Final Presentation

StrainLess <3

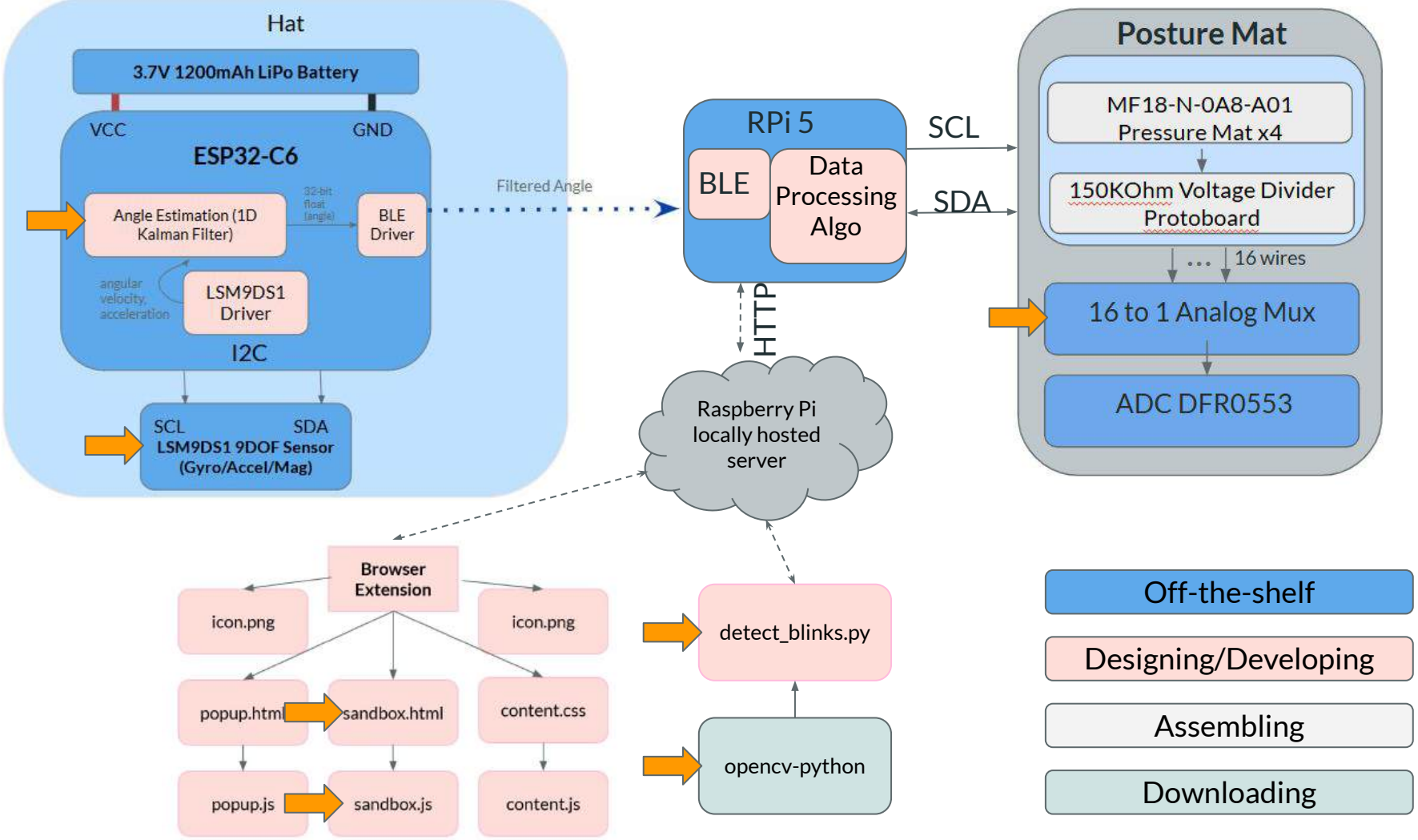
Use Case/Application

Goal: reduce neck strain and back pain due to poor posture, reduce eye strain

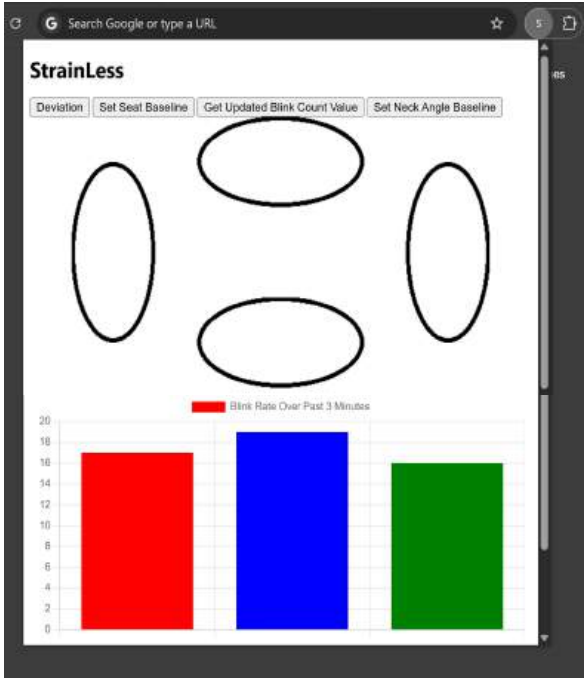
Overall System	Posture tracking	Eye strain mitigation	Browser extension
Prompts a detectable change to eye strain or posture measures in <1 minute	Neck angle and weight distribution correctly measured with >95% accuracy	Blink rate correctly measured within +/- 1 blink/min	User can see their posture/blink behavior later on
Latency <1 min	Not restrictive of user motion/comfort while working 1+ hrs.	Works in different ambient lighting conditions	Runs in background on user opening Chrome without requiring user to open extension
Alerts for all measures have >95% true-positive, <5% false-positive rates	Head components <75g		Notifications not more intrusive than user selects
Functional for duration of 8hrs without charging	100-300lbs supported		

Design Requirements

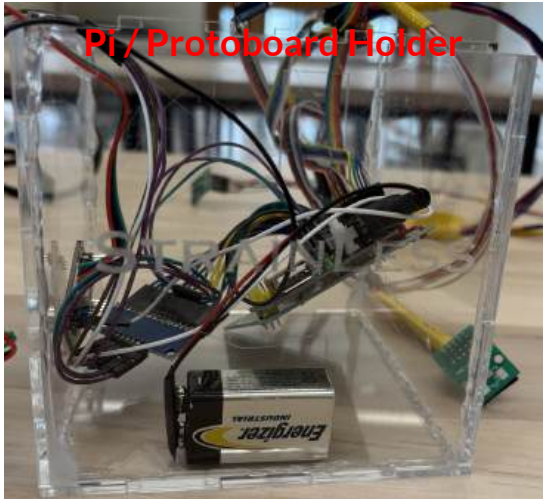
Head module	Seat module	Browser Extension
