Footballytics

Electrical & Computer Engineering

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May 2, 2023

Objective

https://preview.thenewsmarket.com/Previews/ADID/StillAssets/320x320/618232.jpg

- Sports like soccer and basketball have incorporated for accurate referee calls

- Football scoring is still done by eye

- Goal is to incorporate location tracking and sensors into a football to improve accuracy

- Tracking system locating football within a given space within the length of a football (30 cm).

- The football is able to retrieve motion data from the 9-axis inertial measurement unit.

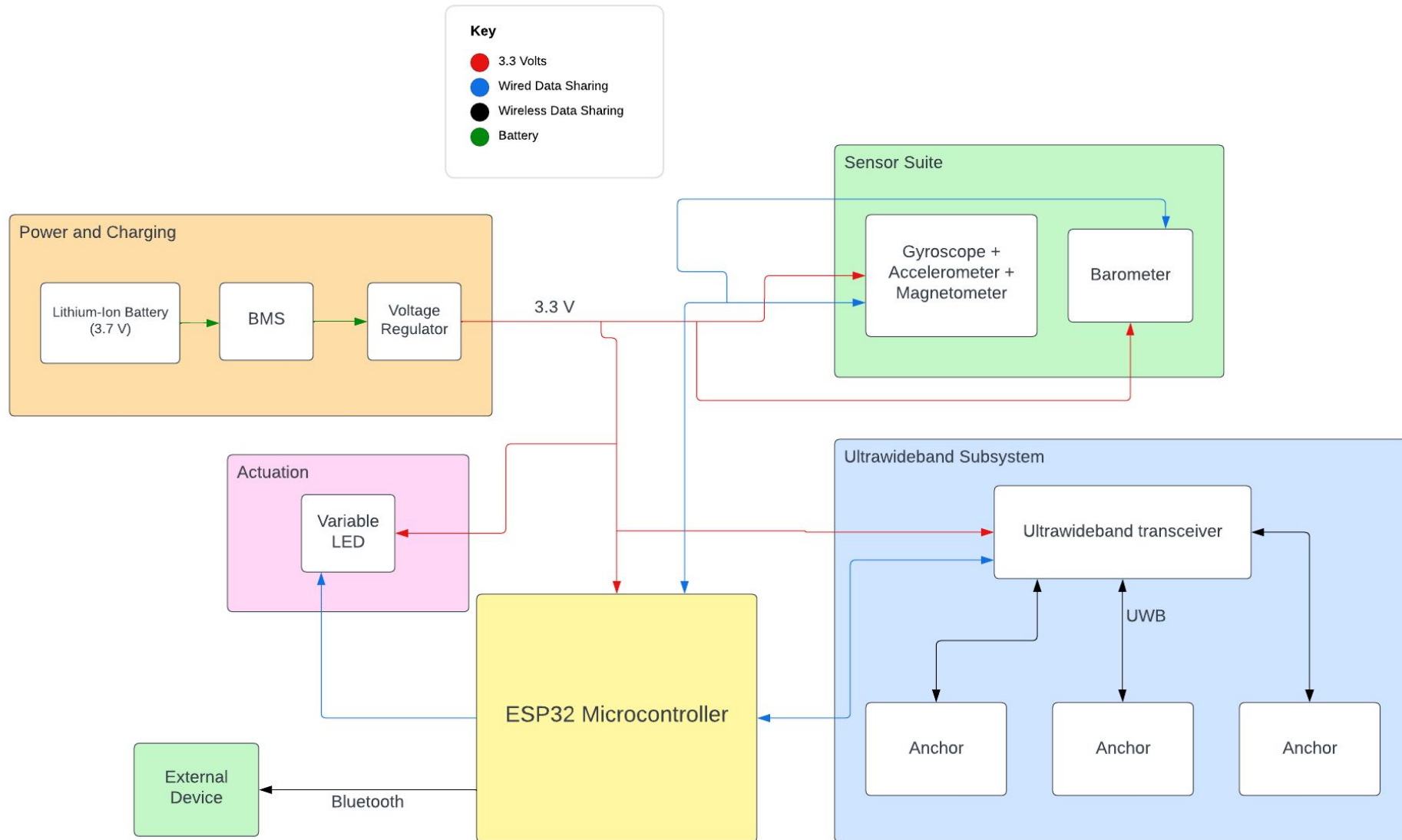- The air pressure of the football is measured and reported.
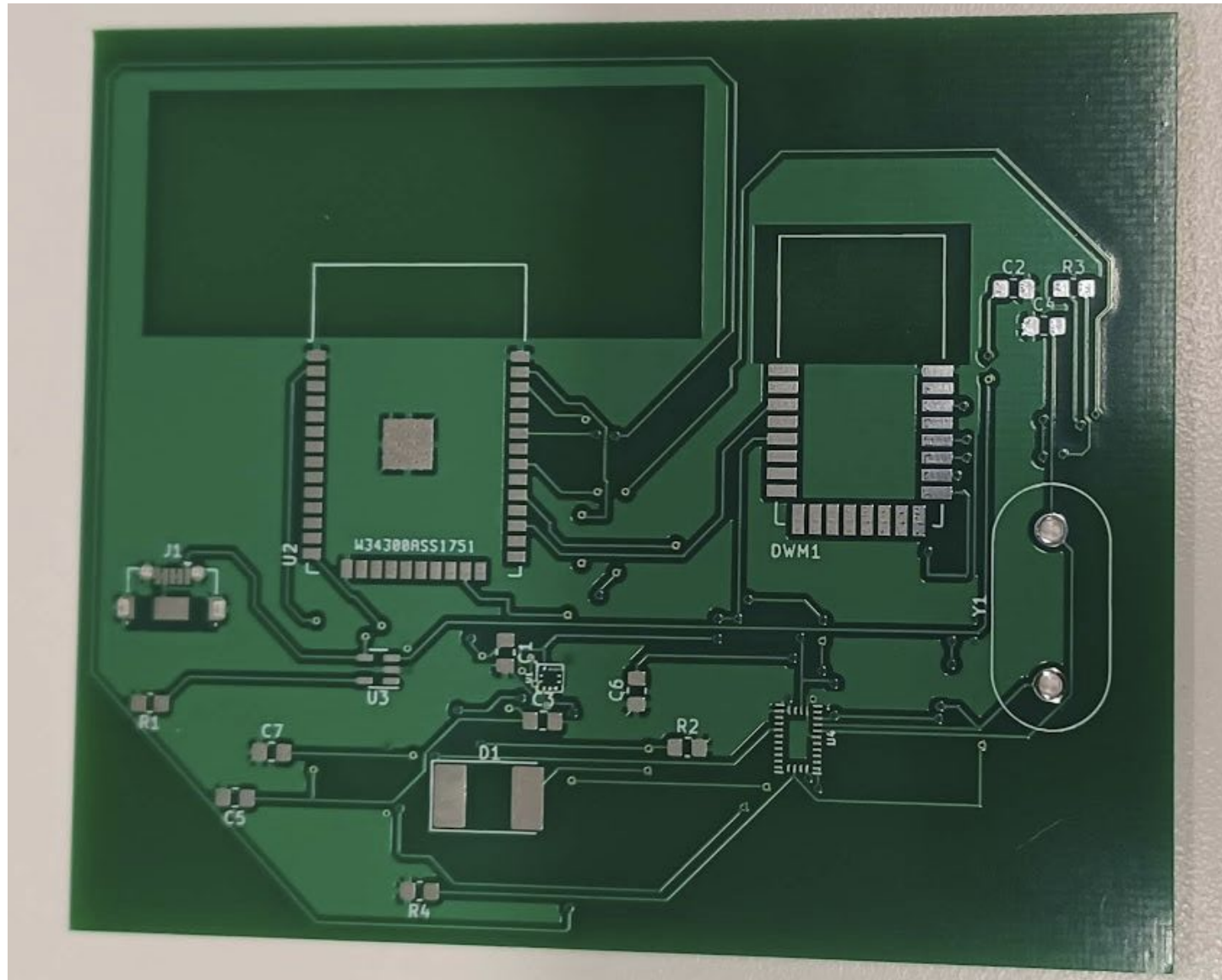
Design
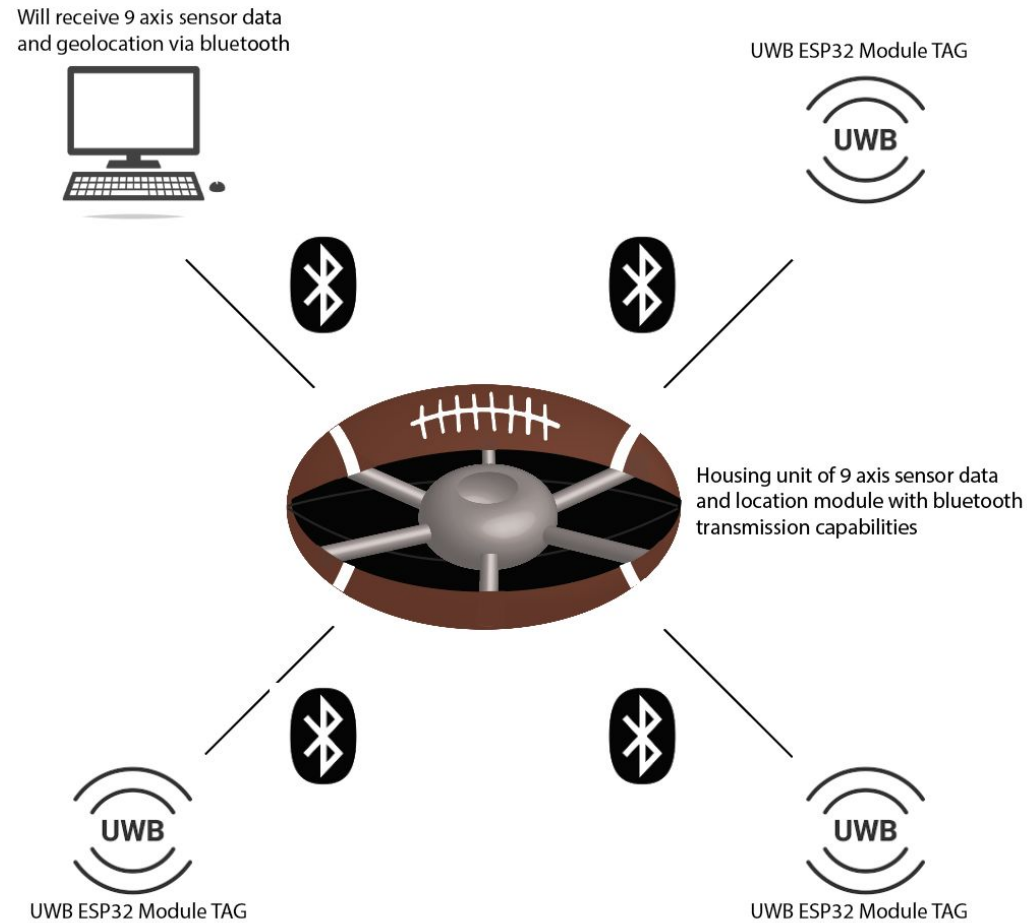
A PCB enclosed in the football, communicating with three