Ankle Injury Prevention

ECE 445 Fall 2020:
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Introduction

- 13% of injuries at NBA level
- 40% of injuries at High School level
- Prevent this by monitoring stress

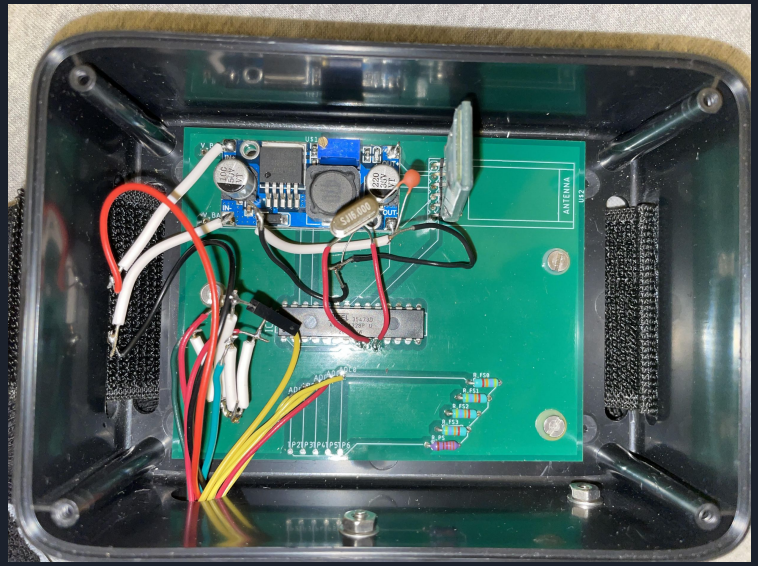
- NBA injuries: loss of revenue, disappointed fans, less competitive team
- High School injuries: affect performance, might result in chronic effects

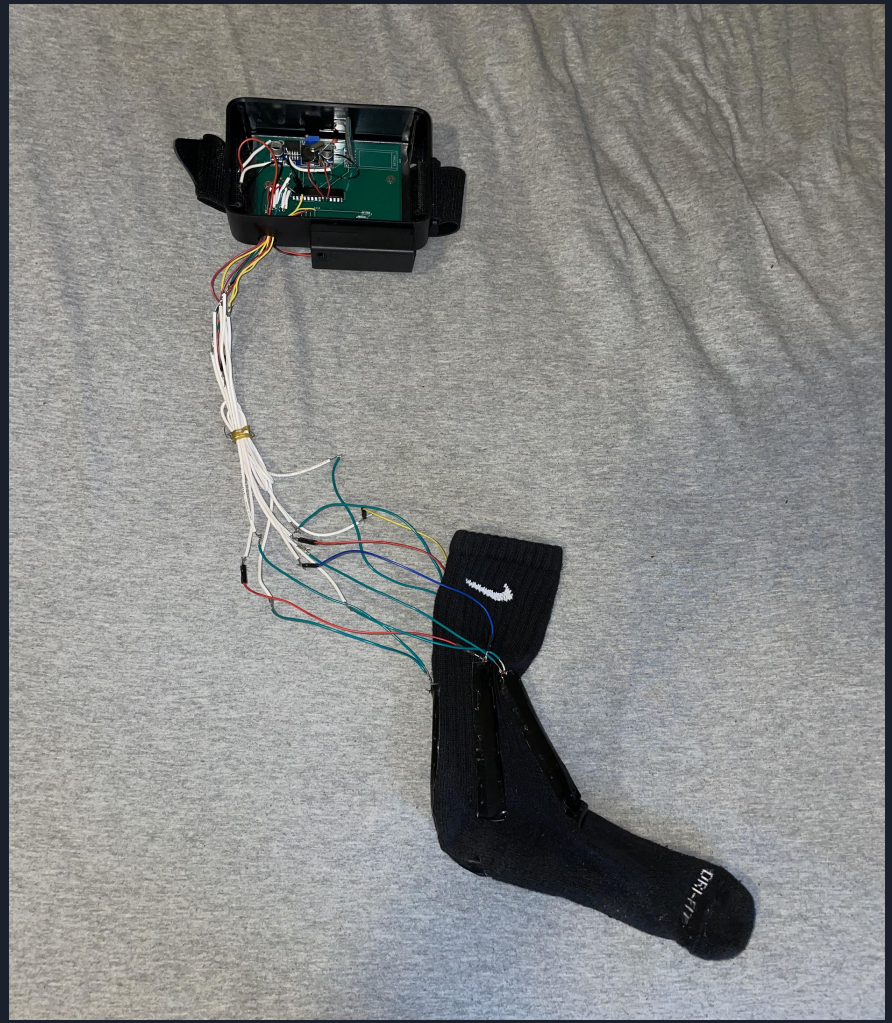
Objectives

Overall objective is to monitor a user's ankle to determine when they are putting stress on their ankle and how much stress they are inducing

