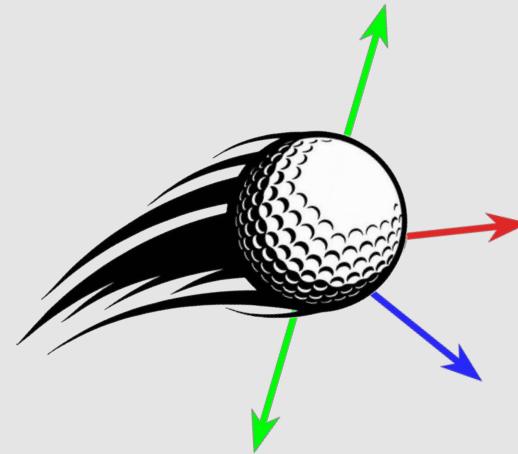
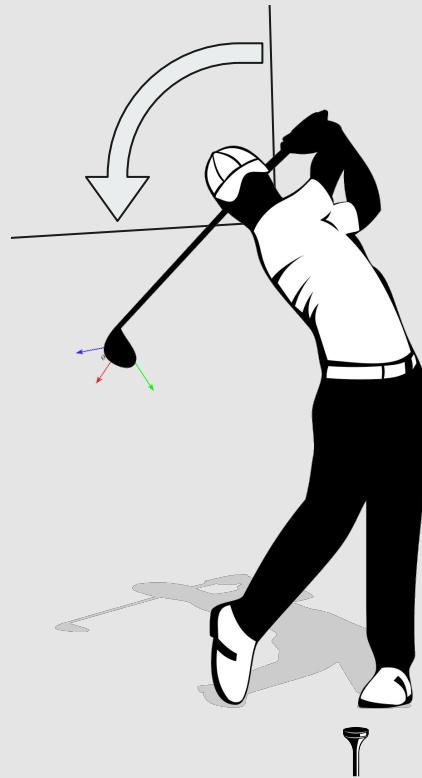




MISSISSIPPI STATE  
UNIVERSITY™

# Golf Glove



# Team

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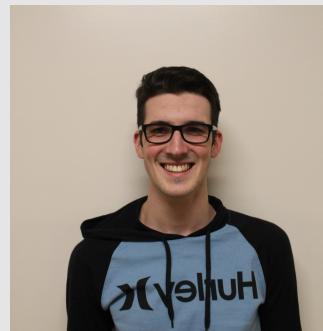
**Christian Bush**  
Computer Engineering  
Software



**Spencer Callicott**  
Computer Engineering  
Firmware



**Will Carroll**  
Computer Engineering  
Firmware



**Landon Casey**  
Computer Engineering  
Hardware



**Jack Fletcher**  
Computer Engineering  
Software

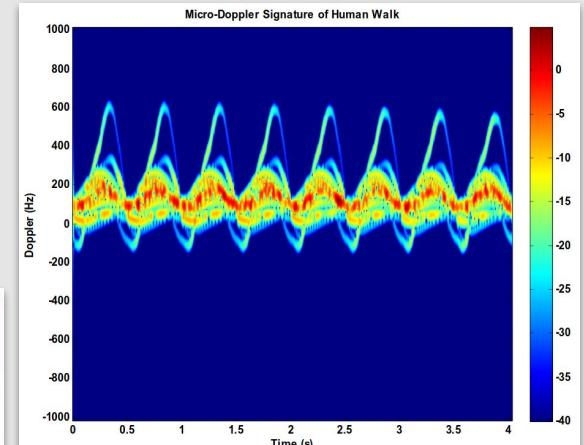
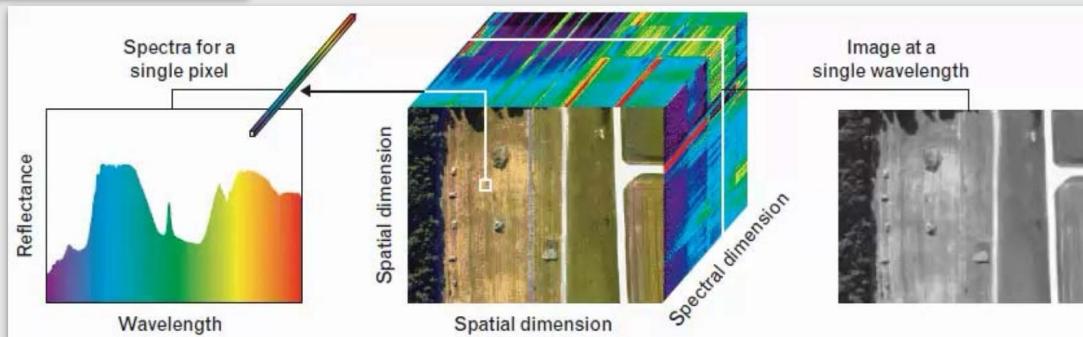
# Advisor



Dr. John E. Ball

PhD, Electrical Engineering, Mississippi State University, 2007  
MS, Electrical Engineering, Georgia Institute of Technology, 1993

- Radar Systems
- Digital Signal Processing
- Digital Image Processing
- Remote Sensing
- Automated Target Detection



[1]



# Presentation Outline

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Problem

Solution

System Overview

Constraints

Subsystem Testing

Integrated System Testing

Progress and Timeline

# Problem Statement

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Amateur Golf  
failures [2]



Modern golf coaching  
technology [3]



