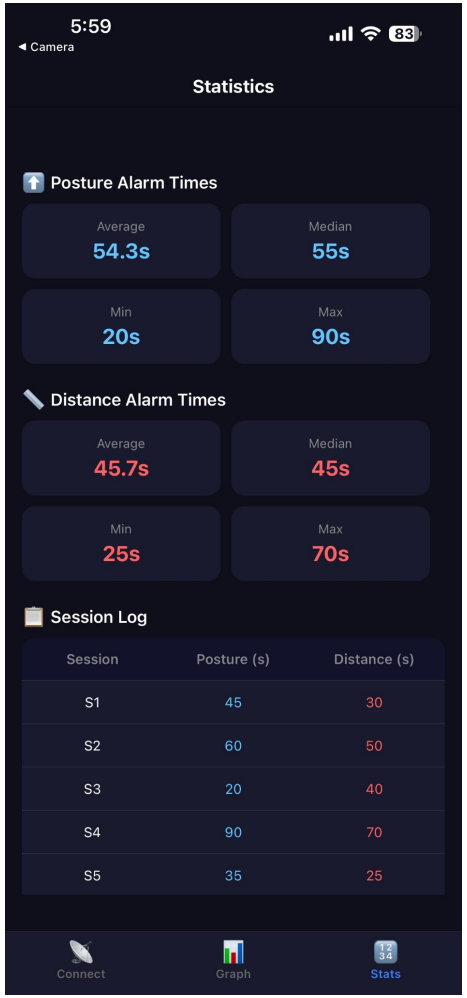


App

- **Session tracking dashboard:** Displays real-time and historical data showing time spent in between alarm states
- **Active data retrieval:** Receives time from ESP32 when alarm is activated
- **Wireless headband connection:** Discovers and connects to headband's WiFi access point

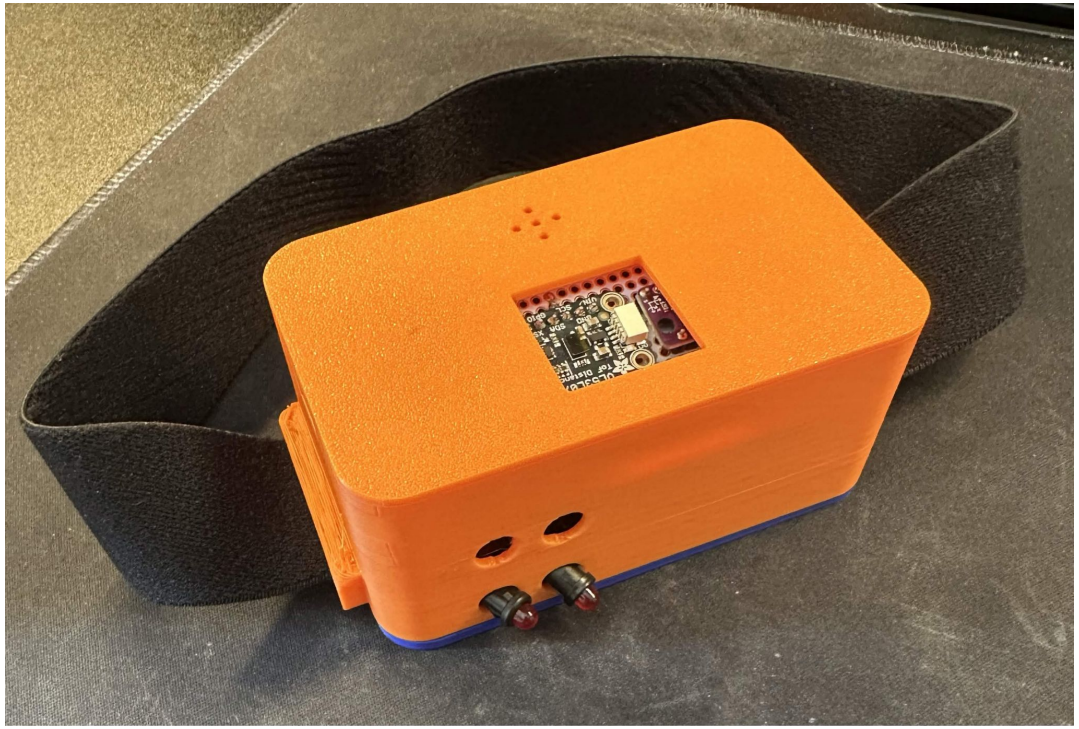






Summary

- Goal: Build better habits
- Lightweight, compact, and rechargeable low-power design
- Integration of an IMU and ToF sensor in order to make measurements
- Variety of feedback and implementation of gradual feedback
- Combination of Wi-Fi and companion app tracks user habits and displays it with a user-friendly design



