University of Massachusetts Amherst

StrideSync

A Gait Analysis Tool

Alexander Tollman, Rosana Cho, Liam Beguhn, Patrick Walsh

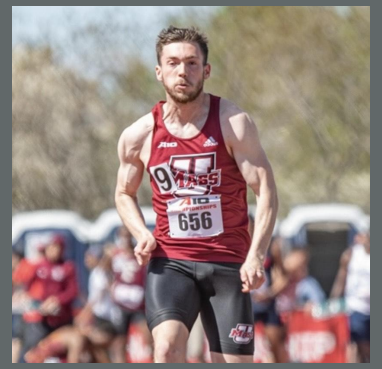
Our Team

Alexander Tollman
EE

Rosana Cho
CompE

Prof. Goeckel
Faculty Advisor

Liam Beguhn
EE



Patrick Walsh
CompE

Problem Statement

Runners at all levels of experience continually seek to enhance their performance by gaining insightful metrics. Commonly utilized data points like cadence, heart rate, and elevation gain provide valuable feedback. However, a critical metric like gait analysis currently remains confined to laboratory settings, limiting accessibility to the average runner. Our mission is to bridge this gap and provide everyday runners with the ability to access and interpret this invaluable gait analysis, empowering them to better comprehend and optimize their athletic capabilities.

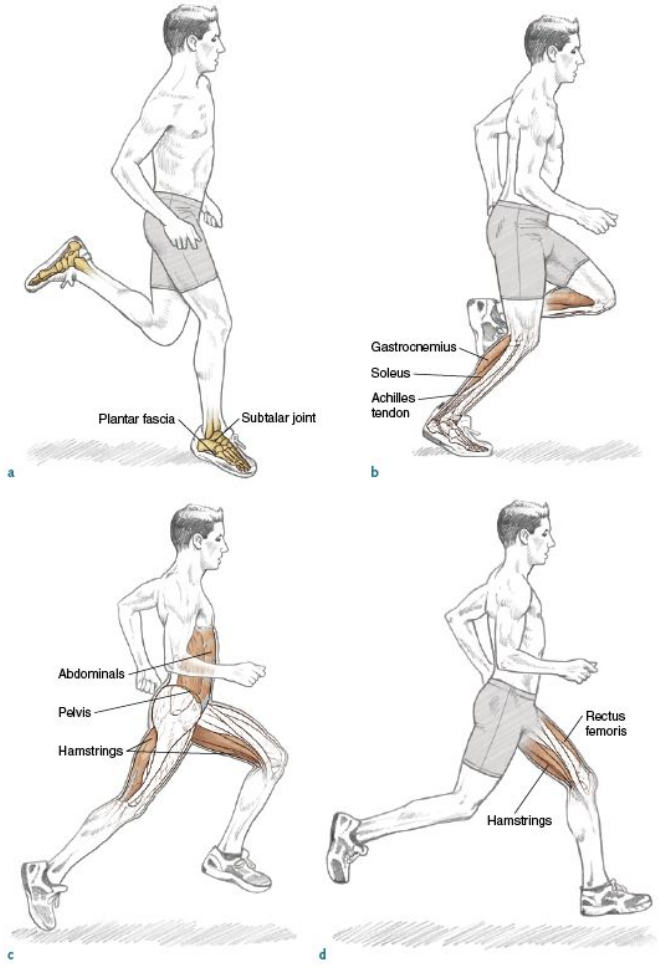


Figure 3.1 The gait cycle: *(a)* initial contact, *(b)* stance phase, *(c)* takeoff, and *(d)* forward swing phase.

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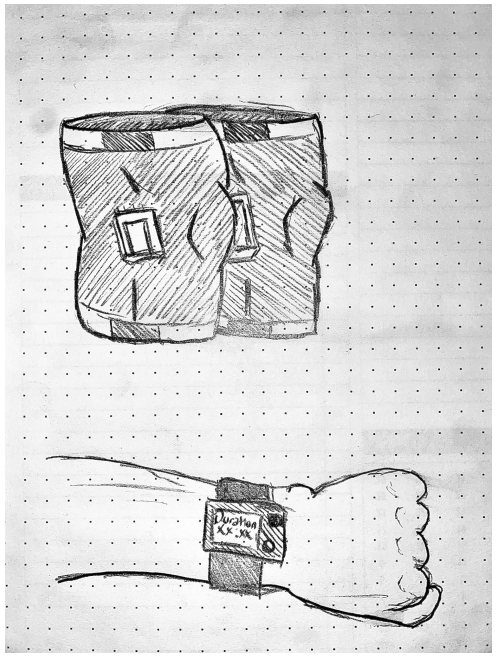
Goals

1. Measure the gait of a run ✔
2. Collect the data from gait system, store the data until the run is done, then sync with a device ✔
3. Display relevant data on the wrist ✔
4. Analyze and visualize the relevant data on a computer ✔

Our Solution: StrideSync

- Measure knee flexion and motion metrics using knee sleeves with built-in IMUs
  - Pronation/Supination
  - Overstriding
  - Knee angles
- System capable of lasting throughout a run comfortably
- Wrist element to start and stop runs and view run statistics