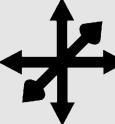
Next-generation  
coaching application [4]



# Solution

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-  Accelerometer measures hand and club velocity through the swing
-  User friendly application to give intelligent swing feedback.
-  Gyroscopes track hand and club orientation through the swing.
-  BLE provides wireless transfer of coaching data.
-  On board battery allows for hours of runtime



# Technical Constraints

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Name	Description
Hand Orientation	Wrist flexion, extension, and deviation within <b>3°</b> . Wrist acceleration, hand orientation, and hand acceleration within <b>5%</b> .
Wireless Communication	Communicate Wirelessly <b>&gt;30 feet</b> .
Data Display	Simple visual application that supports <b>120 Hz data rate</b> .
Unobtrusive	Footprint <b>&lt;3 inches</b> . Wires must not interfere with swing motion.
Portability	Battery life <b>&gt;5 hours</b> .

# Practical Constraints

Name	Description
Manufacturability	Modular garment and wrist controller.
Environmental	The glove must be IP54 water and dust resistant.



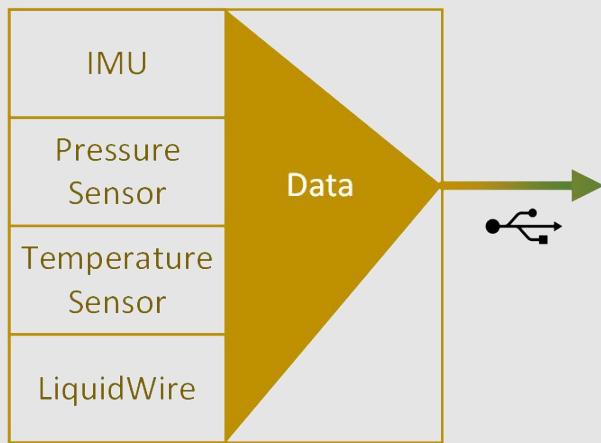
Modular/Replaceable  
parts [13]



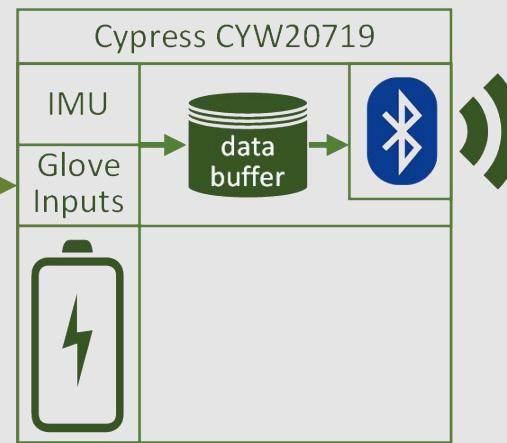
Ingress Protection  
Level 54 [14]

# System Overview

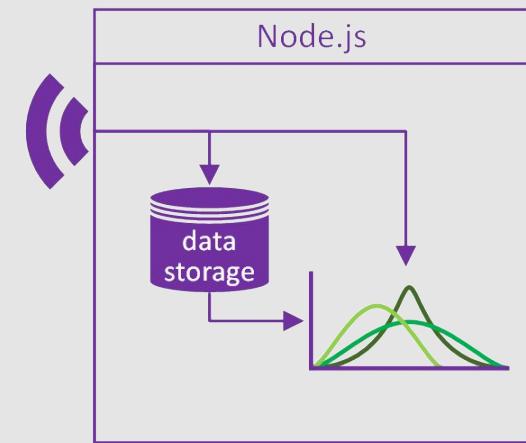
Glove



Wrist Controller



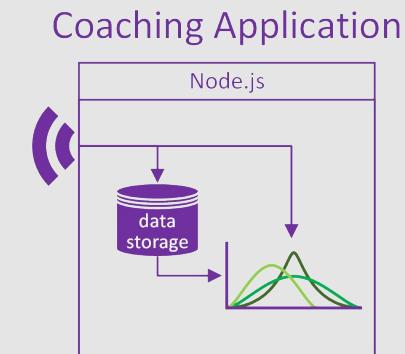
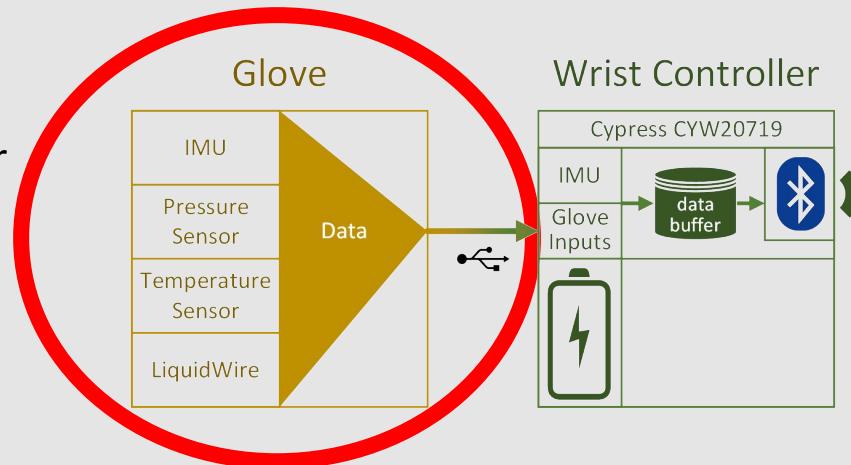
Coaching Application