Power: - Battery size < 6 sq. in. MCU - Bluetooth 5.0 compatible - Battery amp-hour/avg. current draw >= 8 hr Head angle/position - Gyro range: 0 → 200 d/s Mounting - Unobtrusive to user - Stable - Does not overheat Total Weight < 75g	Main MCU: - Compatible with/ onboard ADC - Can process/ analyze inputs - Compatible with SPI or I2C - Bluetooth 5.0 Weight distribution sensing: - 0-300 lb min weight range - Some way of connecting to MCU - Detect < 0.5 lb shift for analysis - Sampling rate: 1 uS	User is able to view a summary of their data User is able to hear and/or see alert User is able to toggle level of intrusiveness of system Camera supports at least 30fps for blink detection CV algorithm is able to detect blinks in dim conditions

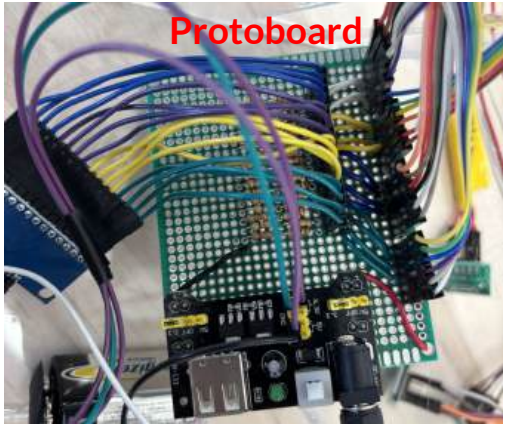

Hat
3.7V 1200mAh LiPo Battery
VCC
GND
ESP32-C6
Angle Estimation (1D Kalman Filter)
32-bit float (angle)
BLE Driver
angular velocity, acceleration
LSM9DS1 Driver
I2C
SCL
SDA
LSM9DS1 9DOF Sensor (Gyro/Accel/Mag)
Filtered Angle
RPi 5
BLE
Data Processing Algo
SCL
SDA
HTTP
Posture Mat
MF18-N-0A8-A01 Pressure Mat x4
150KOhm Voltage Divider Protoboard
16 wires
16 to 1 Analog Mux
ADC DFR0553
Raspberry Pi locally hosted server
Browser Extension
icon.png
icon.png
popup.html
sandbox.html
content.css
popup.js
sandbox.js
content.js
detect_blinks.py
opencv-python
Off-the-shelf
Designing/Developing
Assembling
Downloading