Proposed FPR System

Knee Sleeves
- Battery pocket

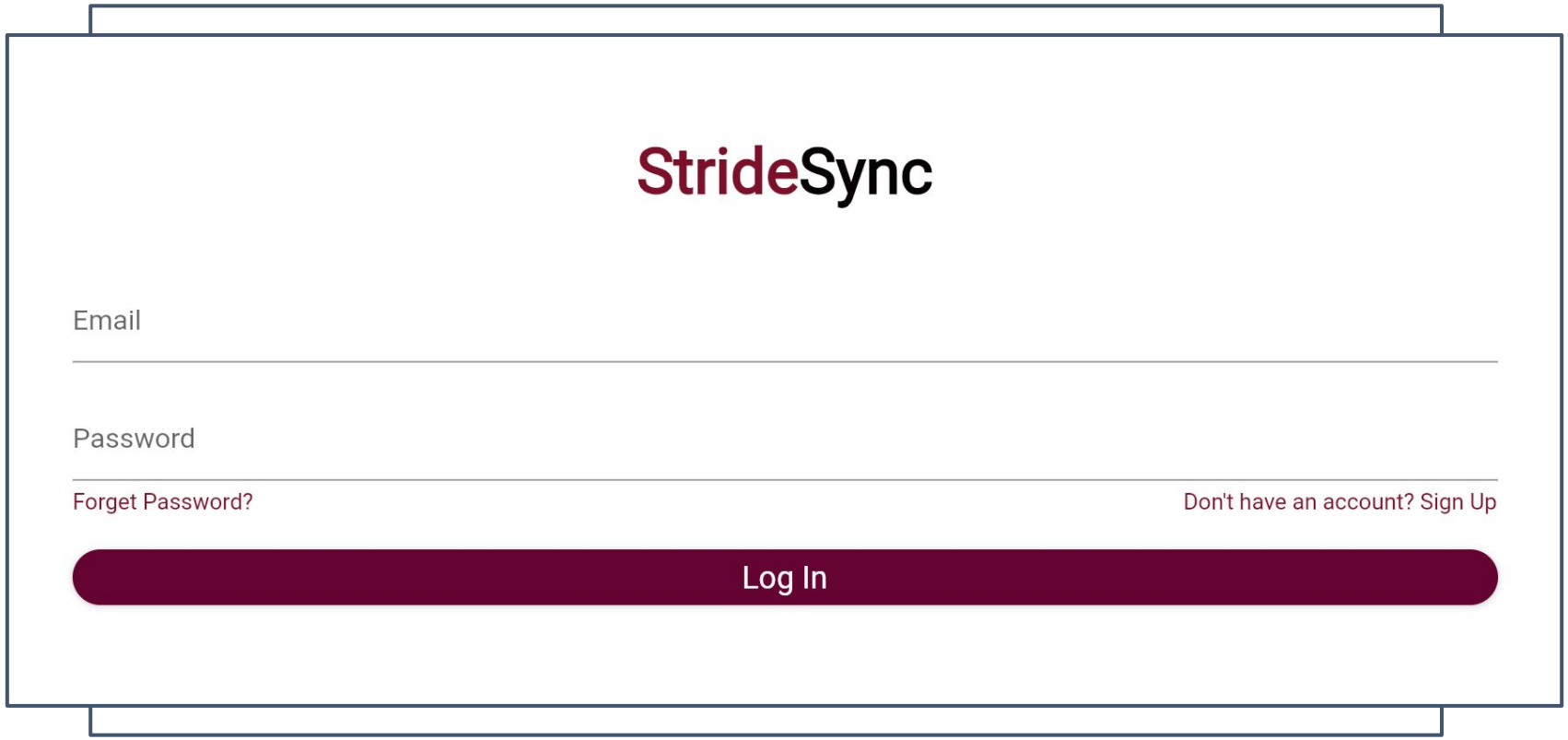
Wrist
- On board indication for relevant information (not breadboard)
- Hardware mounting mechanism

Analysis
- Produce different movements for more test benches
- Experiment with filtering the data

Main Concern for FPR

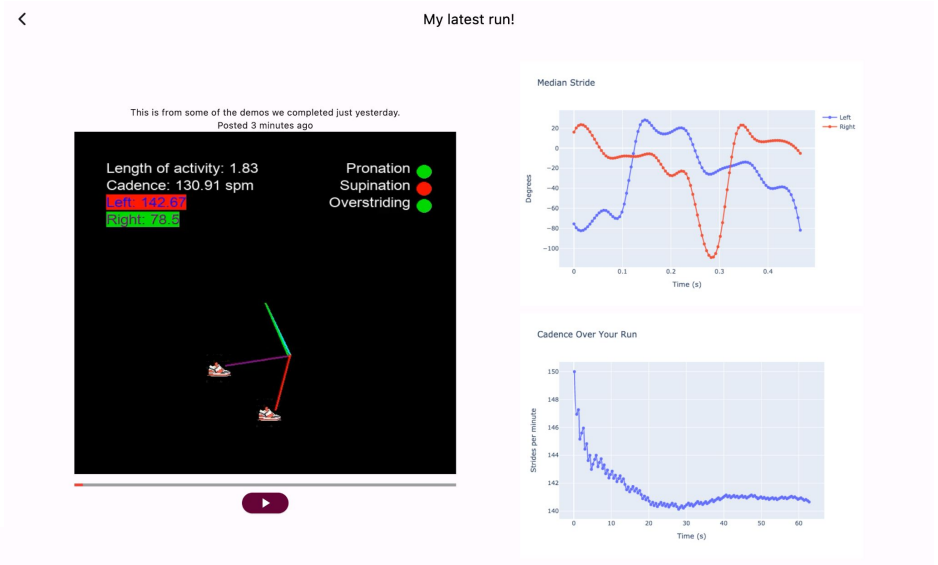
No user-friendly interface for laptop or phone demonstrated or even mentioned

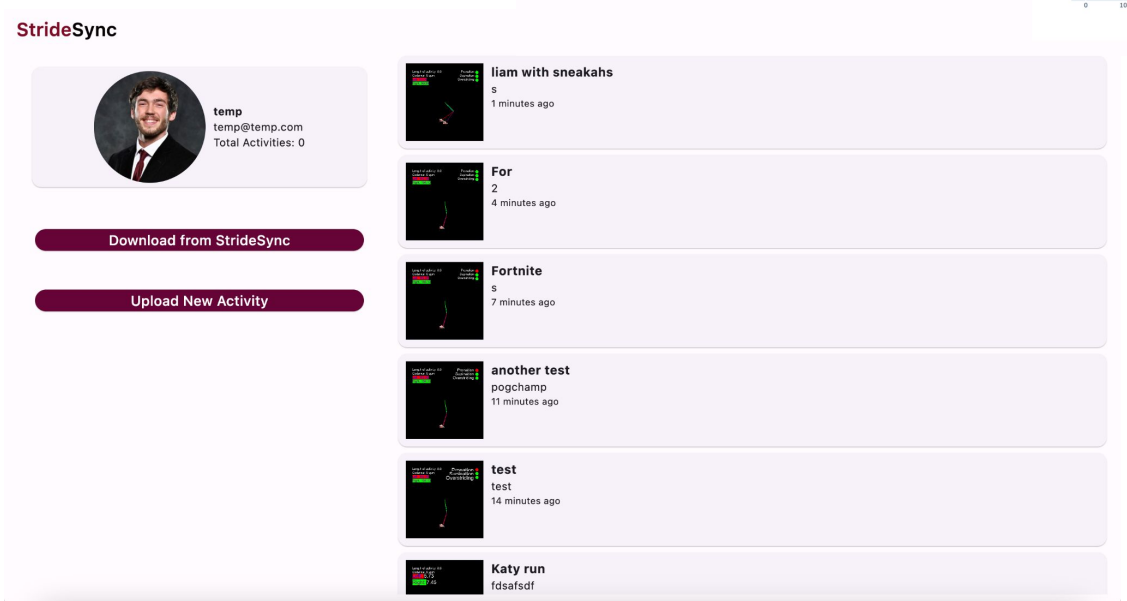
User-Friendly Interfacing



User-Friendly Interfacing

- User-friendly interface for analyzing runs
- Start stop, “scrub” bar
- Plots for median stride, cadence over time





FPR Design Overview

- Knee Sleeves
  - Sleeves that are comfortable to the user
  - Robust wiring to account for movement
- Wrist Module
  - Comparable to modern watch dimensions (40mm in diameter)
  - Functionalities (start/stop, display of running time, retains activity data)
- Graphical User Interface (GUI)
  - Easy to follow and understand visualization
  - Notable metrics computed and shown
  - User friendly interfacing