- Collect and stream data for a 30-minute period
- Ability to detect a player's range of motion in two planes
- Ability to detect jumps and landings
- User interface displays informative metrics describing a player's ankle stress

Physical Design

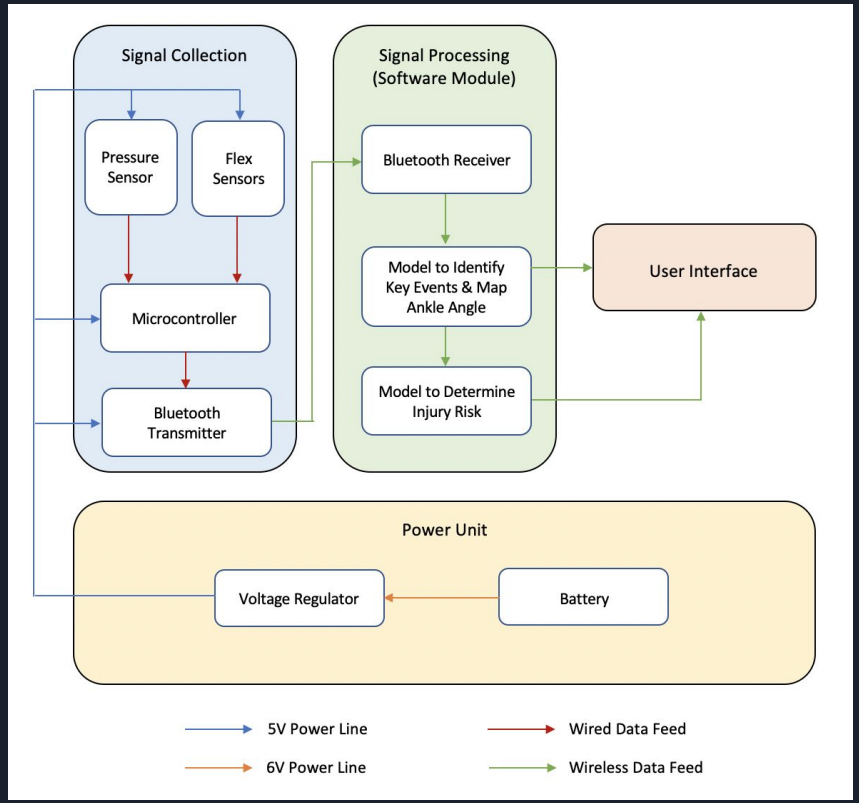




System Overview

- Hardware
  - Power Unit: Battery and DC-DC Buck Converter
  - Signal Collection Unit: Flex Sensors, Pressure Sensor, Microcontroller, and Bluetooth Transmitter
- Software
  - Signal Processing Unit: Model to Identify Key Events & Map Ankle Angle, Model to Determine Injury Risk, and User Interface