Solution Approach

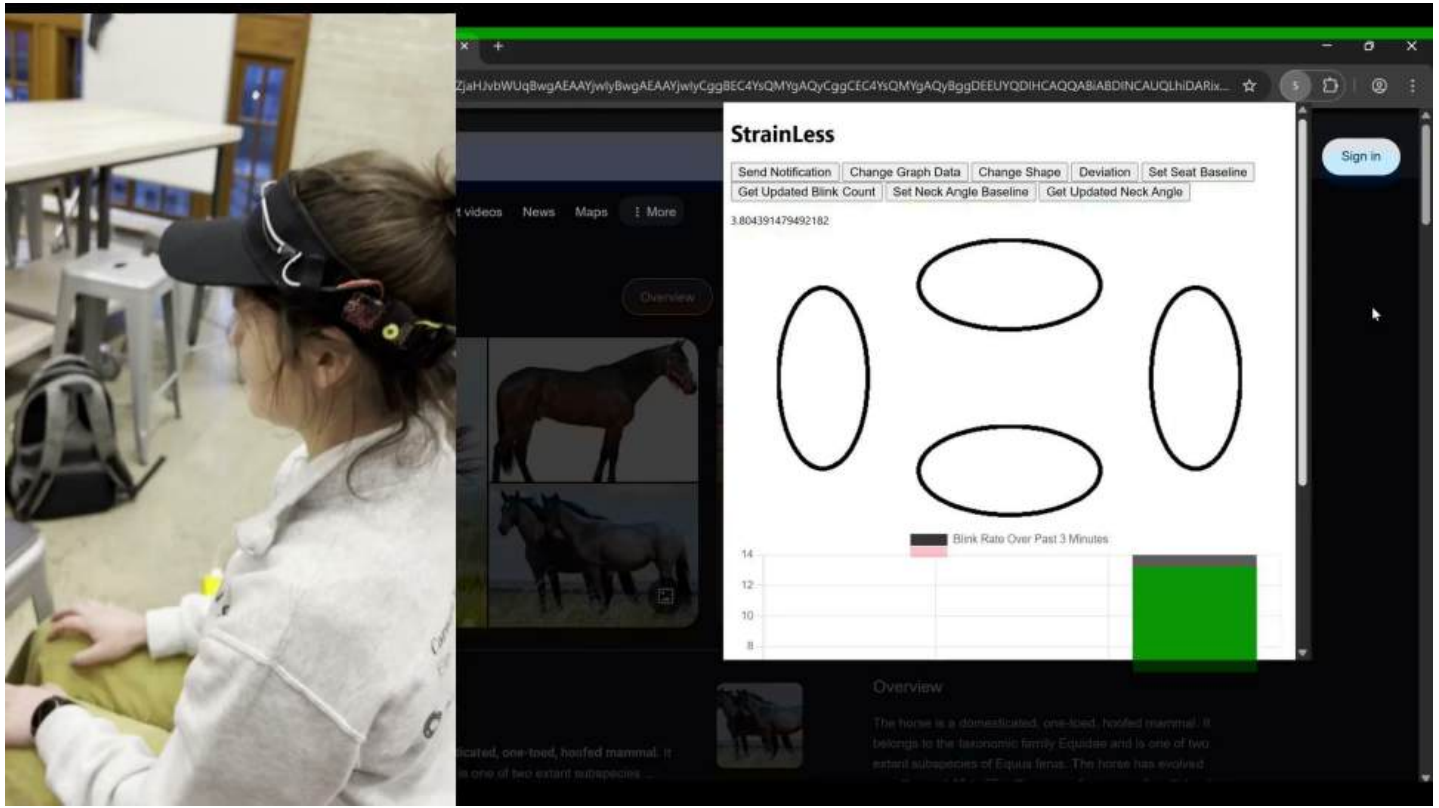


Browser Extension View



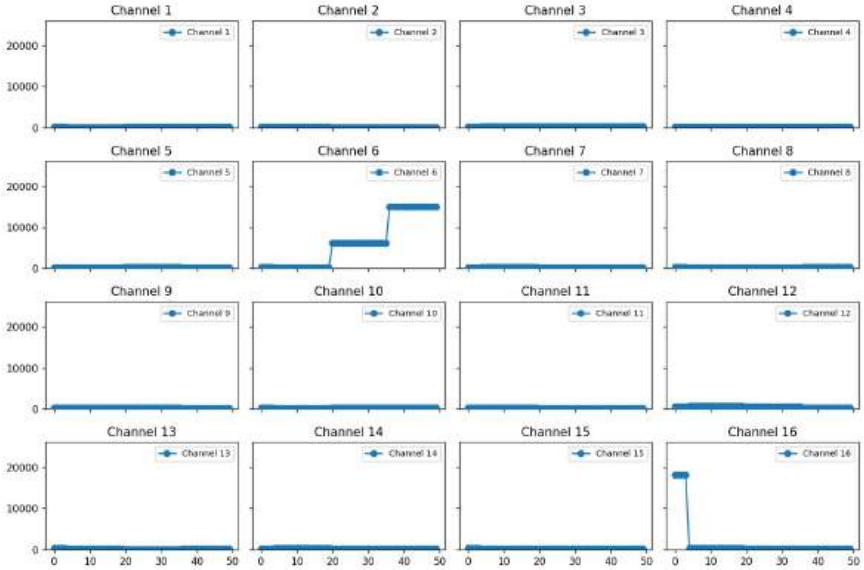


Complete Solution



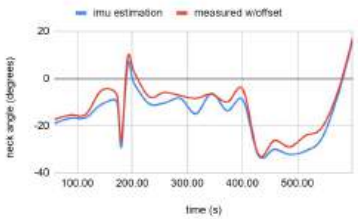
Complete Solution (cont.)

- Instantaneous feedback vs averaging data



Pressure mat individual sensor data

Test, Verification, Validation

Test	Procedure	Passing Test	Results
Neck angle accuracy 	Record user from side for 10-60min with current angle displayed on laptop in video, compare calculated angles with manually measured angles using Kinovea software in ~20 frames throughout video	RMS error < 5 degrees 	10 min: Passes (RMS = 3.62 degrees, max diff = -6.55 degrees) 30 min: In Progress 60 min: In Progress
System 8hr battery life	Fully charge LiPo battery, connect ESP32 and RPi, leave system running (continually sending data) for 8hrs.	LiPo + seat batteries do not drop below 3.3V	Seat battery: Passes 500 mAh/10 ma per hour LiPo: In Progress
Browser Extension UI	Exhibit poor posture via sensors for > 1 min, measure latency between time of poor posture and time of alert.	Latency in seconds. Should be < 1 minute.	Pressure mat:✅ Neck angle:✅ Blink rate:✅

Test, Verification, Validation (cont.)