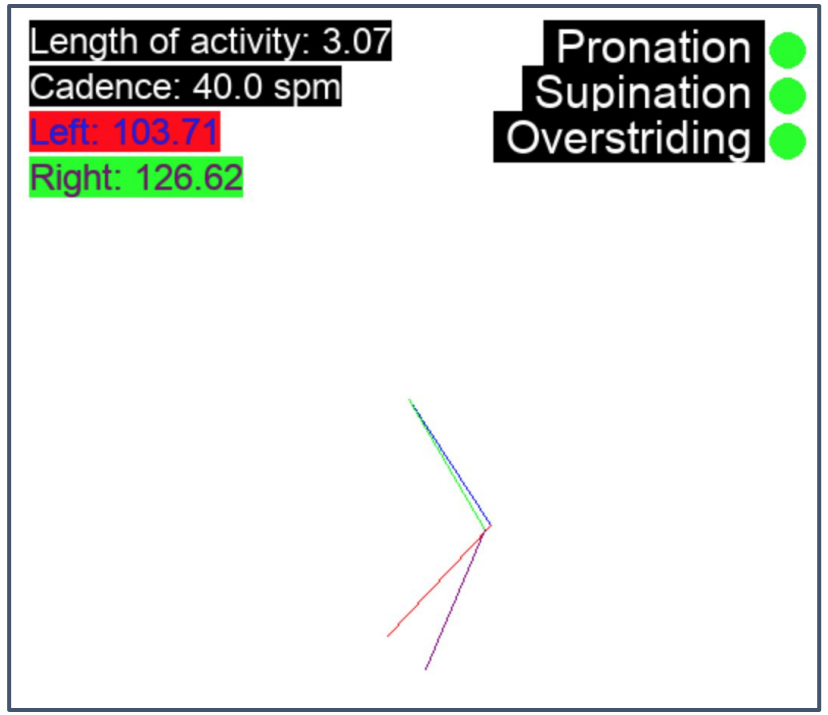
Specifications & Testing Plans Overview

Specification	Corresponding Testing Plan
Visualization of leg motion throughout your stride through a digestible GUI.	A user will see a relative model to represent leg movement.
Comfortable to wear with minimal lateral movement.	Survey users about comfortability post-activity.
System is less than 2 lbs.	Weigh the system and check to be under 2 lbs.
System should provide gait analysis after activity.	After gathering data from an activity and uploading to the device, it will show results of new activity.
Knee angles computed will be accurate within ± 15°.	A user will be recorded with POI dots on the same positions as IMUs and compared to our computations.
Be able to record dynamic movement.	Have users walk in a circle doing high knees or a sample activity with rotation of some kind.
Pronation/Supination will be told by in and outwards rotation of at least 15°. Overstriding will be seen at 25°.	Record users explicitly doing in and outwards or overstriding movements and compare to our results. In addition, several users will run at distances of 400m, 800m, and 5000m to see if movement is captured.

Specification #1 & #2

System should provide gait analysis after activity, where the visualization of leg motion throughout your stride is seen through a digestible GUI.

After gathering data from an activity and uploading to the device, it will show results of new activity, where a user will see a relative model to represent leg movement



Specification #3

Comfortable to wear with minimal lateral movement, less than 2 lbs

Survey user about comfortability and weigh each system

Survey:

1. Were the knee sleeves comfortable or were they distracting in any way?
2. Getting metrics like cadence, where you're pronating/supinating, and knee angles, is this a system that you would wear throughout a run of yours?

Specification #4

Knee angles computed will be accurate within ± 15°.

A user will be recorded with POI dots on the same positions as IMUs and compared to our computations.

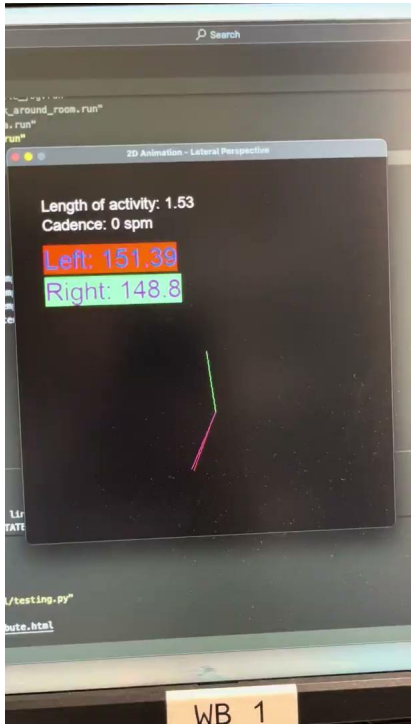
Average difference between actual and expected		
B	**M**	**F**
53.64285714	9.24	16.21428571

Pass Rate		
B	**M**	**F**
0.00%	84.00%	64.29%

Specification #5

Shift across axes without gimbal lock

Have users walk in a circle doing high knees or a sample activity with rotation of some kind



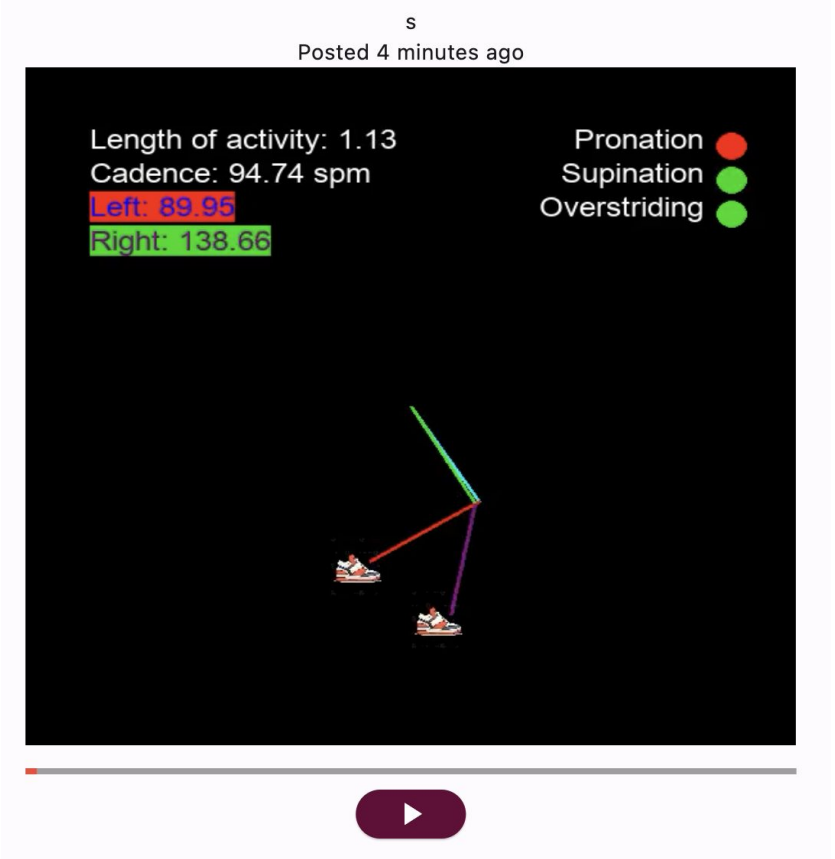
Specification #6

Pronation/Supination will be told by in and outwards rotation of at least 15°.