anchors via ultra wideband to find its location, and then have that PCB send the location and sensor information to an external receiver via bluetooth.
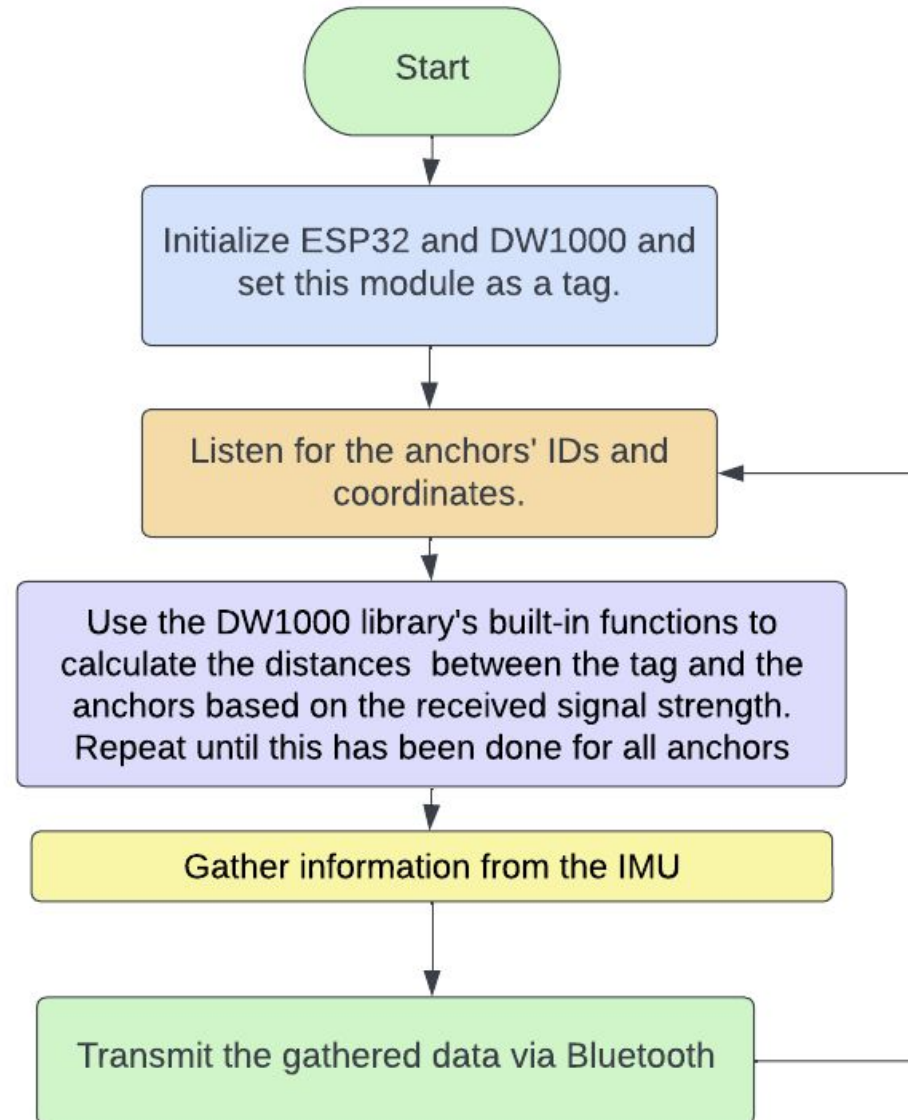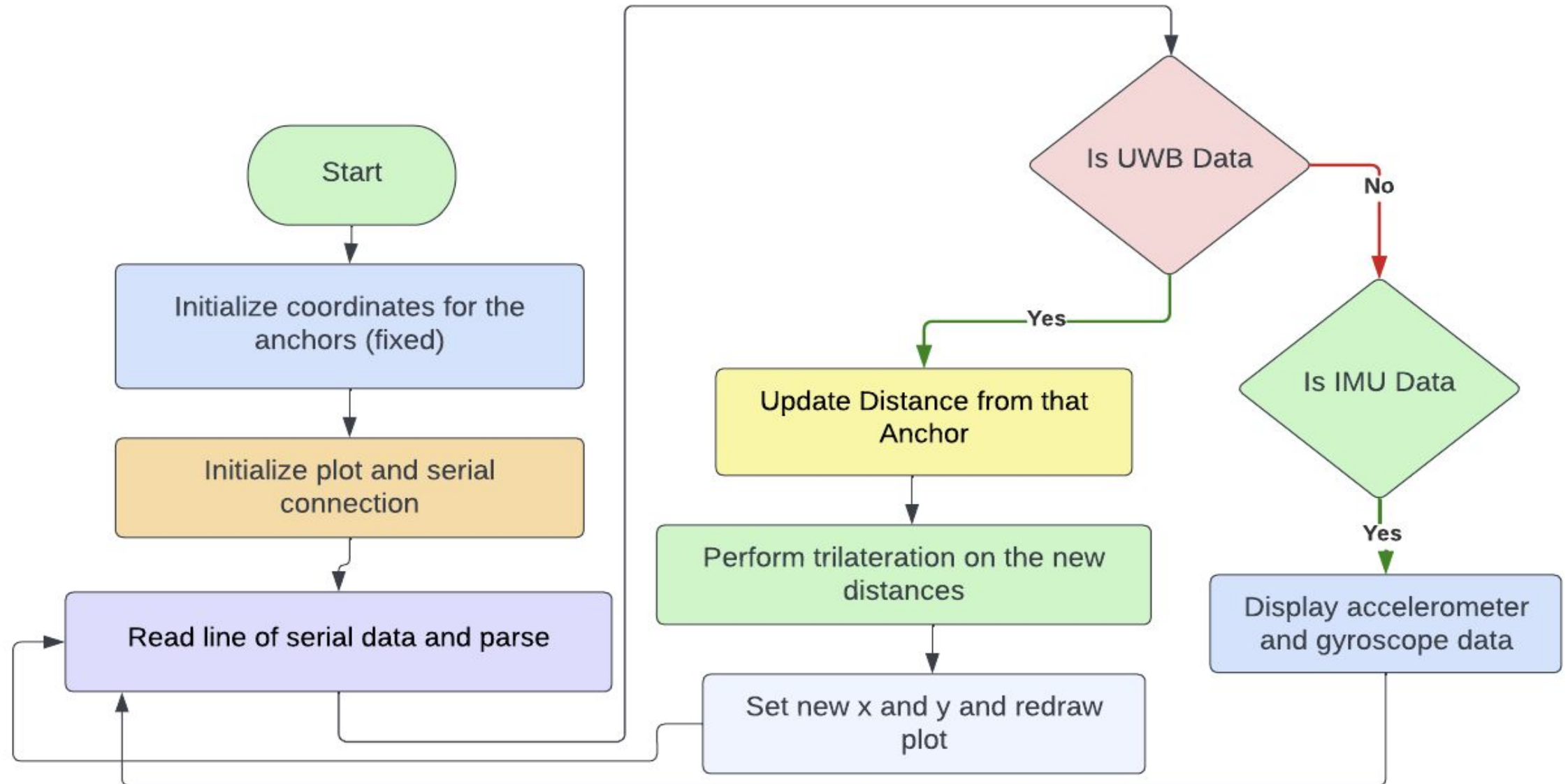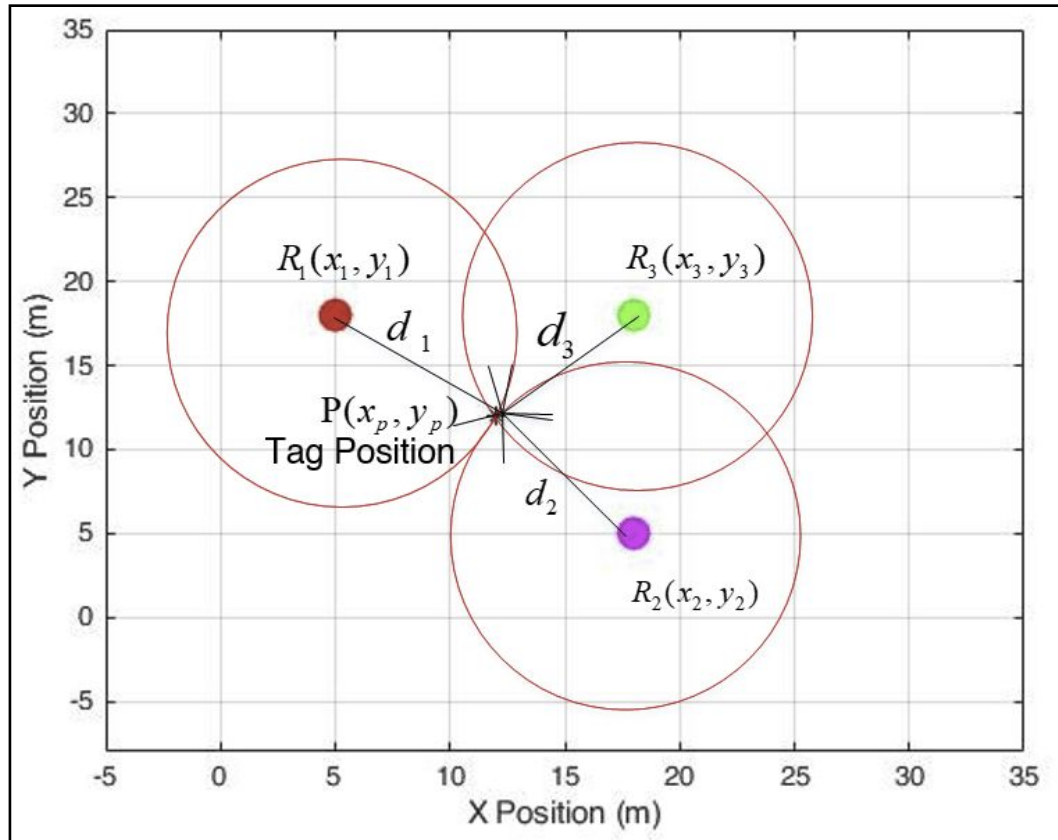
Block Diagram