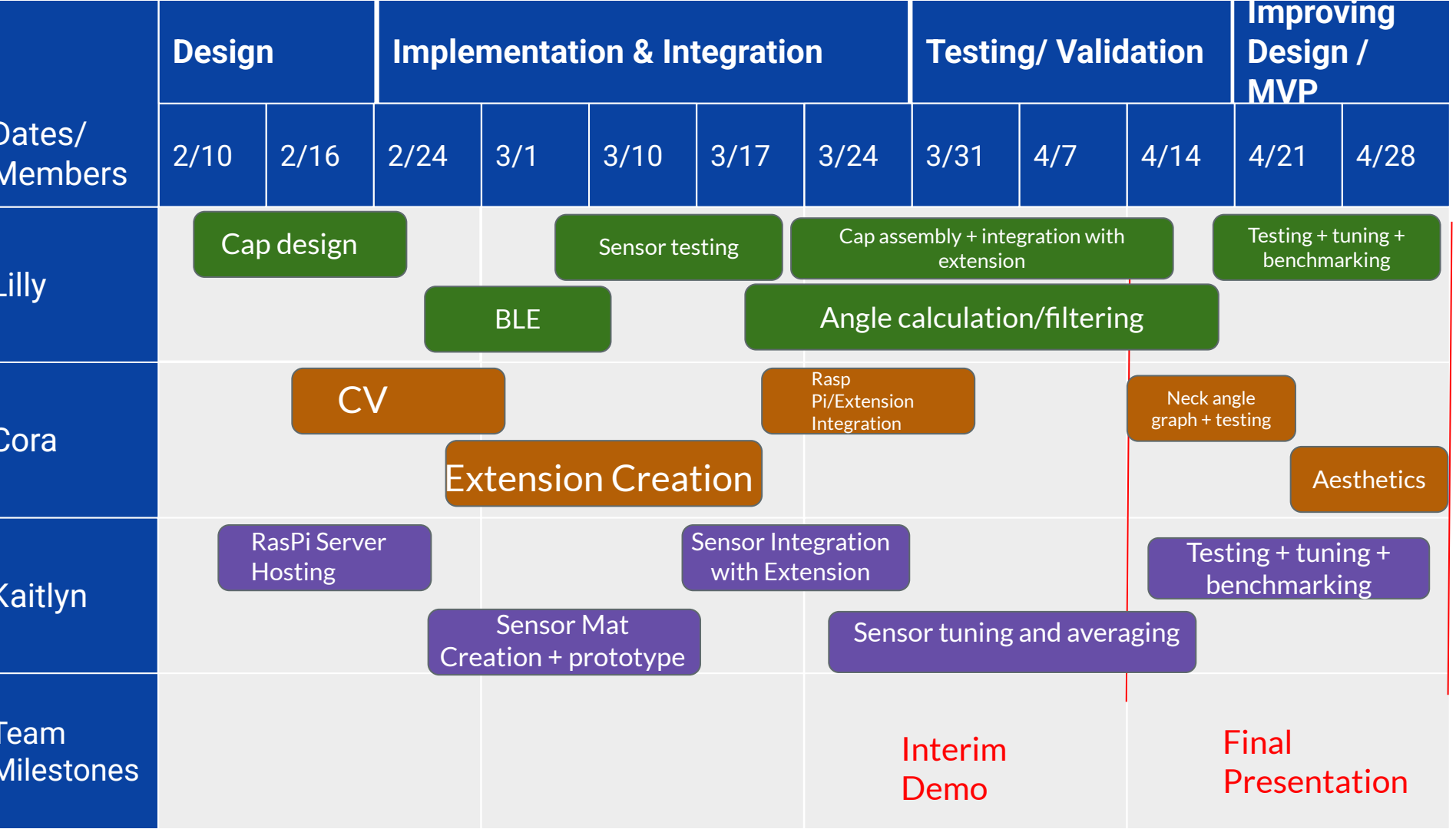
Test	Procedure	Passing Test	Results
Posture Mat Comfort	Google form regarding whether they felt any discomfort, were impeded by the mat, and perceived accuracy of alert (0 is worst, 10 is best)	Out of each category >7 rating	Impeded: In Progress Discomfort: In Progress
Blink rate	Compare number of blinks detected vs. manual count over 1 min. Vary lighting from well-lit to dim (3 diff. conditions).	Counts should be within 1 blink for all conditions.	Dim: In Progress Average: In Progress Bright: In Progress
Posture accuracy 	Record user from side and front for 10 minutes (x10 people) and 1 hour (1 person), compare the posture deviations being sent with those from the video	When a visible lean or other incorrect posture is detected on the video, >95% of visible leans are alerted	10 min: Passes (False positive rate of 3% when averaged) 60 min: In Progress

Design Tradeoffs

Neck System	❖ Distribution of angle processing workloads across the two MCUs
Sitting Posture System	❖ Battery Powered Sensors vs. In-Wall Power ❖ Protoboard ❖ 1 ADC + 16:1 MUX vs 4 ADC - latency between switching between I2C addresses and switching MUX channels ❖ Pressure sensor location - accuracy on lean direction with 1 tester vs overall alert accuracy with all testers
Blink rate system	❖ Running script locally vs on Raspi vs on web app/browser extension
Browser extension	❖ Liberal use of permission granting vs functionality

Challenges/Lessons Learned

- Pi Web Server Hosting and Integration
- Early integration of small portions of project
- Black-boxed library code vs. tunable/modifiable algorithms
- Not overfitting algorithms for data analysis
- Testing on user setup vs. breadboarding
- Security issues with third-party code


Design
Implementation & Integration
Testing/ Validation
Improving Design / MVP
Dates/ Members
2/10
2/16
2/24
3/1
3/10
3/17
3/24
3/31
4/7
4/14
4/21
4/28
Lilly
Cap design
Sensor testing
Cap assembly + integration with extension
Testing + tuning + benchmarking
BLE
Angle calculation/filtering
Cora
CV
Rasp Pi/Extension Integration
Neck angle graph + testing
Extension Creation
Aesthetics
Kaitlyn
RasPi Server Hosting
Sensor Integration with Extension
Testing + tuning + benchmarking
Sensor Mat Creation + prototype
Sensor tuning and averaging
Team Milestones
Interim Demo
Final Presentation