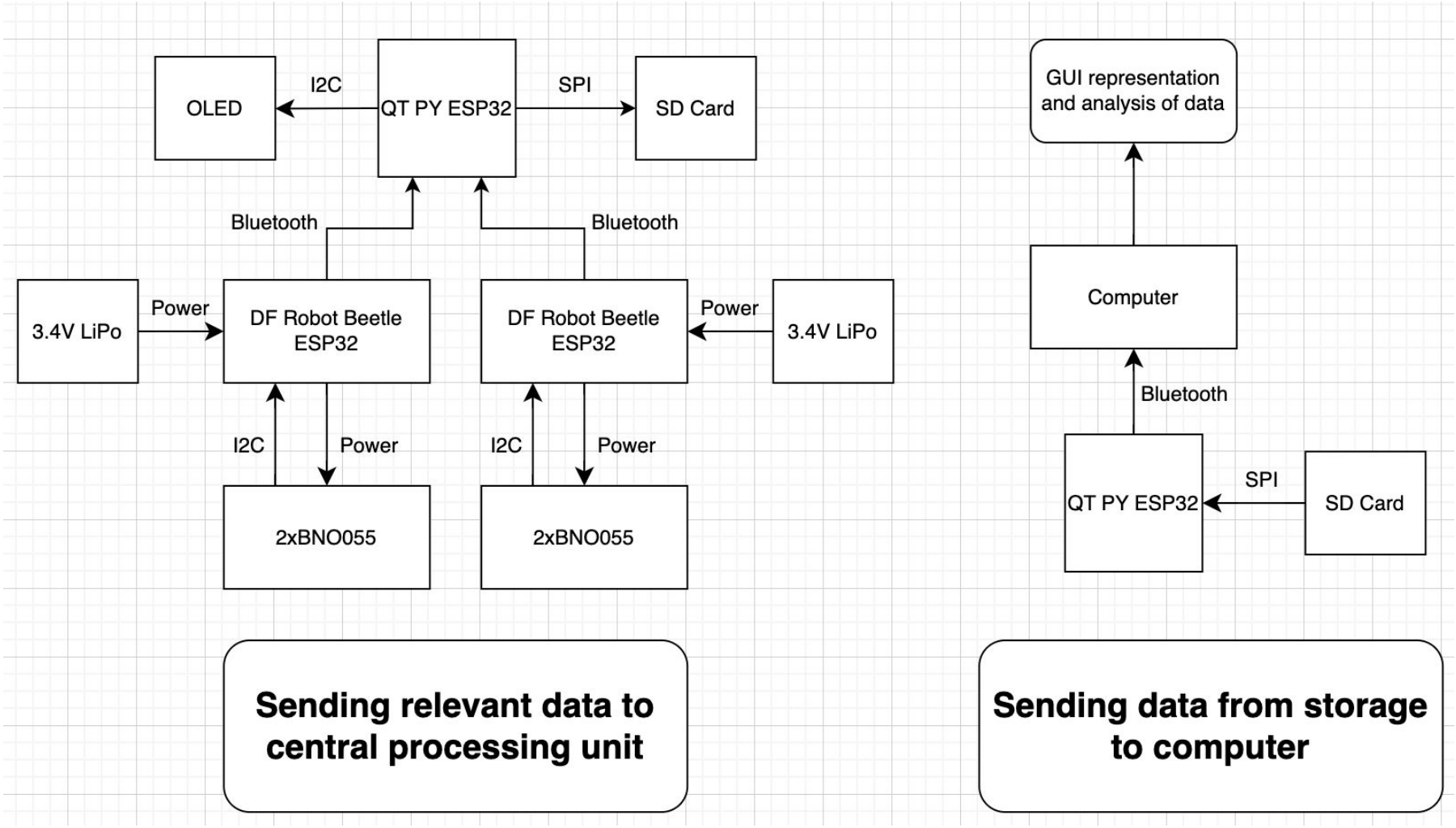
Overstriding will be seen at 25°.

Record users explicitly doing in and outwards or overstriding movements and compare to our results.

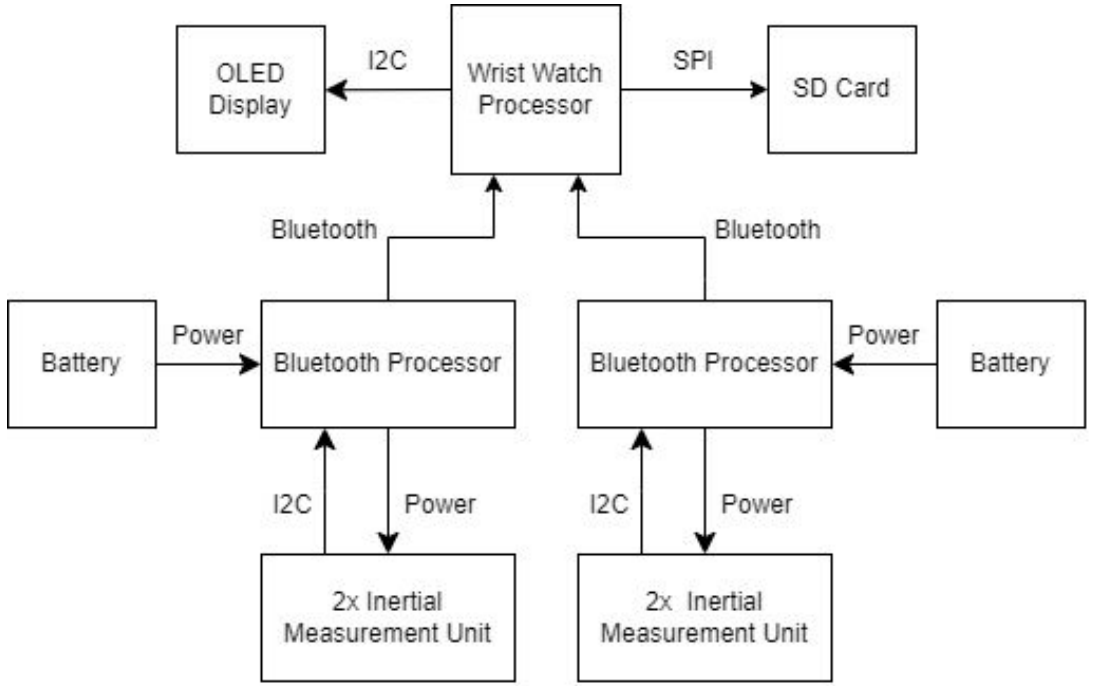
In addition, several users will run at distances of 400m, 800m, and 5000m to see if movement is captured.