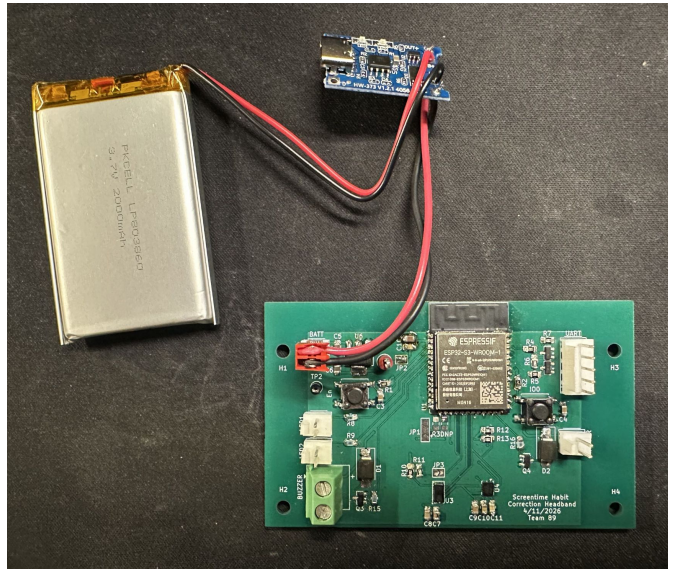
Summary

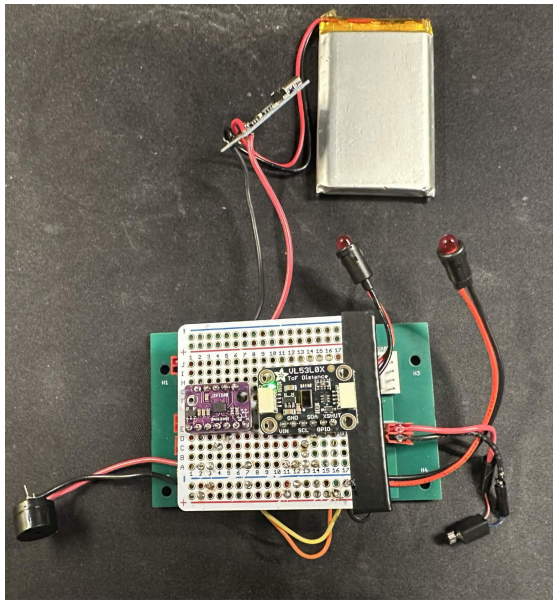
What We Learned

- I2C bus scanning and sensor debugging
- Setting up ESP32 as HTTP endpoint to send sensor data to an app via WiFi
- General PCB design and organization

Challenges

- Soldering for sensors and ESP32
- ToF sensor returning erratic readings
- UART programming required manual bootloader entry via buttons