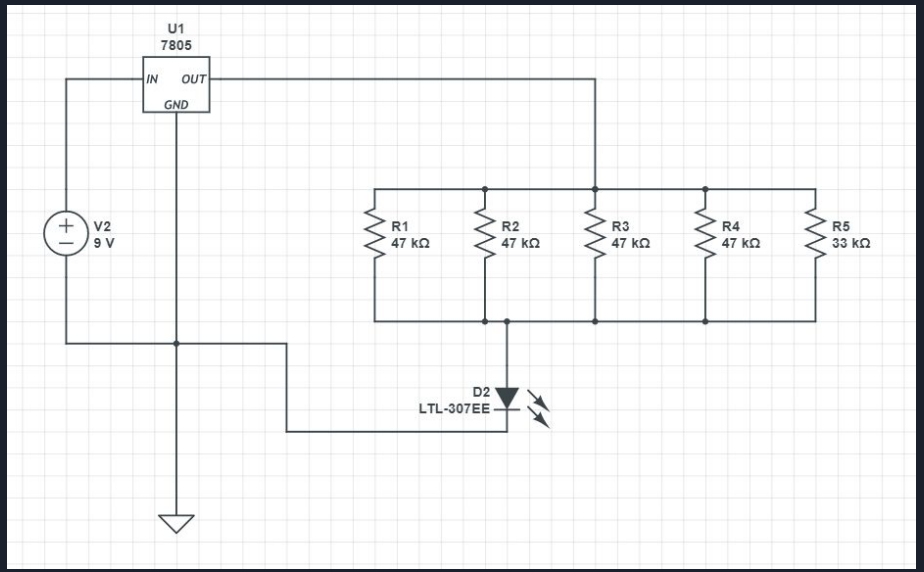
Block Diagram



Power Unit

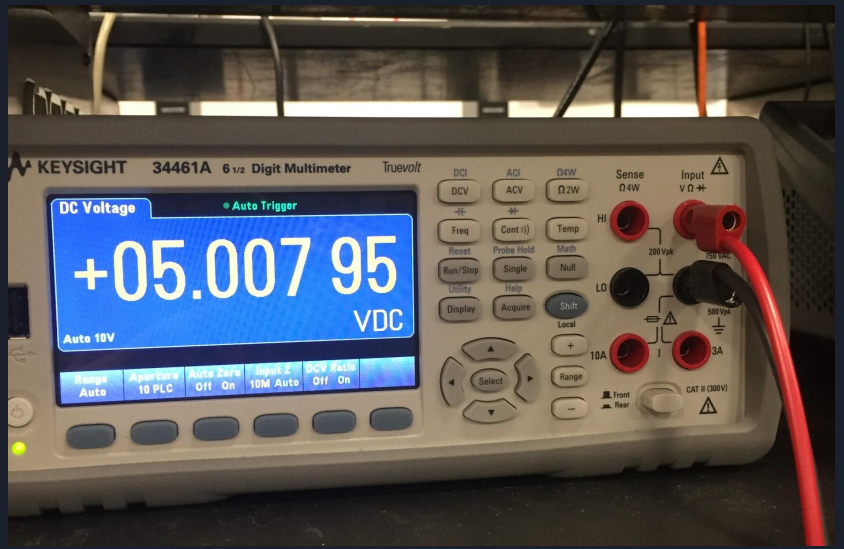
Battery

Time (minutes)	LED on?
0	Yes
5	Yes
10	Yes
15	Yes
20	Yes
25	Yes
30	Yes



DC-DC Buck Converter

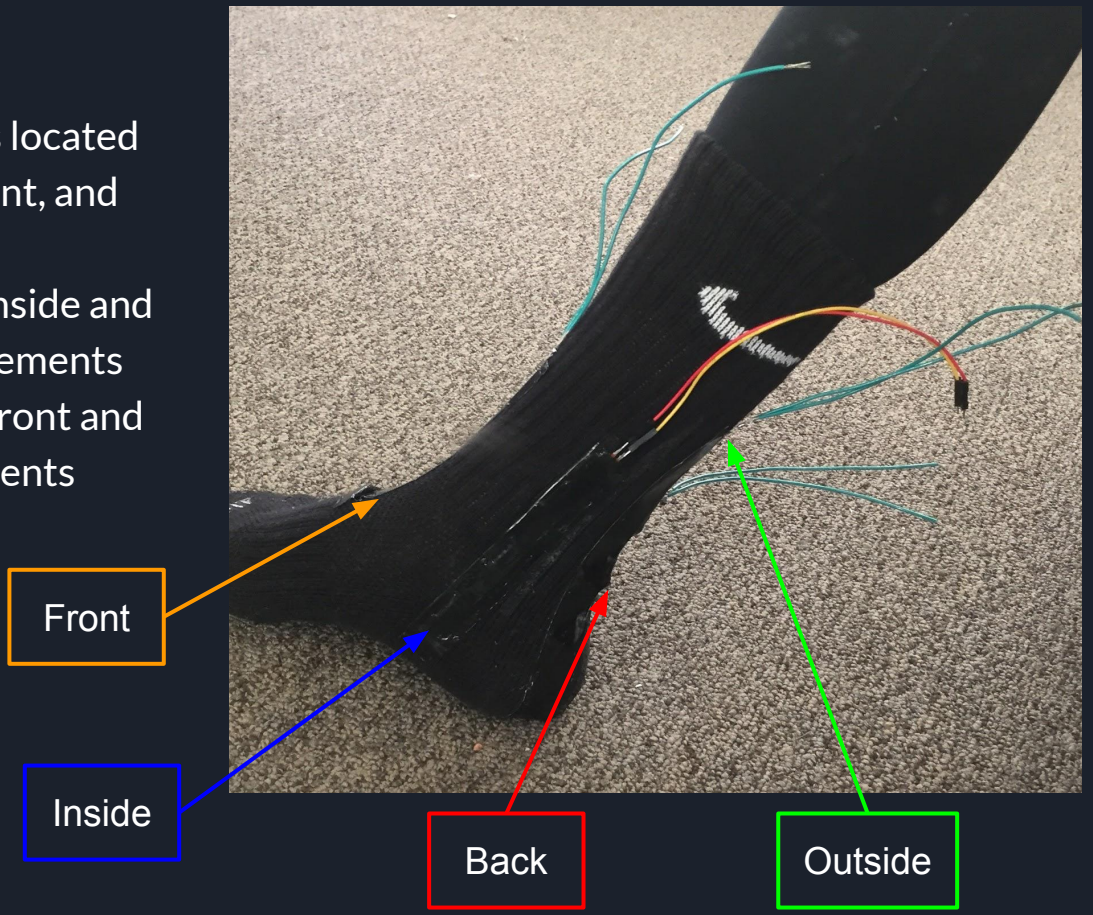
- Vmax: 5 + 5(0.05) = 5.25 V
- Vmin: 5 - 5(0.05) = 4.75 V
- 5.00795 V → within 5% of 5V DC output