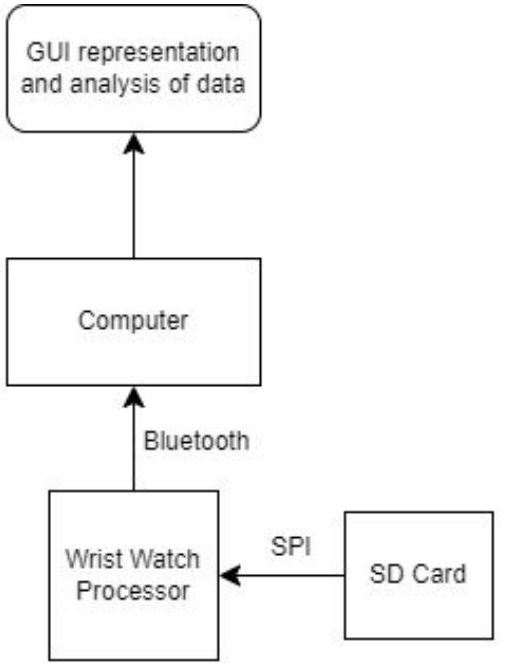
CDR Hardware Block Diagram



FPR Hardware Block Diagram

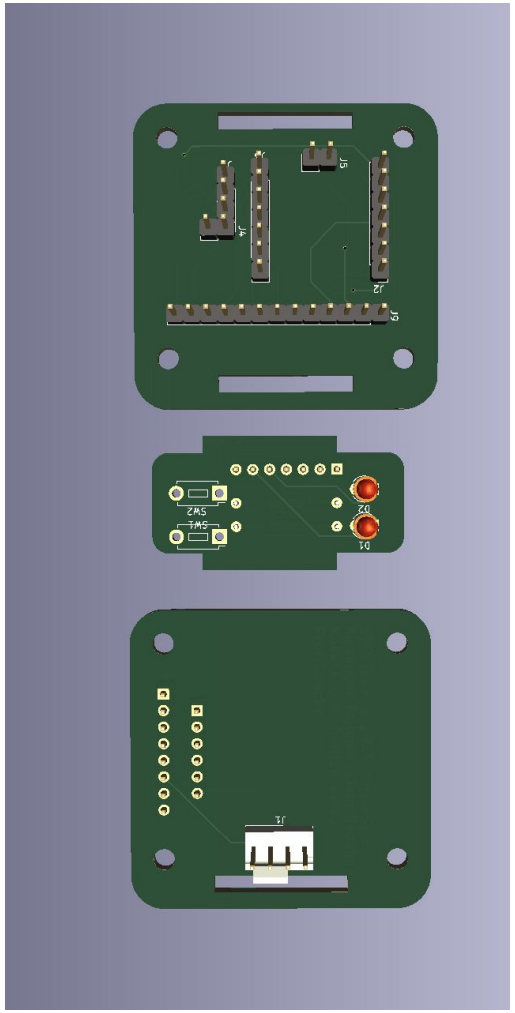


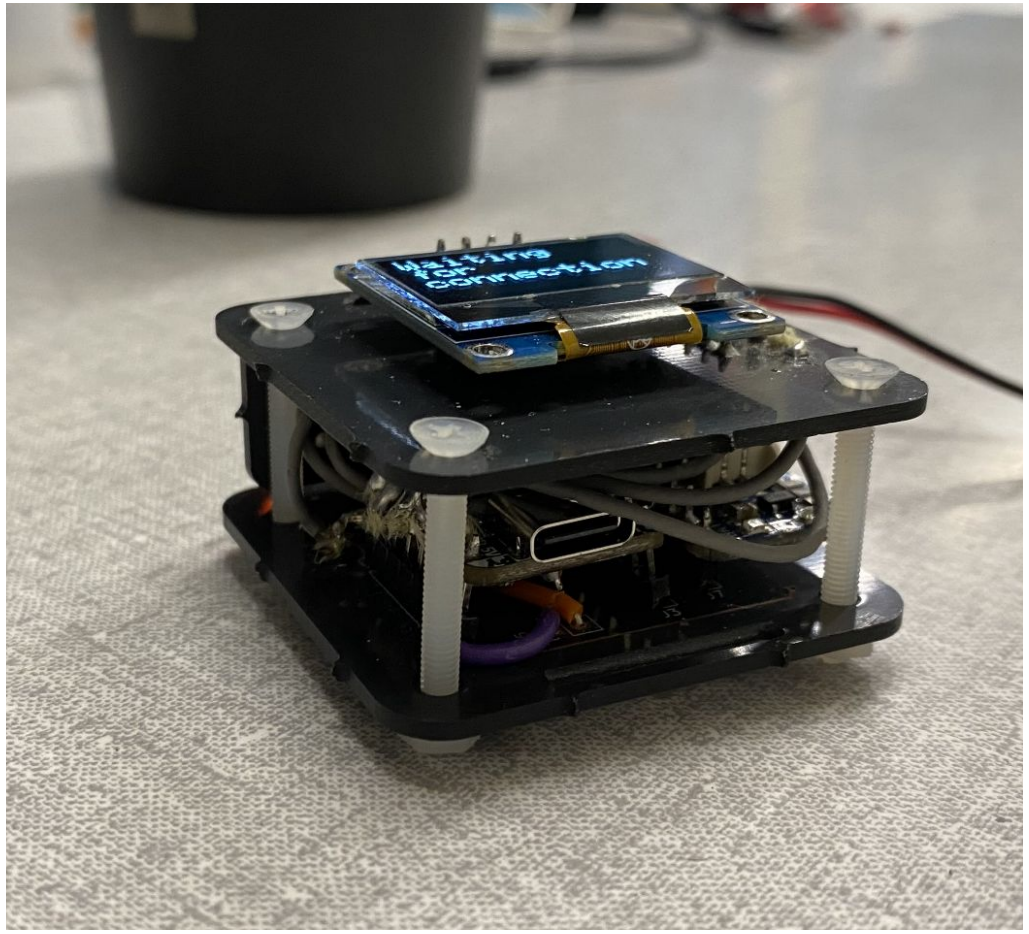
Sending relevant data to central processing unit