PCB

- Combined actuation and external device

  - Improvement to give us more real-time data

- Did not implement barometer in the sensor suite

- Decided to power the ball and anchors by microUSB power sources instead of making it rechargeable

Software

Python Program for Actuation

Start

Initialize coordinates for the anchors (fixed)

Initialize plot and serial connection

Read line of serial data and parse

Is UWB Data

No

Yes

Update Distance from that Anchor

Perform trilateration on the new distances

Set new x and y and redraw plot

Is IMU Data

Yes

Display accelerometer and gyroscope data

$$(x_p - x_1)^2 + (y_p - y_1)^2 = d_1^2$$

$$(x_p - x_2)^2 + (y_p - y_2)^2 = d_2^2$$

$$(x_p - x_3)^2 + (y_p - y_3)^2 = d_3^2$$

Requirements and Verification

The tag is able to communicate with each anchor

- Verification: Upload the Arduino programs to each anchor and the tag. Then connect all the anchors to power and the tag to the computer.
  - If communication occurs, the tag prints the address of the anchor and the calculated distance to serial. Three addresses should be seen printed.

- Verification passed

Requirement 2

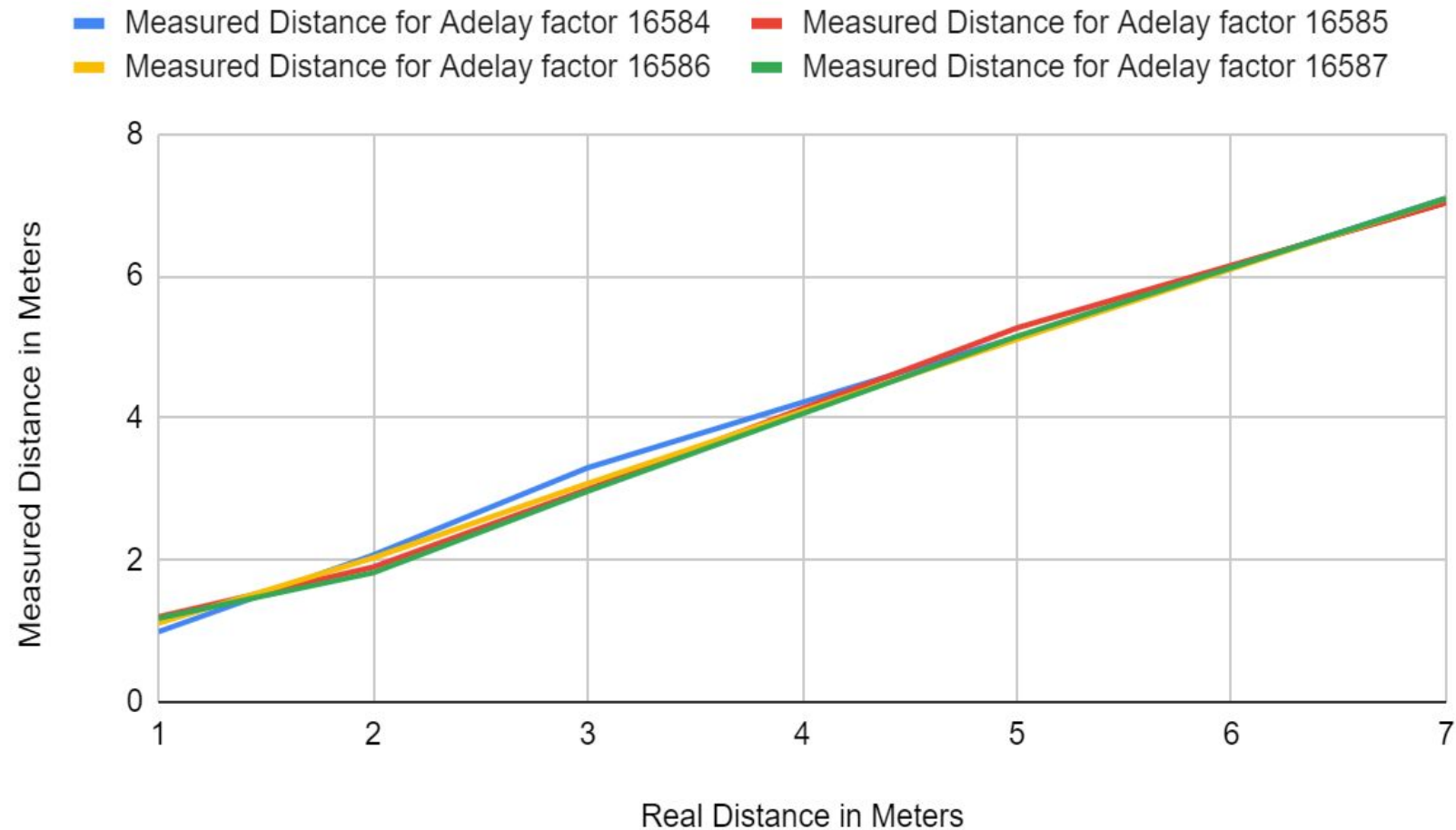## The distance for each anchor is accurate within 30 cm

- Verification: Compare the measured and real distances between the anchor and the tag for different real distances and ensure the difference is less than 30 cm.

- Verification passed upto 7.5 m distance

- After 7.5 m distance is passed, the measured distance varies by more than 30 cm
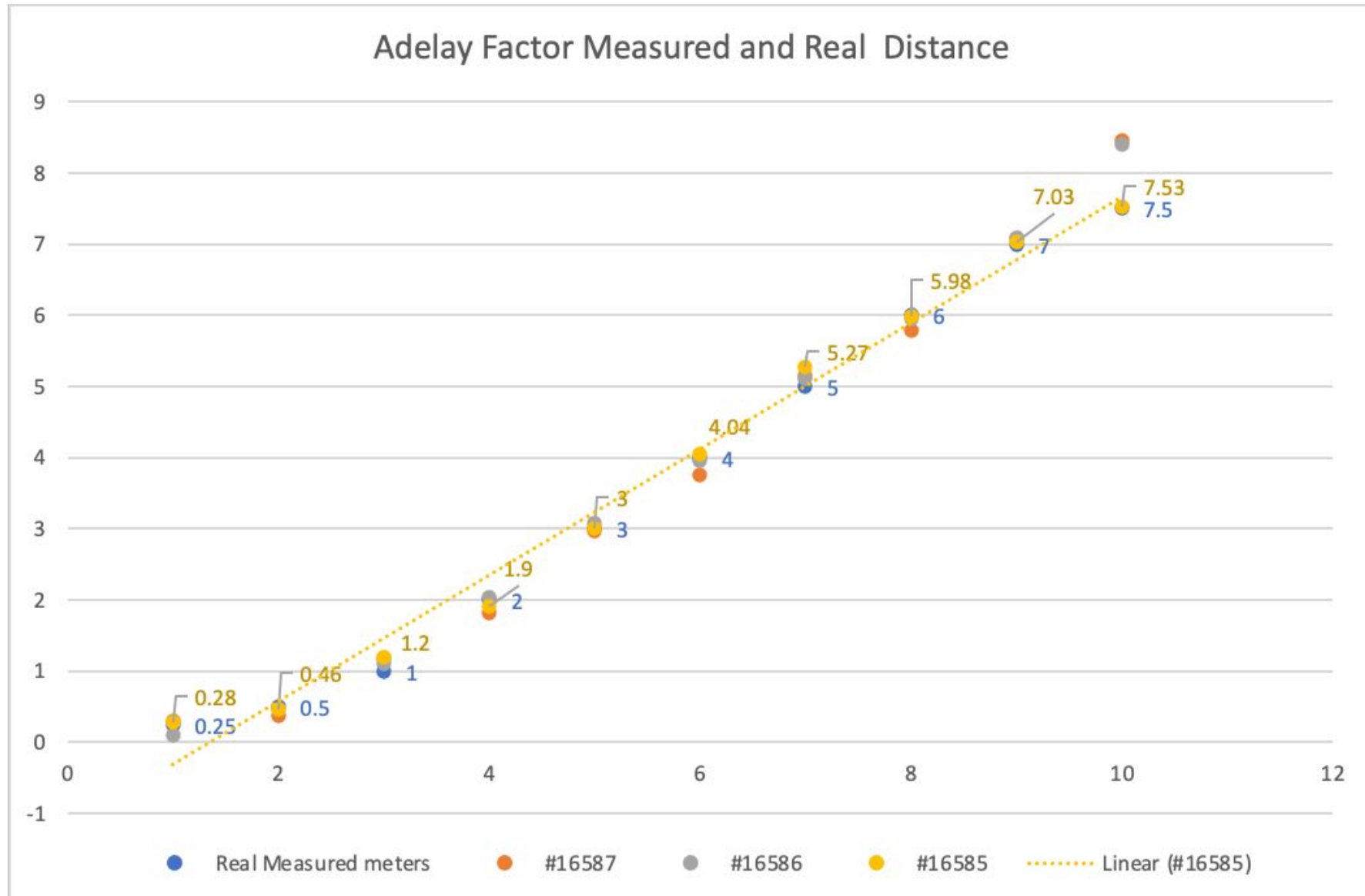
Antenna Delay Factor