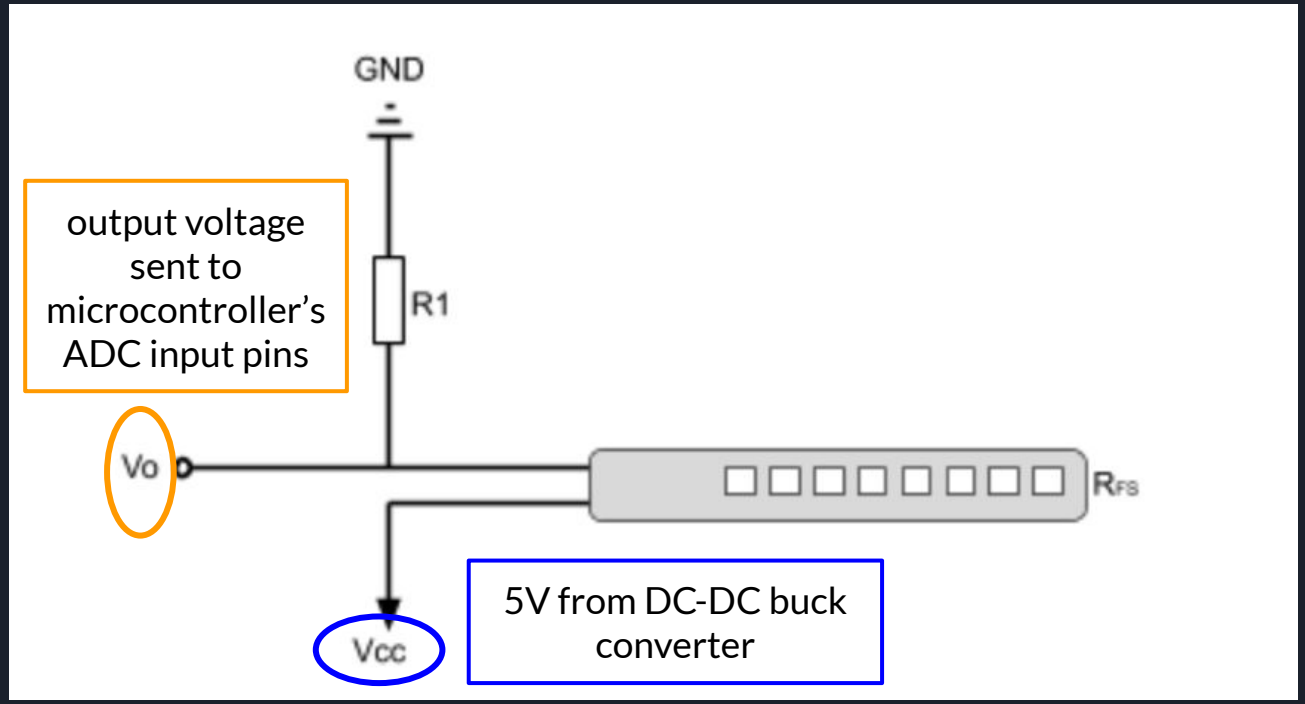
Signal Collection Unit

Flex Sensors

- Four 4.5” flex sensors located on inside, outside, front, and back of ankle
  - Frontal Plane: inside and outside measurements
  - Sagittal Plane: front and back measurements