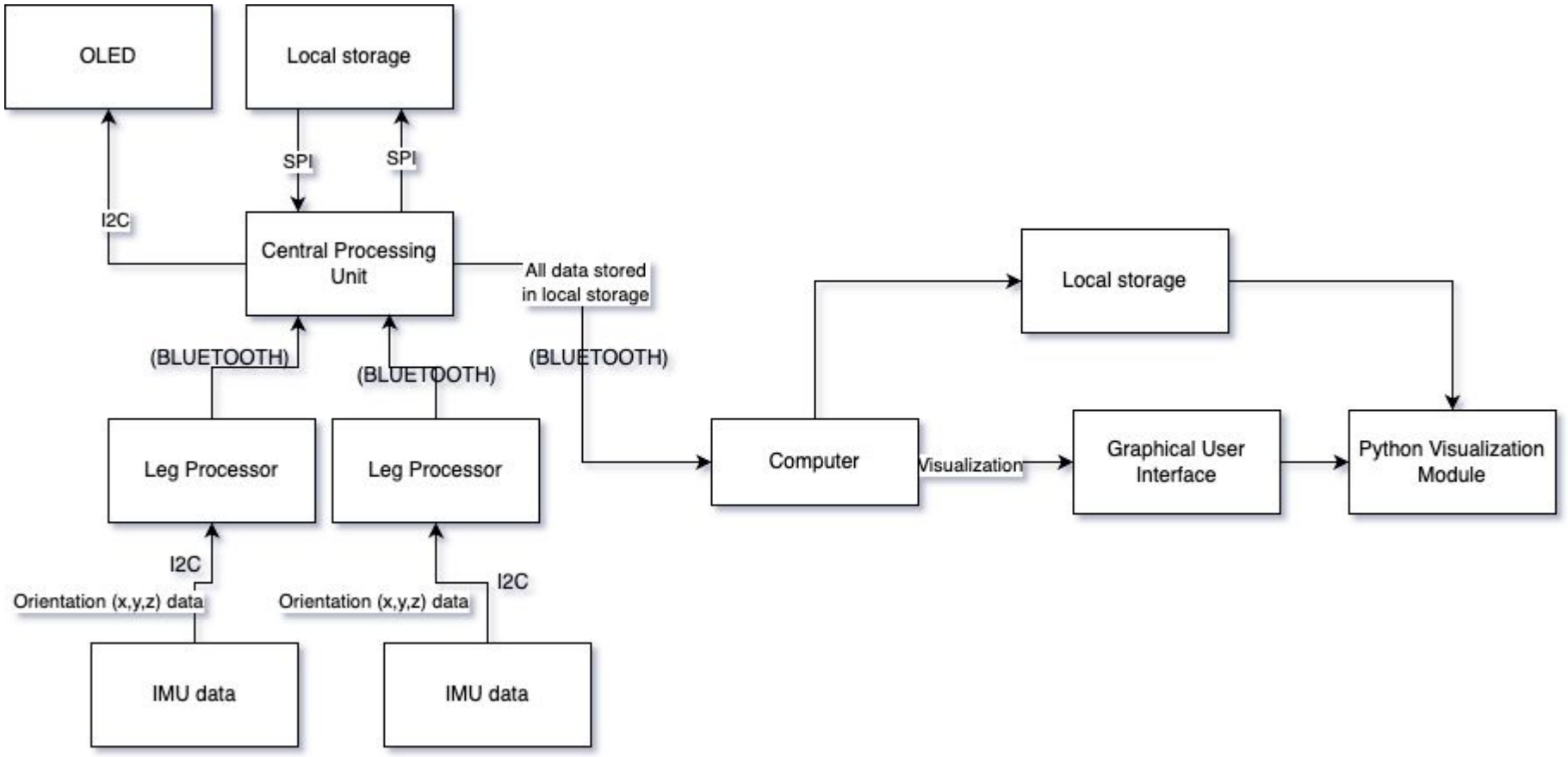
Sending data from storage to computer

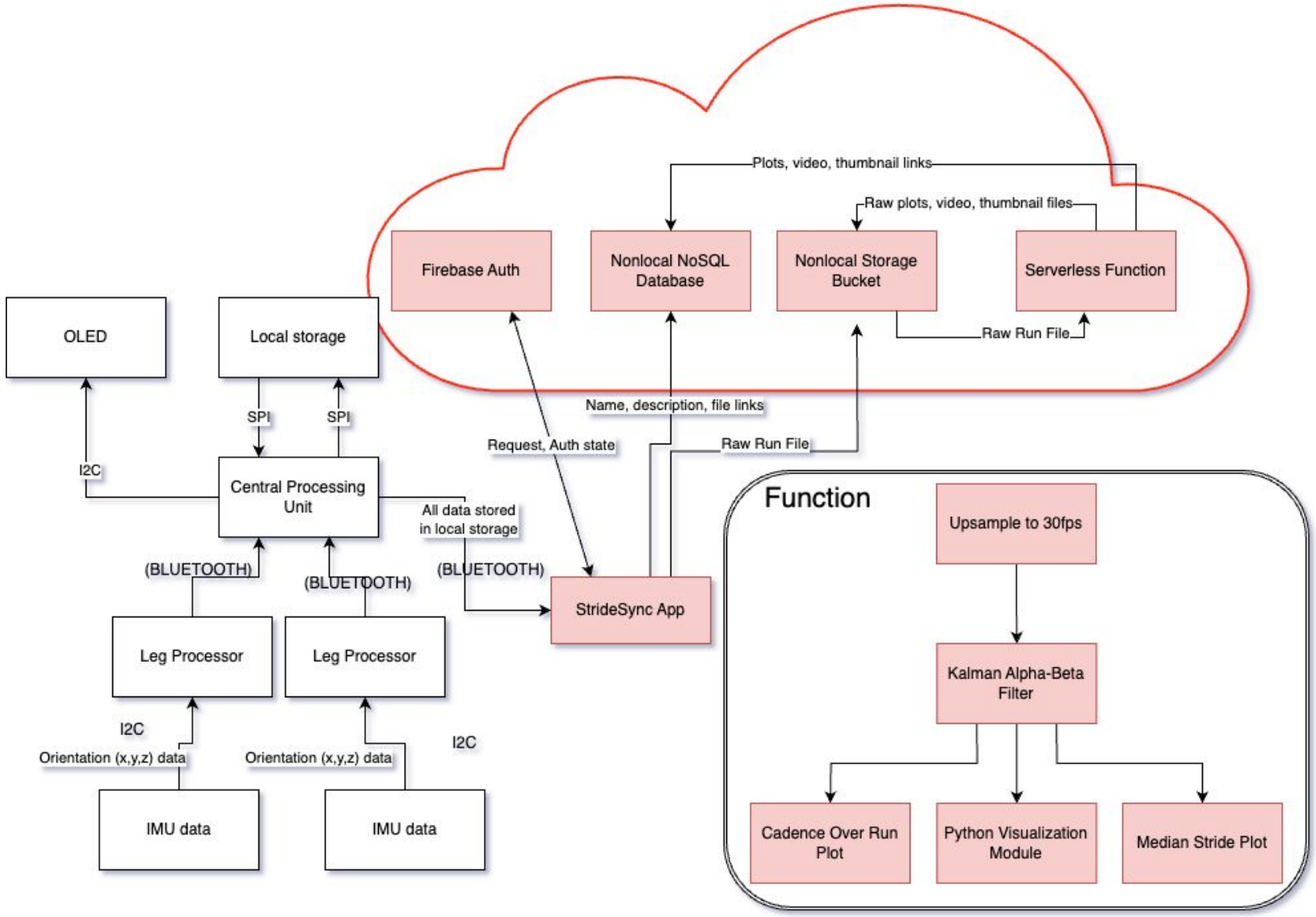
FPR PCB





CDR Software Block Diagram

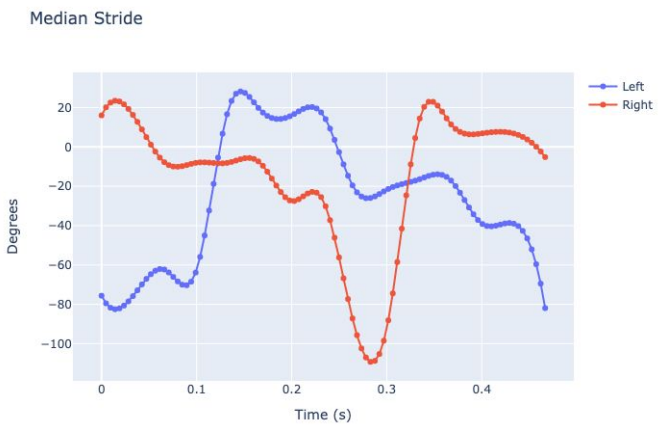


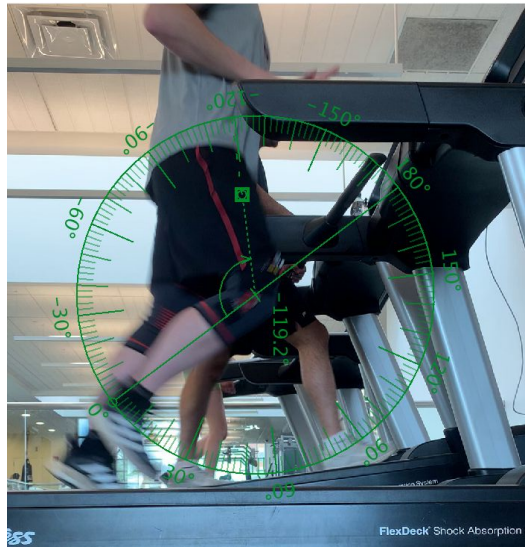


FPR Software Block Diagram

Testing Results & Analysis

- Conducted 6x 400m runs
- 2x 1-mile run
  - one 1-mile run with side camera for knee angle analysis
- Mid stride (M) during beginning of run and extension (F) remain in specification range or just outside
- Drift over time significantly increases inaccuracy of system
  - Approx 2 minutes until drift becomes a major concern