# Sensor Subsystem

## Sensors

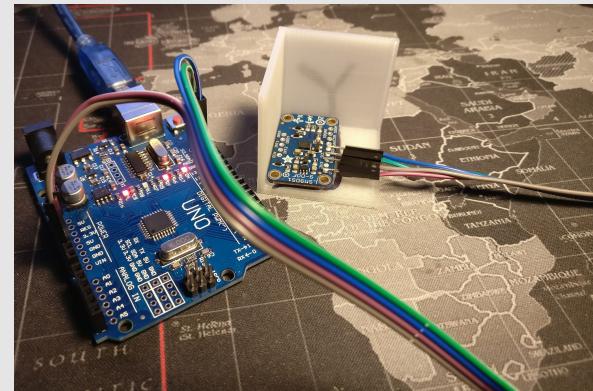
1. Accelerometer
2. Gyroscope
3. Pressure Sensor
4. Liquid Wire



# Sensor Subsystem - Accelerometer

Test	Xexp (m/s <sup>2</sup> )	Yexp	Zexp	Xact (% err)	Yact	Zact
X-Axis	9.8	0	0	<b>10.050 (2.5%)</b>	0.106	0.374
Y-Axis	0	9.8	0	0.167	<b>9.786 (0.14%)</b>	0.894
Z-Axis	0	0	9.8	0.668	0.159	<b>10.135 (3.4%)</b>

Resting on each axis, measuring acceleration due to gravity.





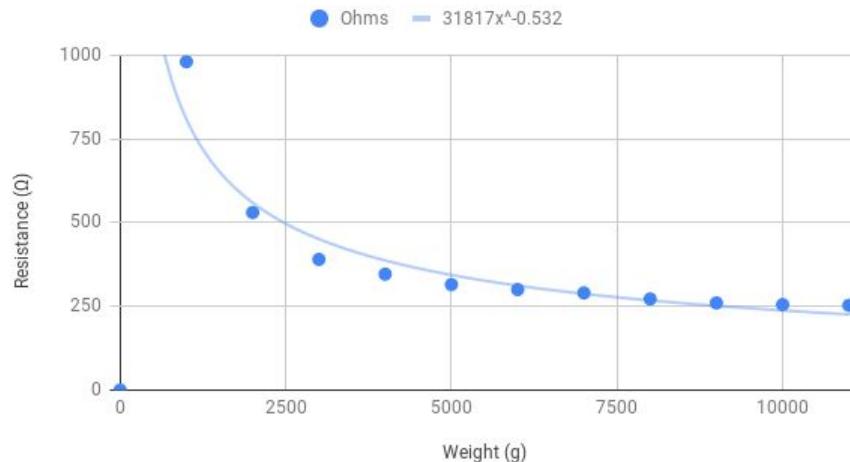
# Sensor Subsystem - Gyroscope

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Test	Xexp (dps)	Yexp	Zexp	Xact	Yact	Zact
X-axis	104.65	0	0	<b>102.417 (2.13%)</b>	0.300	0.264
Y-axis	0	104.65	0	5.101	<b>101.726 (2.79%)</b>	6.70
Z-axis	0	0	104.65	0.002	3.025	<b>103.129 (1.45%)</b>

90 degree movement from stepper motor over 860 ms.

# Sensor Subsystem - Pressure Sensor

Weight (g) vs Resistance ( $\Omega$ )

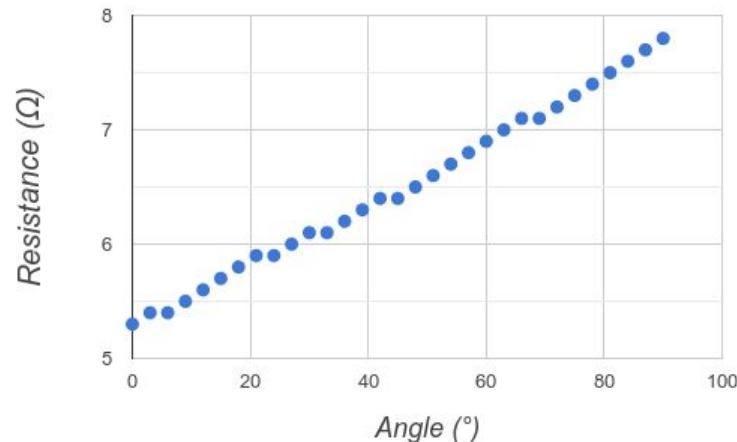
Weight (g)	Measured ( $\Omega$ )
0	$\infty$
1000	980
2000	530
3000	390
4000	346
5000	315
6000	300
7000	290
8000	272
9000	260
10000	255
11000	253

# Sensor Subsystem - LiquidWire

Angle (°)	Resistance (Ω)	Angle (°)	Resistance (Ω)
0	5.3	48	6.5
3	5.4	51	6.6
6	5.4	54	6.7
9	5.5	57	6.8
12	5.6	60	6.9
15	5.7	63	7
18	5.8	66	7.1
21	5.9	69	7.1
24	5.9	72	7.2
27	6	75	7.3
30	6.1	78	7.4
33	6.1	81	7.5
36	6.2	84	7.6
39	6.3	87	7.7
42	6.4	90	7.8
45	6.4		