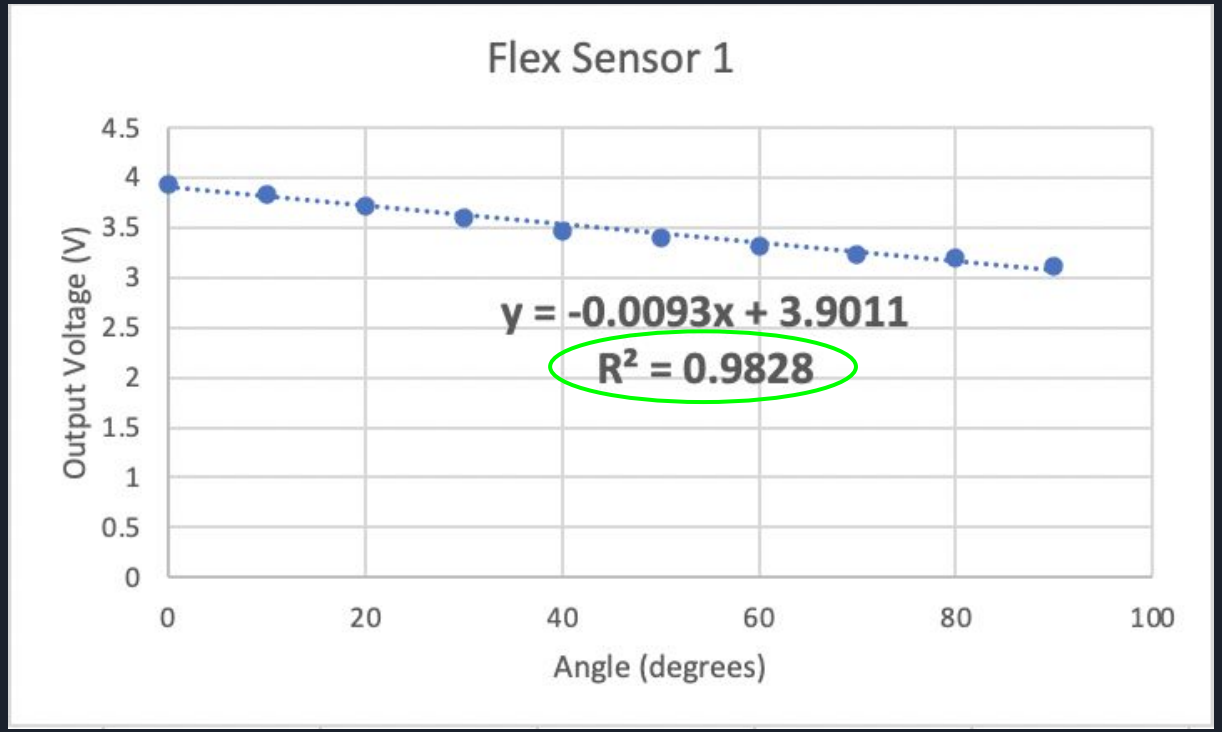
Flex Sensor Configuration



Flex Sensor Measurements

Angle	V_o (V) – trial #1	V_o (V) – trial #2	Average V_o (V)
0°	3.88	4.00	3.94
10°	3.73	3.95	3.84
20°	3.62	3.82	3.72
30°	3.56	3.65	3.605
40°	3.43	3.51	3.47
50°	3.35	3.44	3.395
60°	3.26	3.38	3.32
70°	3.16	3.31	3.235
80°	3.12	3.26	3.19
90°	3.04	3.19	3.115

Flex Sensor Bend Angle vs Output Voltage

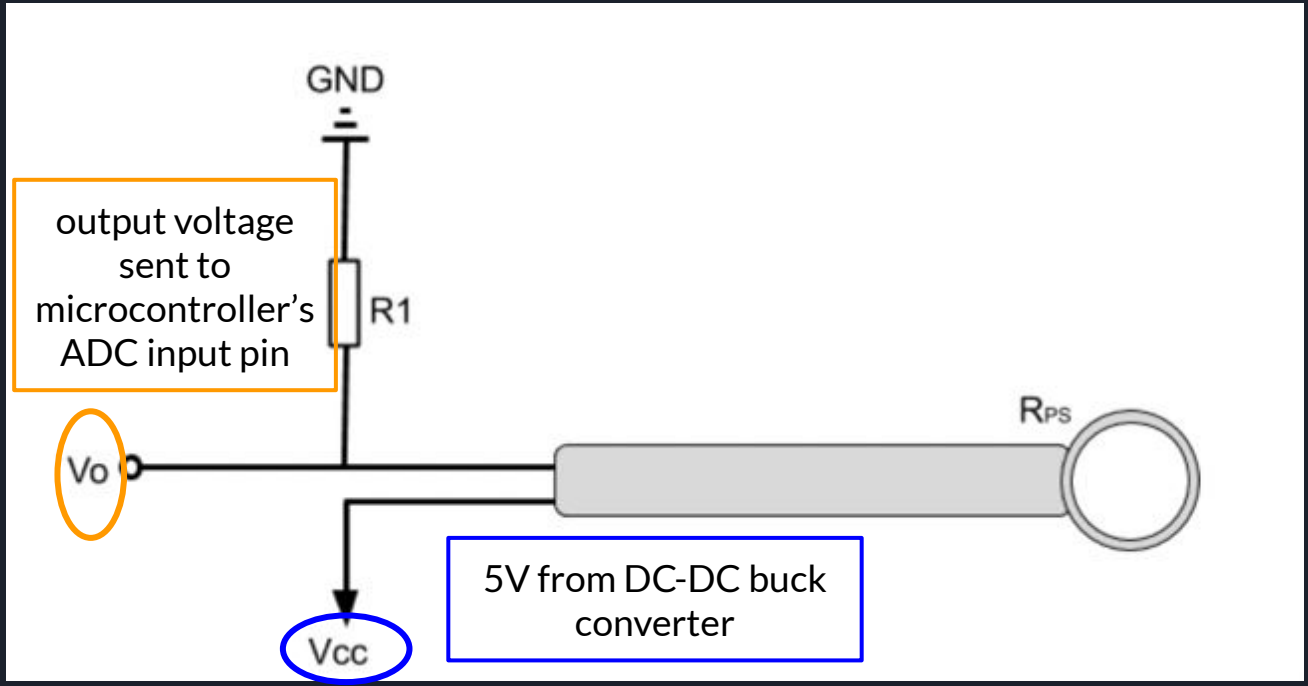


98.28% > 90%

Pressure Sensor

- One pressure sensor located under the heel of the foot
  - Can measure up to 100 pounds
  - Useful for detecting jumps and landings