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B	**M**	**F**
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Pass Rate		
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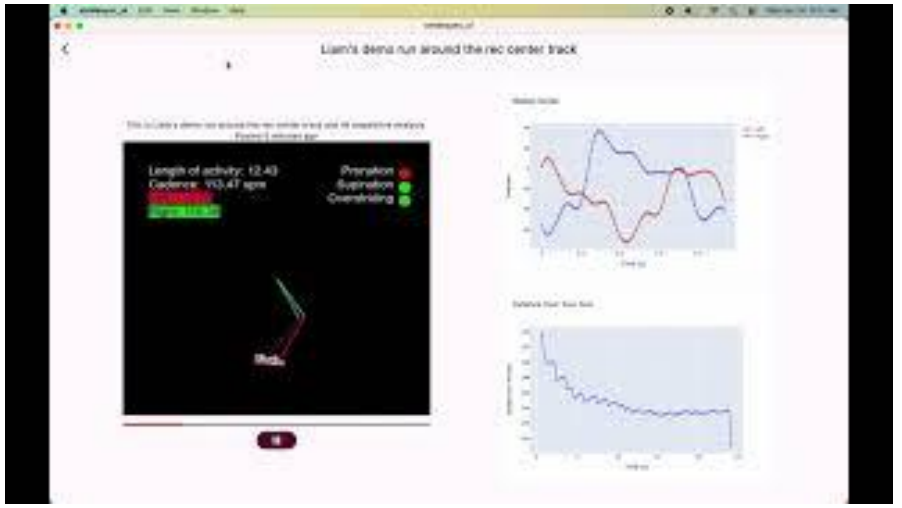
Proposed FPR Demonstration

1. Have User put knee sleeves and wrist device
2. Power on while in a vertical, upright, standing position to calibrate the system.
3. Jog around the quad to gather data
4. After activity, data that has been collected will be uploaded to a computer/laptop.
5. Computations will be done and show analysis of collected data.