$\Delta\text{Resistance} (\Omega) \text{ from } 0^\circ \text{ to } 90^\circ = 2.5 \Omega$   
 $\Rightarrow \text{Angle (°)} = 0.0278 \times \text{Resistance} (\Omega)$

**Angle vs. Resistance**



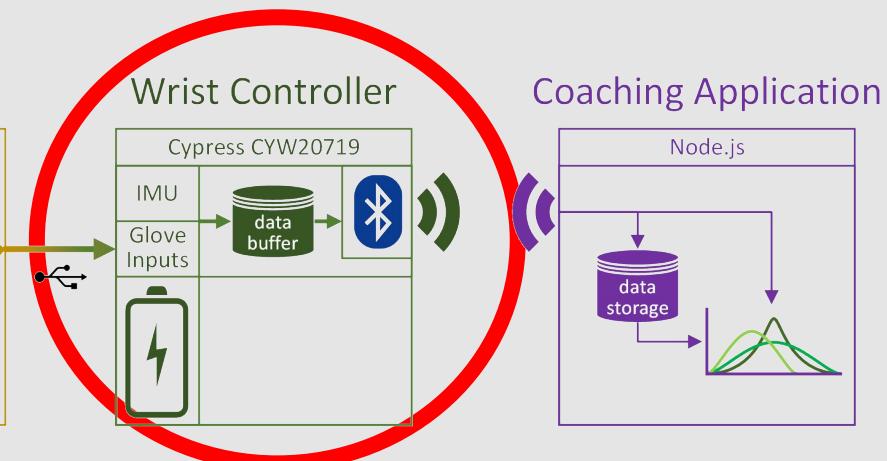
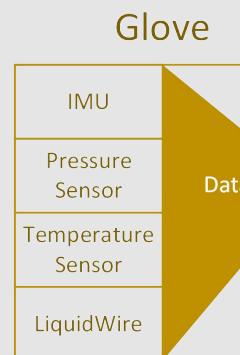
# Wrist Controller Subsystem

## Wrist-mounted Microcontroller

Battery

Sensor Polling

Bluetooth Broadcast





# Wrist Controller Subsystem - Sensor Polling

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Test	Expected	Actual
Total # of Readings in 3 seconds	$\geq 360$ frames	4470 frames
Time to read 10000 sensor frames	$\leq 83.3$ sec	7 seconds

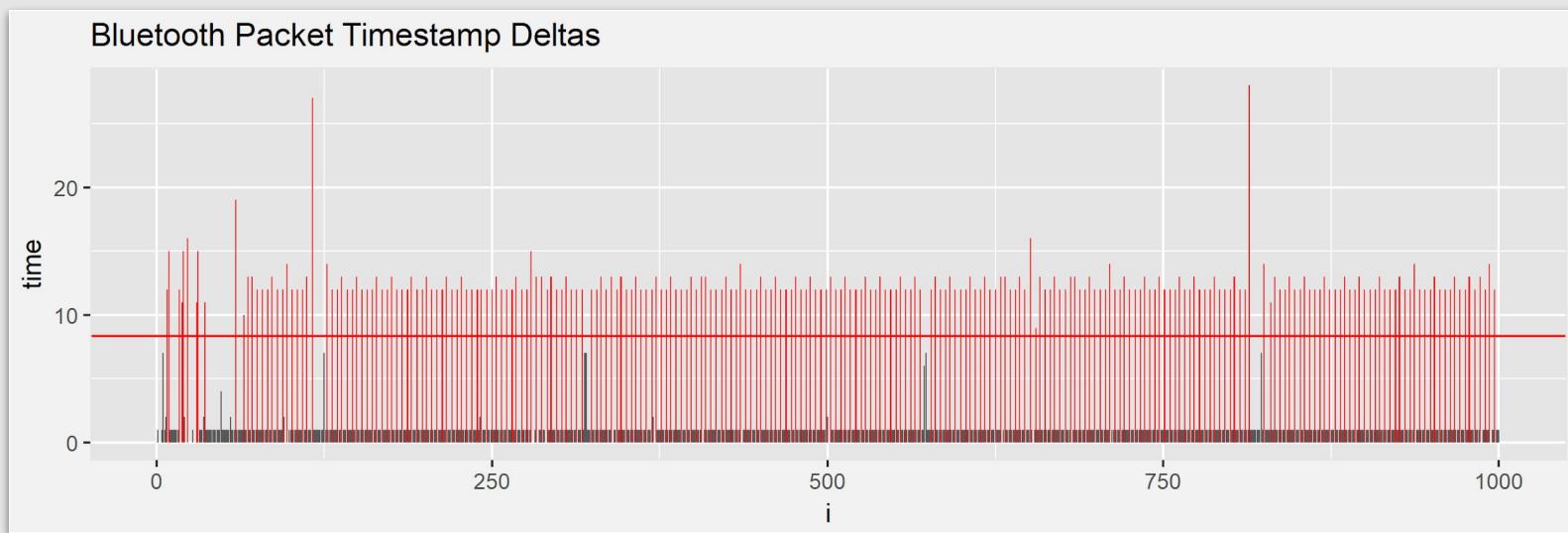
# Wrist Controller Subsystem - BLE Broadcast

Constraints:

**120 Hz** = 1 sample per 8.33ms

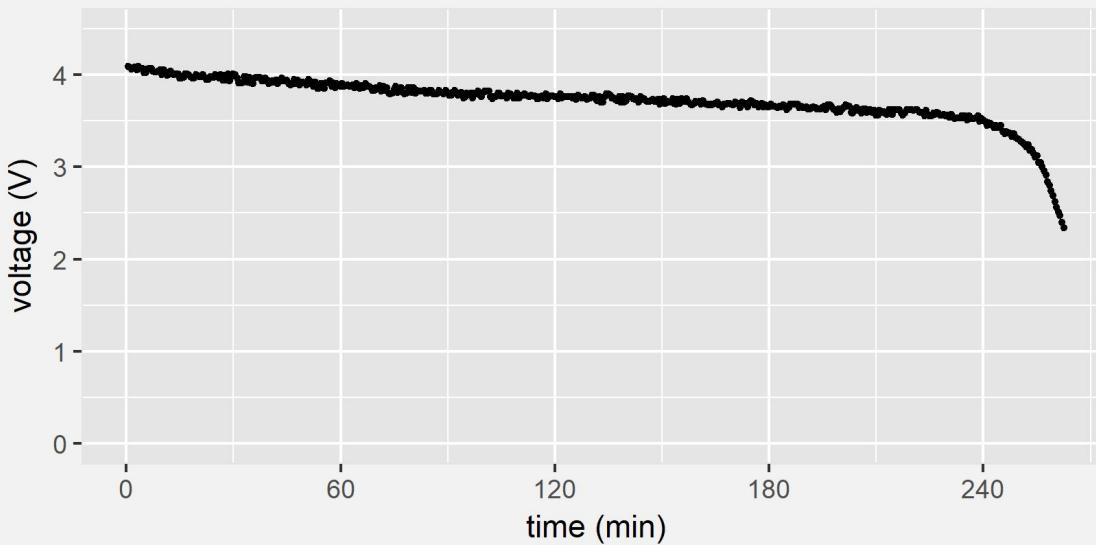
Conclusion:

Avg. Broadcast Speed: **125 Hz**



# Wrist Controller Subsystem - Battery

Battery Voltage vs. Time

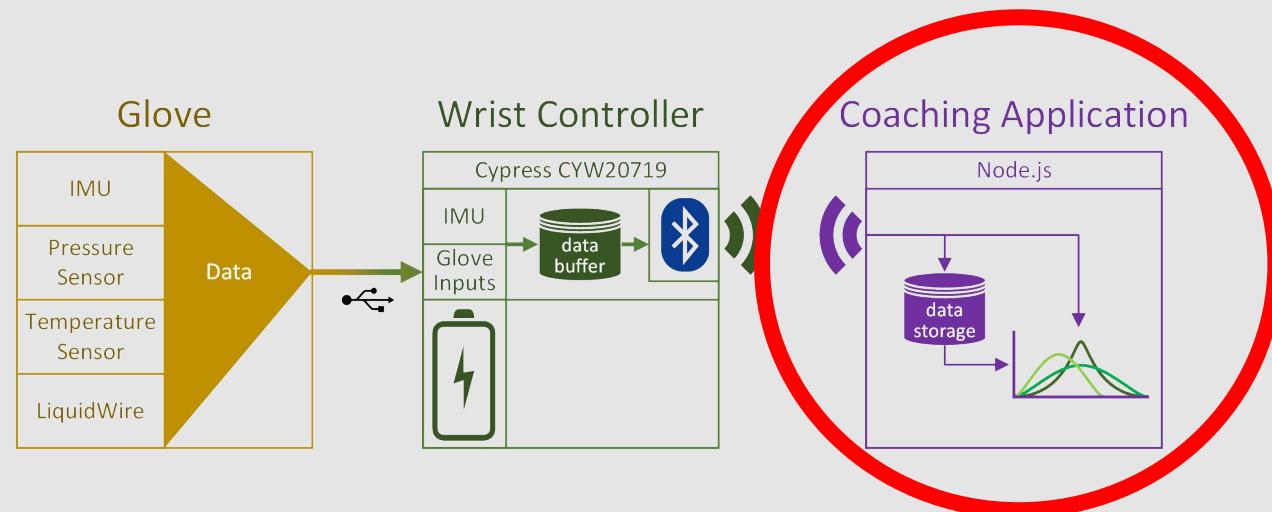


- Elapsed Time: 4.375 Hours
- Avg. Current Draw: .1032 A
- Capacity Utilized: 451.5 mAh
- \*Calculated Req. : 423.5 mAh
- % Difference: 6.61%