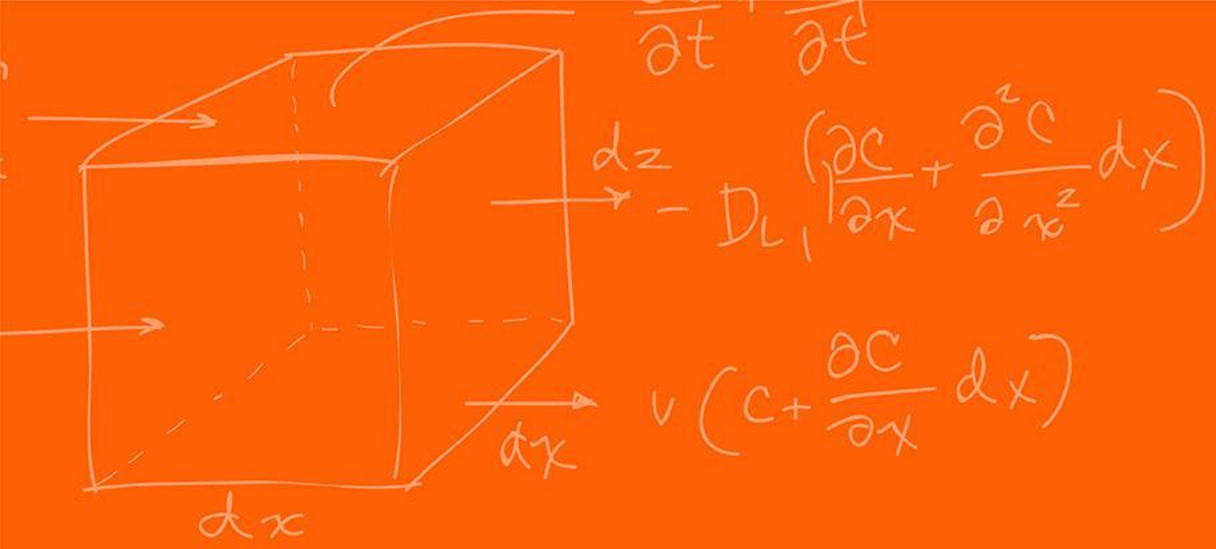
Future Improvements

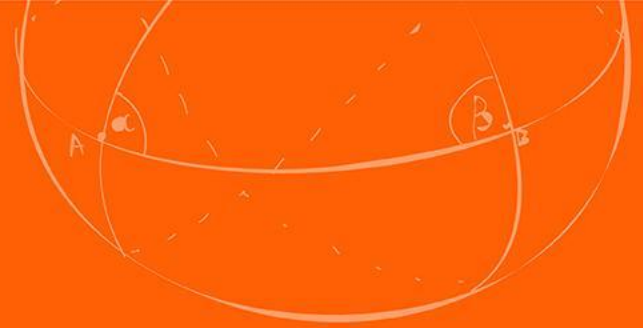
Hardware

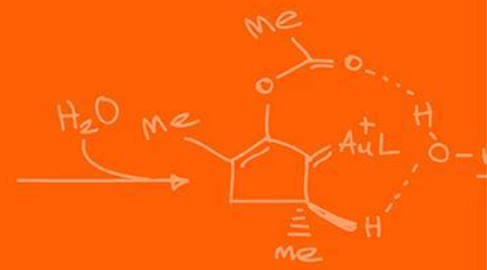
- Reduce wire lengths, remove breakout boards, and miniaturize and clean up PCB and enclosure designs for user convenience
- Fine-tune capacitors and resistors to improve power consumption and sensor accuracy
- Implement accelerometer of IMU for head position

Software

- Integrate Bluetooth Low Energy for low power consumption and extended battery life
- Implement machine learning model to personalize distance and angles thresholds based on individual user posture patterns
- Add configurable modes (relaxed/moderate/strict) for different use cases such as studying vs casual browsing







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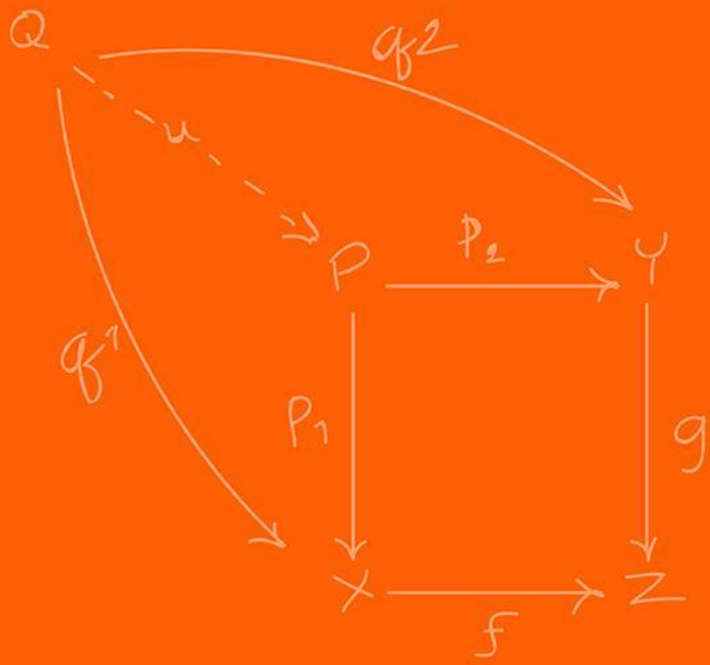

Appendix A: PCB Schematic