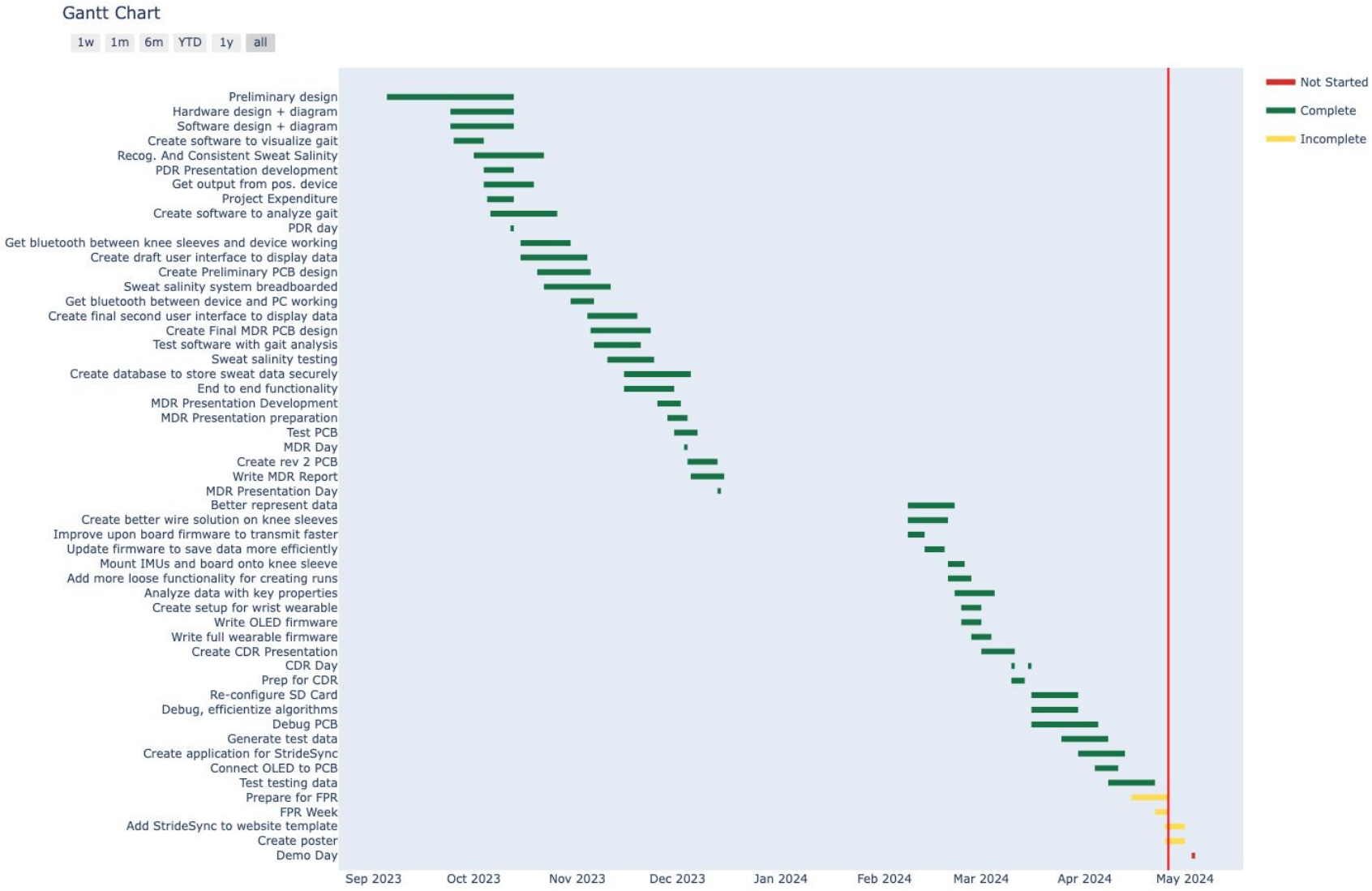
FPR Demonstration / Recorded Demo



Final Project Expenditures

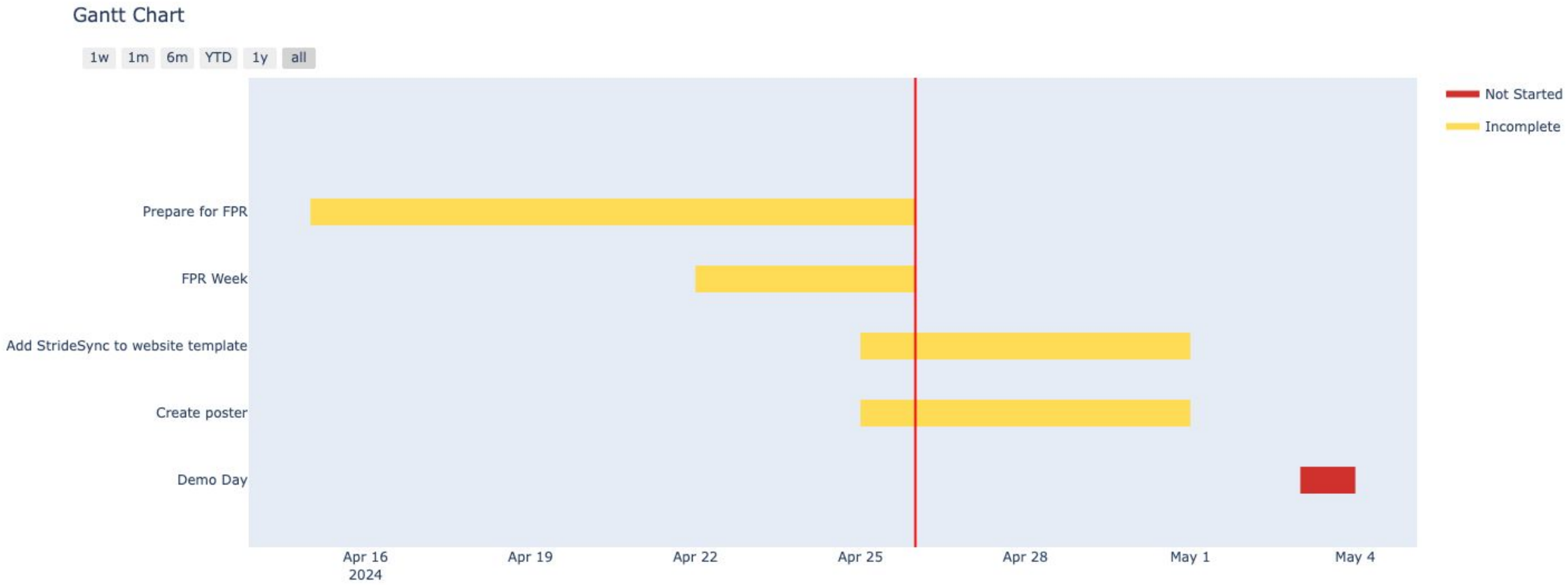
Item name	Link	Price	Quantity	Total Cost
BNO055	https://www.adaf	$34.95	6	$209.70
Beetle ESP32	https://www.dfrol	$9.90	3	$29.70
MDR PCB		$30.00	1	$30.00
Rev1 PCB		$30.00	1	$30.00
MicroSD Reader	https://www.adaf	$7.50	1	$7.50
SD Card	https://www.adaf	$10.00	1	$10.00
QT PY ESP32-S3	https://www.adaf	$20.04	1	$20.04
CDR PCB		$44.15	1	$44.15
Flexible Cable		$16.50	1	$16.50
Various Materials		$17.16	1	$17.16
Batteries	https://www.adaf	$7.95	6	$47.70
Micro Lipo Charge	https://www.adaf	$5.95	2	$11.90

Net Cost
$474.35


Gantt Chart
1w
1m
6m
YTD
1y
all
Preliminary design
Hardware design + diagram
Software design + diagram
Create software to visualize gait
Recog. And Consistent Sweat Salinity
PDR Presentation development
Get output from pos. device
Project Expenditure
Create software to analyze gait
PDR day
Get bluetooth between knee sleeves and device working
Create draft user interface to display data
Create Preliminary PCB design
Sweat salinity system breadboarded
Get bluetooth between device and PC working
Create final second user interface to display data
Create Final MDR PCB design
Test software with gait analysis
Sweat salinity testing
Create database to store sweat data securely
End to end functionality
MDR Presentation Development
MDR Presentation preparation
Test PCB
MDR Day
Create rev 2 PCB
Write MDR Report
MDR Presentation Day
Better represent data
Create better wire solution on knee sleeves
Improve upon board firmware to transmit faster
Update firmware to save data more efficiently
Mount IMUs and board onto knee sleeve
Add more loose functionality for creating runs
Analyze data with key properties
Create setup for wrist wearable
Write OLED firmware
Write full wearable firmware
Create CDR Presentation
CDR Day
Prep for CDR
Re-configure SD Card
Debug, efficientize algorithms
Debug PCB
Generate test data
Create application for StrideSync
Connect OLED to PCB
Test testing data
Prepare for FPR
FPR Week
Add StrideSync to website template
Create poster
Demo Day
Sep 2023
Oct 2023
Nov 2023
Dec 2023
Jan 2024
Feb 2024
Mar 2024
Apr 2024
May 2024
Not Started
Complete
Incomplete

Gantt Chart

Gantt Chart


Gantt Chart
1w
1m
6m
YTD
1y
all
Not Started
Incomplete
Prepare for FPR
FPR Week
Add StrideSync to website template
Create poster
Demo Day
Apr 16
2024
Apr 19
Apr 22
Apr 25
Apr 28
May 1
May 4

QUESTIONS & ANSWERS

University of Massachusetts Amherst