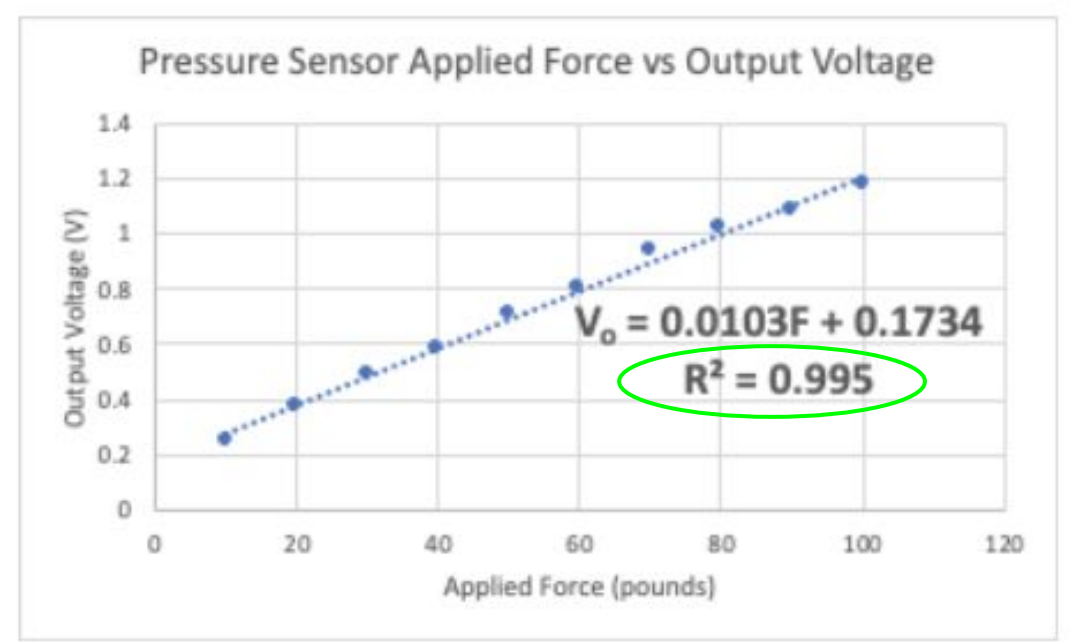
Pressure Sensor Configuration



Pressure Sensor Measurements

Force (pounds)	V_o (V) – trial #1	V_o (V) – trial #2	Average V_o
10	0.265	0.242	0.2535
20	0.378	0.365	0.3715
30	0.530	0.451	0.4905
40	0.624	0.536	0.5800
50	0.737	0.687	0.7120
60	0.854	0.755	0.8045
70	0.940	0.928	0.9340
80	1.024	1.009	1.0165
90	1.092	1.071	1.0815
100	1.225	1.127	1.1760

Pressure Sensor Force vs Output Voltage



99.5% > 90%

Microcontroller

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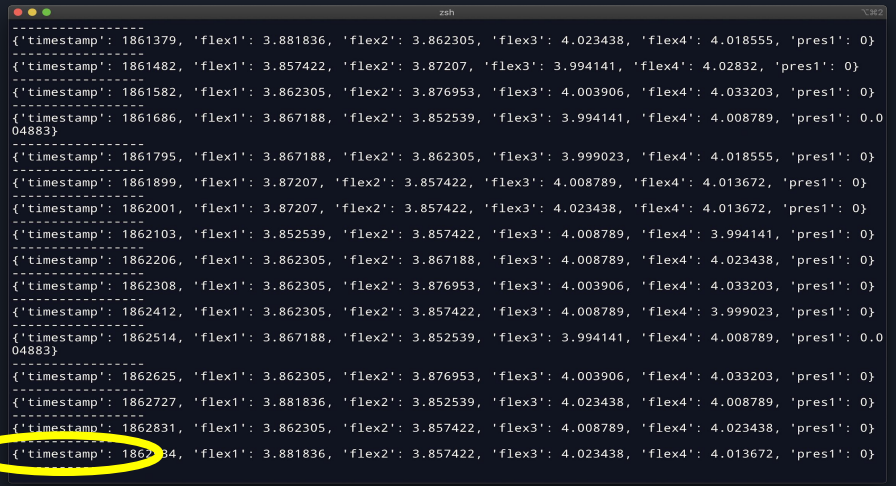
Bluetooth Transmitter