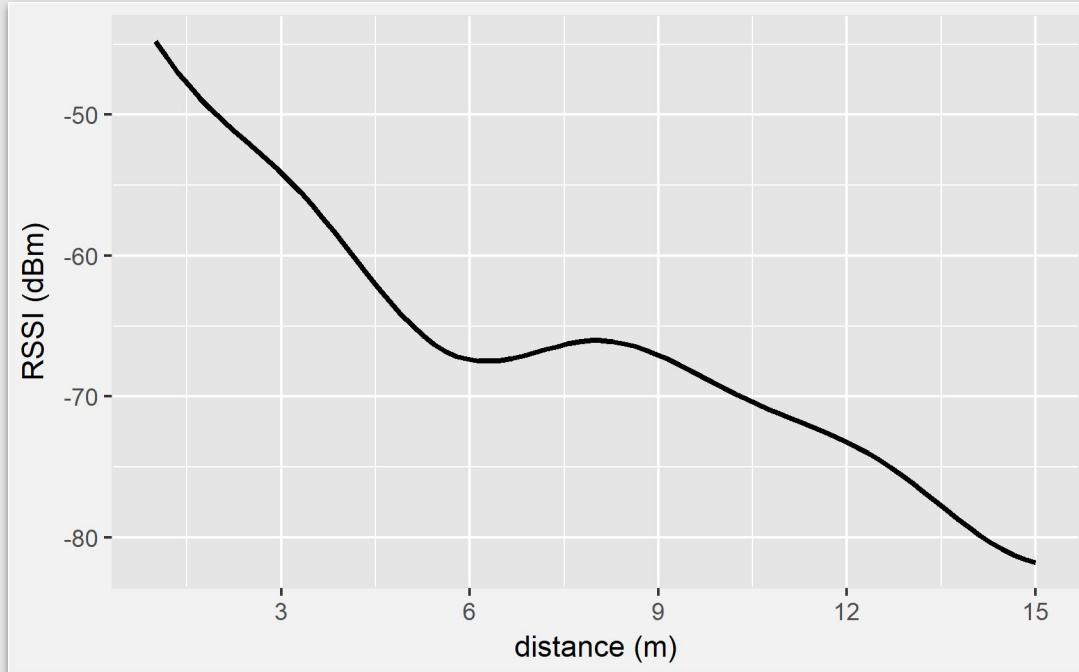
\*Calculated “Required Capacity” is minimum capacity to run device for 5 hours (.0847 Amp Draw)