Distance (feet)	Communicating?
0	Yes
5	Yes
10	Yes
15	Yes
20	Yes
25	Yes
30	Yes

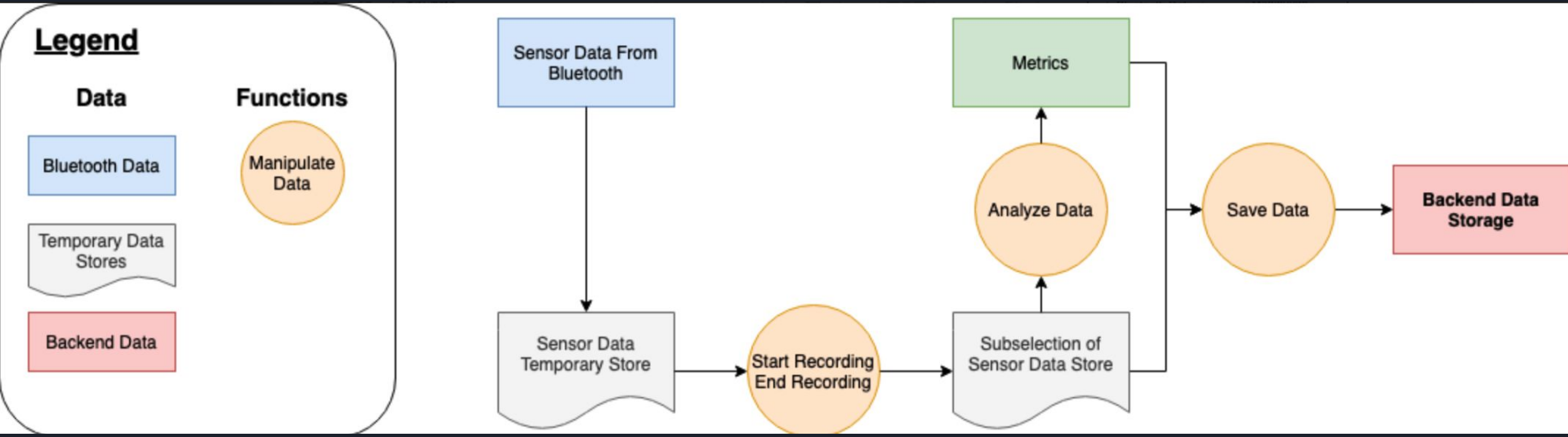
Table 7: Bluetooth Transmitter Test Results

Time Elapsed = 1,862,934 ms = 1,862.934 s =31.0489 minutes

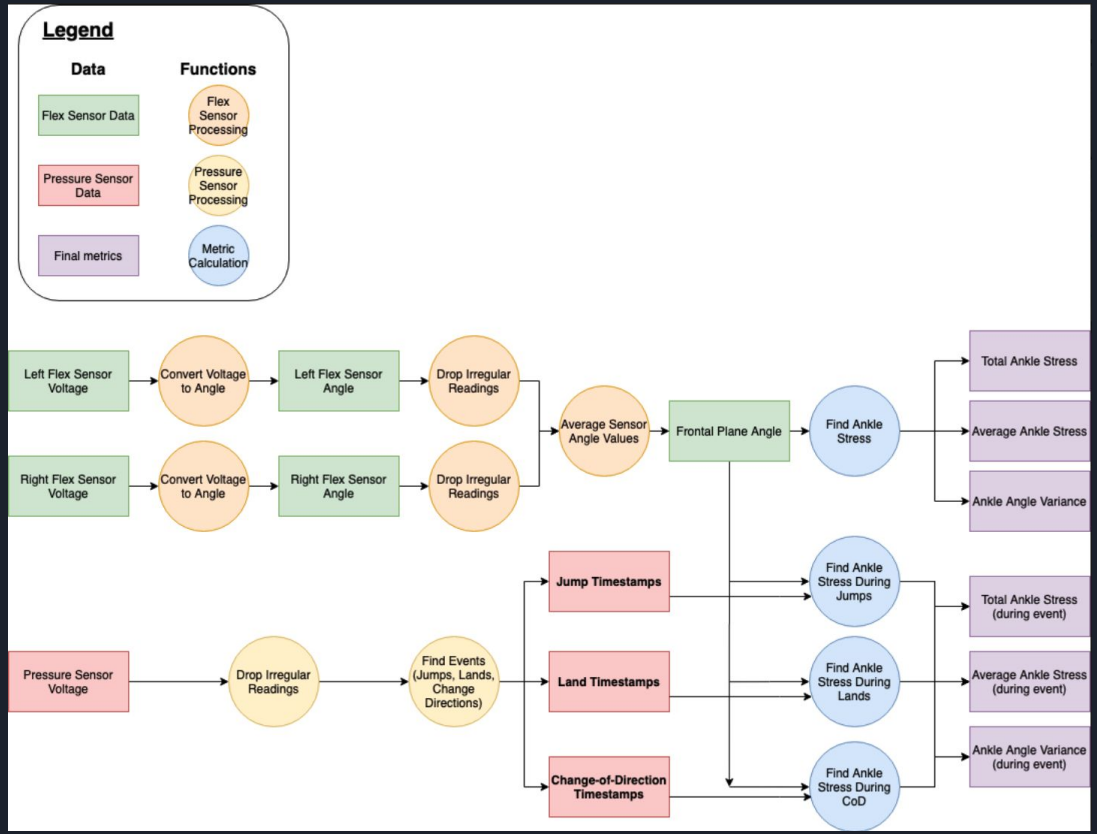


Signal Processing Unit

Software Data Flow



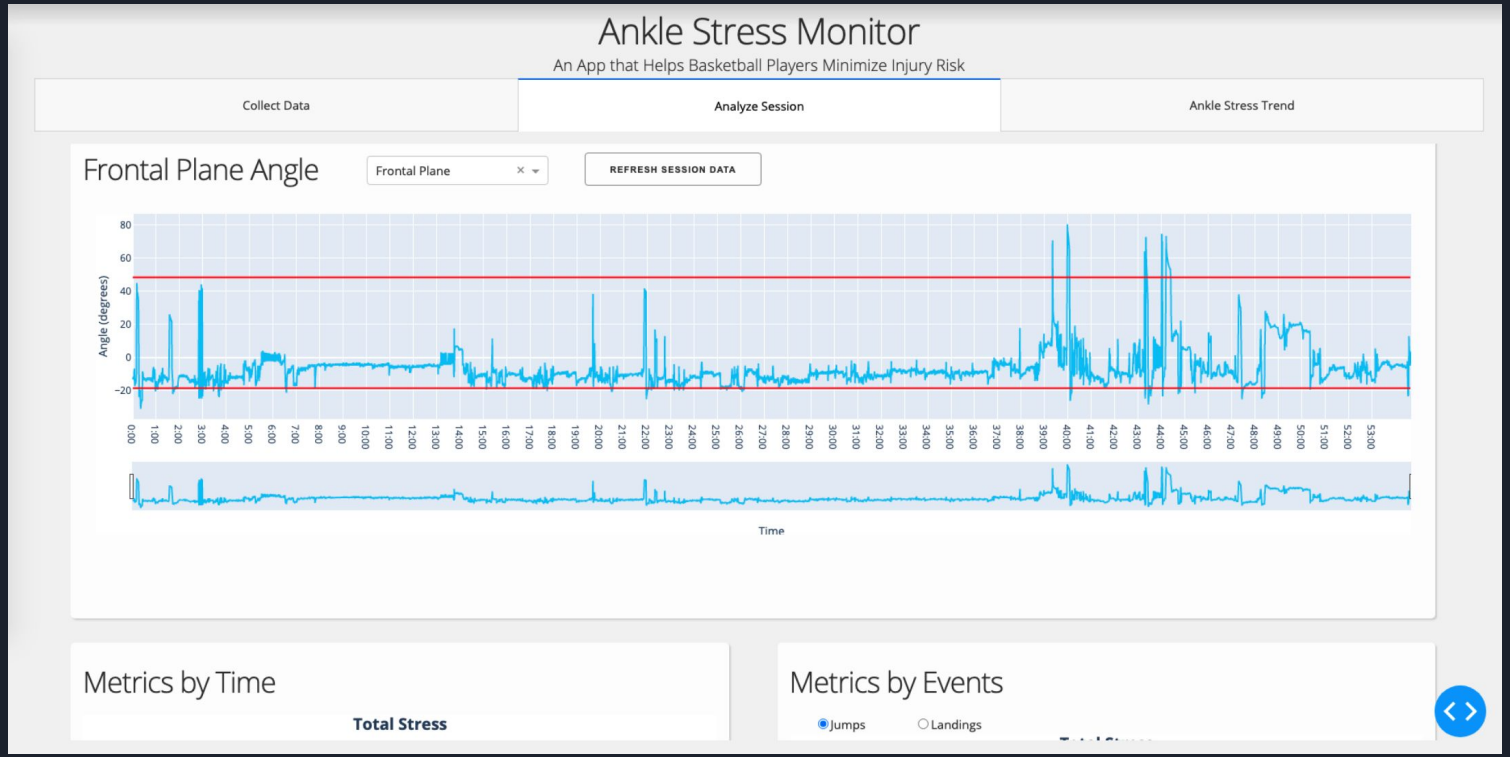
Process Raw Data into Metrics



User Interface

Collect Session Data

Analyze Session Data



Analyze Session Data

Conclusions

- Successful integration of hardware and software modules through Bluetooth
- Ability to represent ankle angles and relative stress levels in both the sagittal and frontal plane

- Key questions our product answers for players/coaches
  - Is a player more injury prone when they are fatigued?
  - Are a player's jump and landing mechanics sustainable?
  - Should we cut back on a player's playing time to reduce injury risk?
  - When a player plays more aggressive, are they more likely to be injured?
  - How important is it to do ankle warm ups? Does it increase ankle ROM?

Improvements & Taking Project Further

- Configure additional sensors to measure full ROM
- Make packaging more compact
- Show comparison data on user interface
- Store user data on backend
- Create a more general solution for all sports

Thank You For Listening!

- Any Questions?