# Coaching App Subsystem

1. Bluetooth Reception
2. Database
3. GUI



# Coaching App Subsystem - BLE Reception



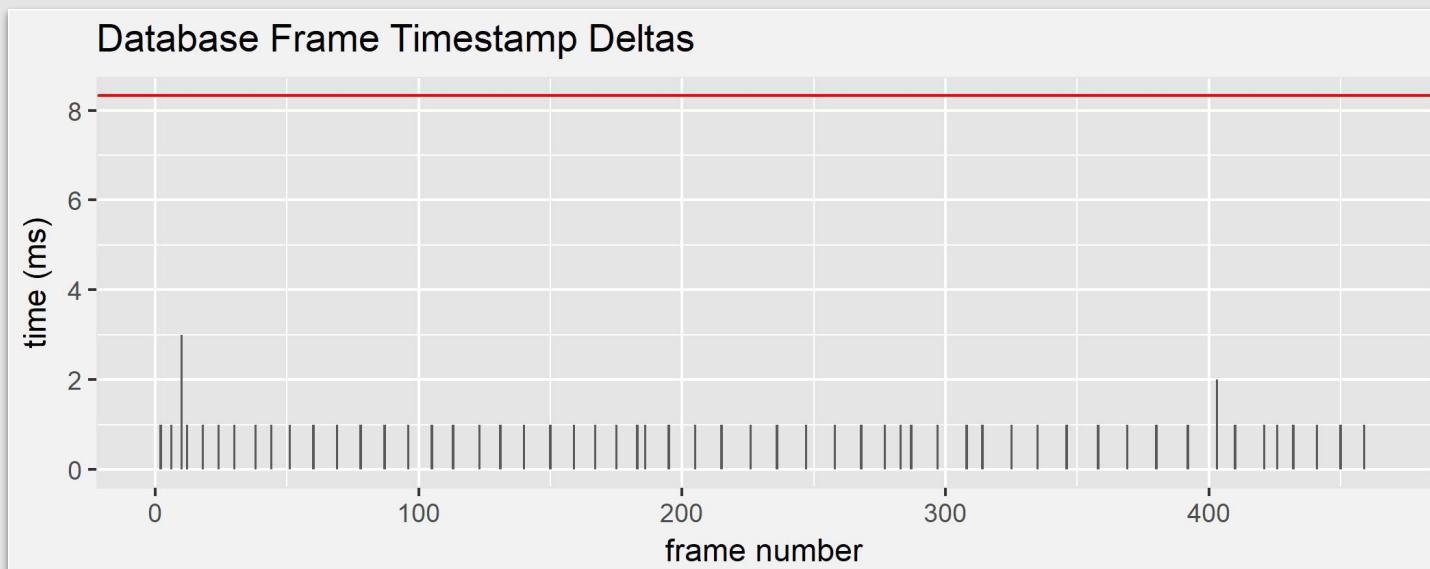
# Coaching App Subsystem - Database

**Constraints:**

**120 Hz** = 1 sample per 8.33ms

**Measured:**

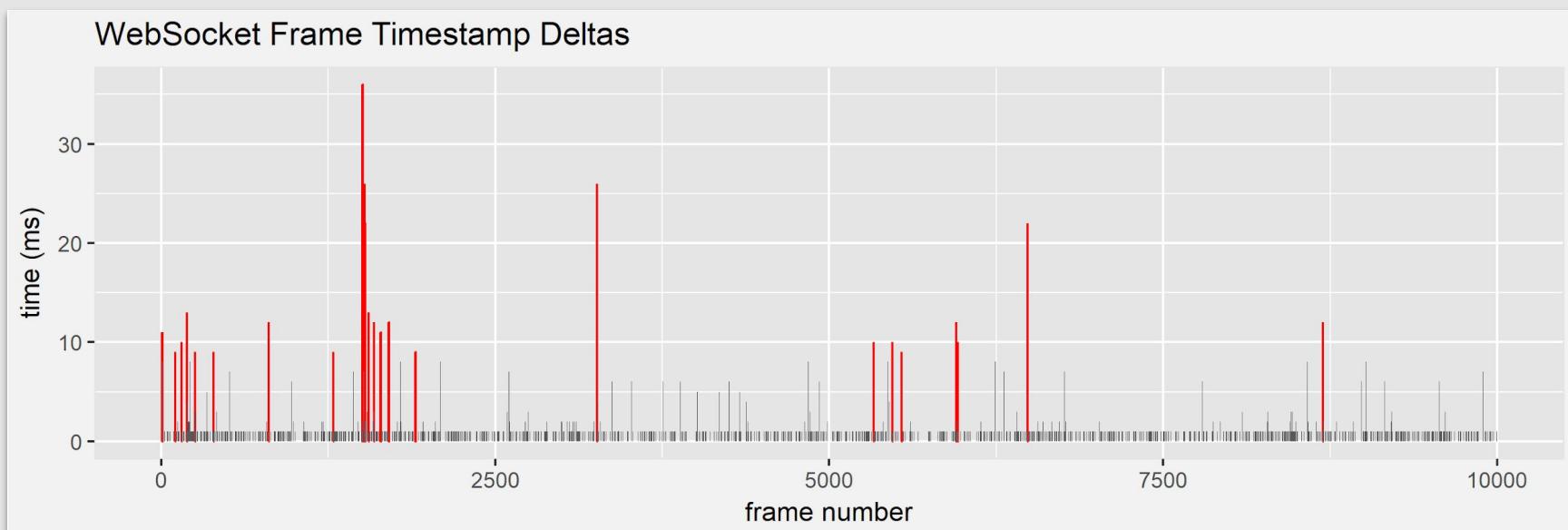
Average Write Speed: **1311 Hz**



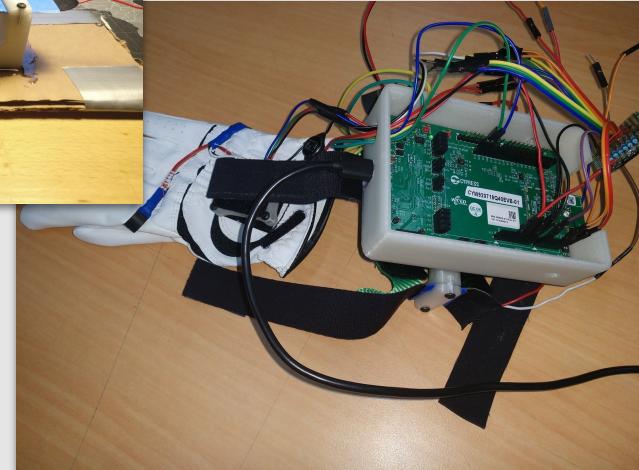
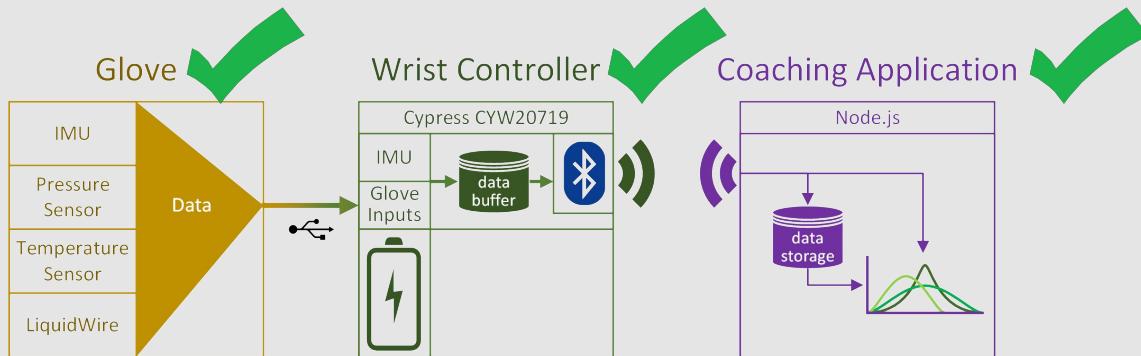
# Coaching App Subsystem - WebSocket Bandwidth

Constraint: **120 Hz**  
Measured: **1600 Hz**

```
> mean(df$time)  
[1] 0.6148
```



# Progress



# Todo

- Sensors

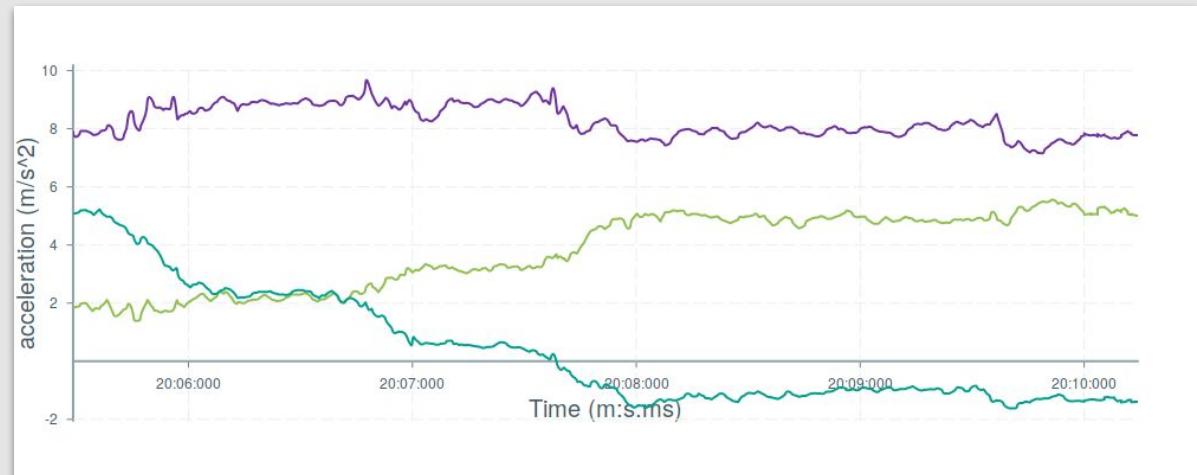
status in progress Calibration

- Wrist-mounted Microcontroller

status in progress Data Filtering

- Coaching Application

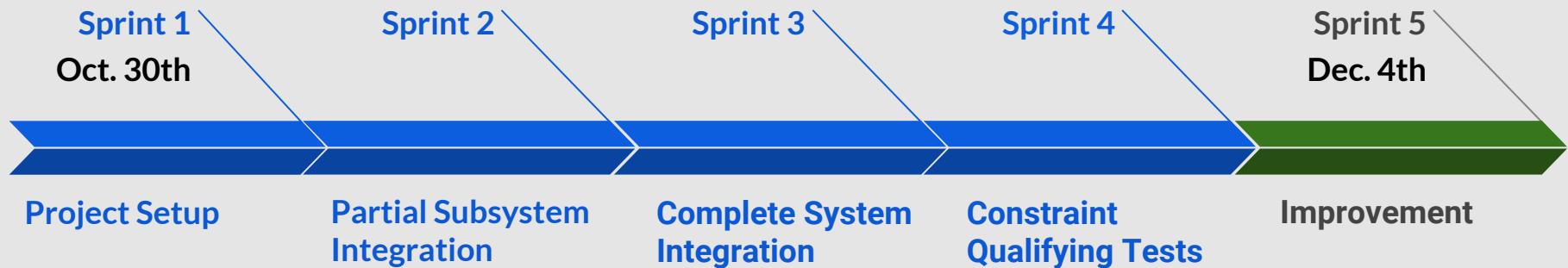
status in progress Improve UI/UX





# Timeline

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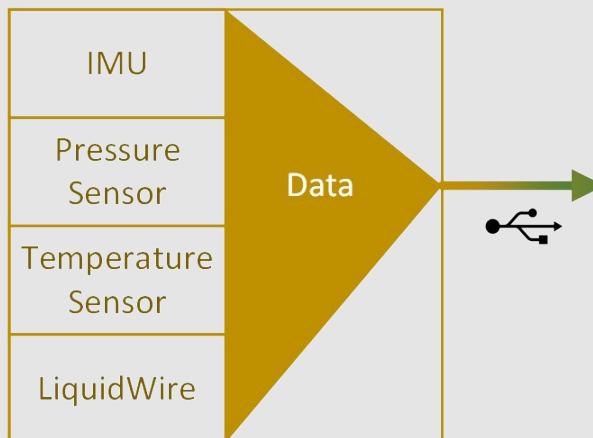
# References

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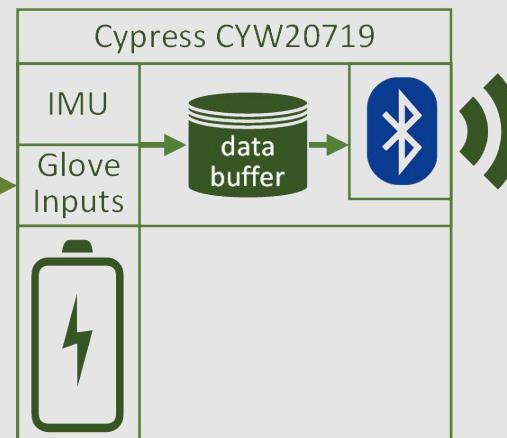
- [1] Introduction to DSP (2018).  
[https://mycourses.msstate.edu/bbcswebdav/pid-1559018-dt-content-rid-26818521\\_1/courses/jeb234.201830.Group01/Module\\_1.1\\_Introduction\\_Student.pdf](https://mycourses.msstate.edu/bbcswebdav/pid-1559018-dt-content-rid-26818521_1/courses/jeb234.201830.Group01/Module_1.1_Introduction_Student.pdf) [online].
- [2] Ebaum's World (2018). <http://cdn.ebaumsworld.com/mediaFiles/picture/604025/84404810.jpg>. [image].
- [3] Exos (2018). [https://www.teamexos.com/wp-content/uploads/2016/10/Hero\\_Capabilities\\_Golf.jpg](https://www.teamexos.com/wp-content/uploads/2016/10/Hero_Capabilities_Golf.jpg). [image].
- [4] Anadea (2018). [https://anadea.info/uploads/image\\_attachment/image/1123/xCoaching\\_app.jpg.pagespeed.ic.eLjZbd84p6.jpg](https://anadea.info/uploads/image_attachment/image/1123/xCoaching_app.jpg.pagespeed.ic.eLjZbd84p6.jpg) [image].

# System Overview

Glove



Wrist Controller



Coaching Application