Real Measured(m)	#16587	#16586	#16585
0.25	0.3	0.1	0.28
0.5	0.37	0.46	0.46
1	1.18	1.11	1.2
2	1.82	2.03	1.9
3	2.97	3.08	3
4	3.76	3.96	4.04
5	5.15	5.11	5.27
6	5.78	5.95	5.98
7	7.09	7.09	7.03
7.5	8.45	8.4	7.53

Antenna Delay Factor

Measured Distance vs Real Distance

- Measured Distance for Adelay factor 16584
- Measured Distance for Adelay factor 16585
- Measured Distance for Adelay factor 16586
- Measured Distance for Adelay factor 16587

Antenna Delay Factor


Adelay Factor Measured and Real Distance

The football is correctly located.

- Verification: Compare the measured and real coordinates of the tag and ensure the distance between the two is less than 30 cm.

- Because of noise and unpredictability of the waves, the measurement jumps around, especially when the tag is moving.

- To counteract, we take the average of 7 distances before updating the coordinates, making it more accurate, and this distance stays within 30 cm.
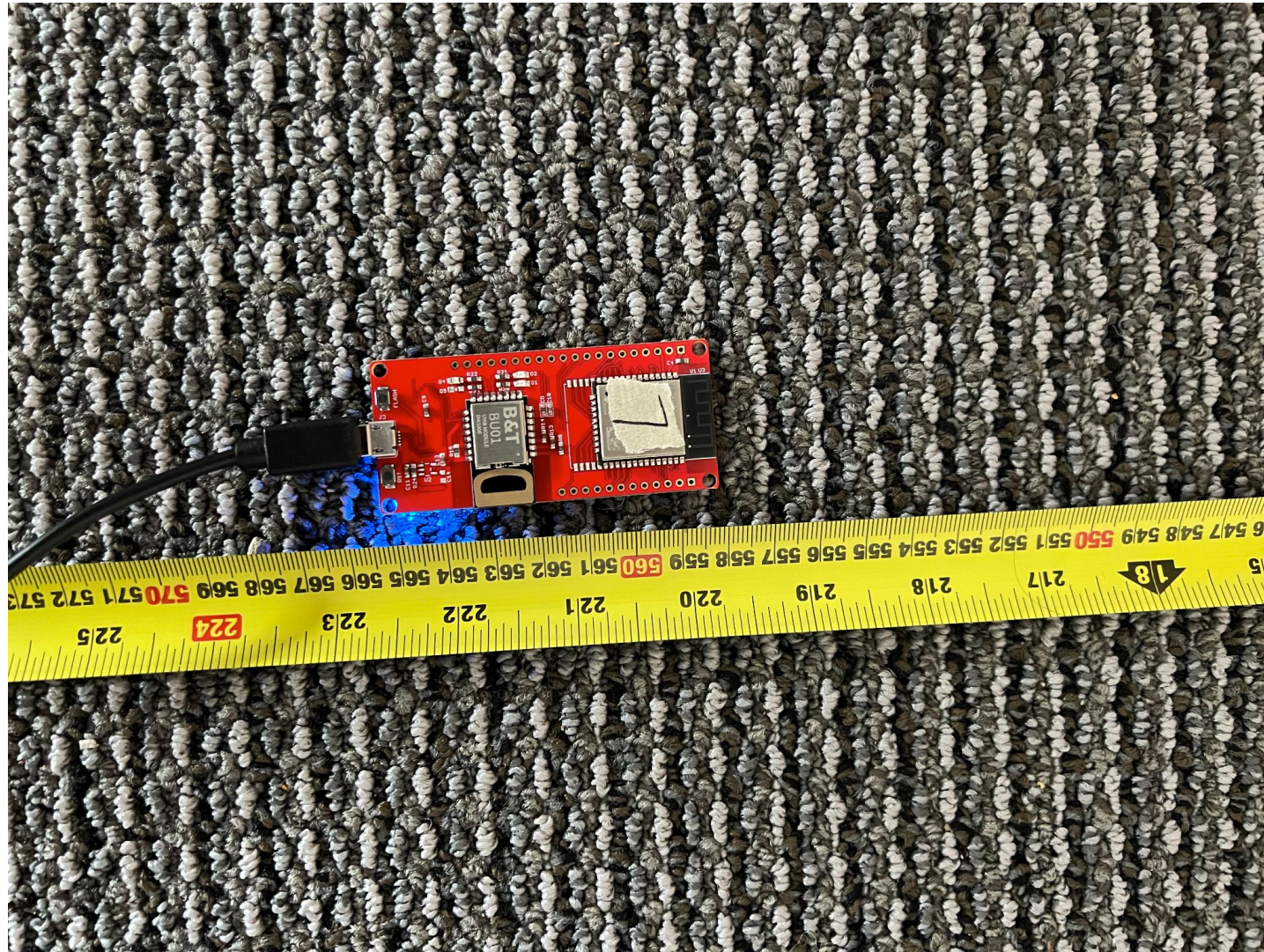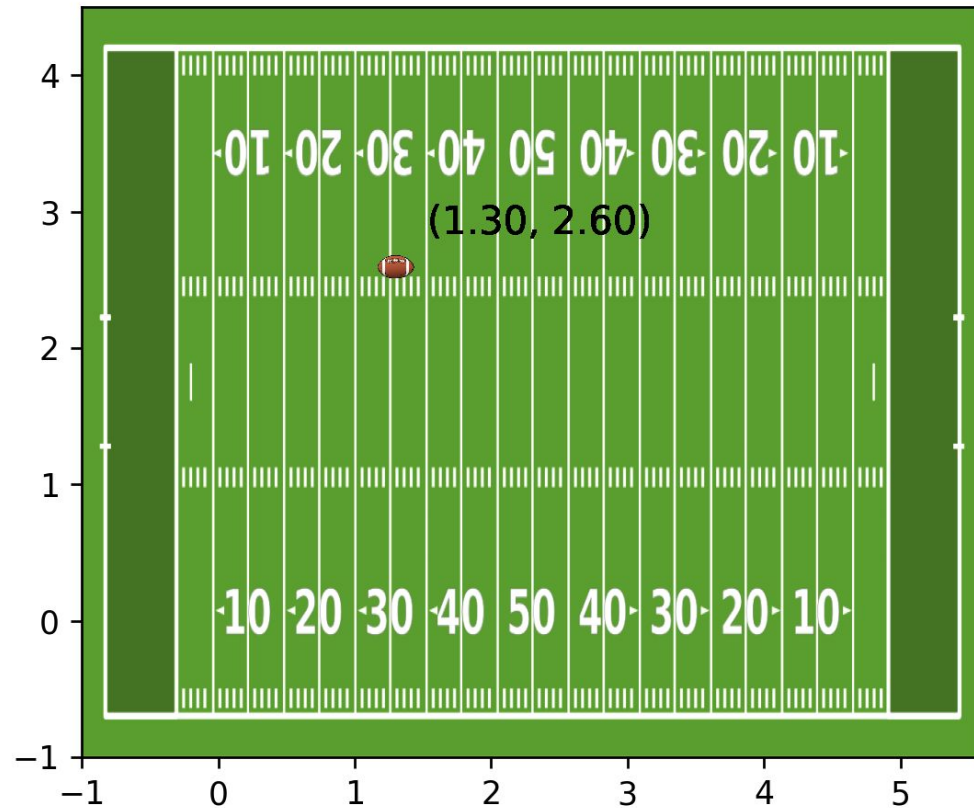
AccX: 0.02
AccY: -0.03
AccZ: 0.00
GyrX: 1.23
GyrY: -2.30
GyrZ: 0.85

(1.30, 2.60)

Accelerometer magnitude is accurate to .5 m/s² to account for noise, and reflects correct direction.

- Verification: Move the tag in the x, y, and z direction. After calibrating the sensor, test acceleration by timing the movement of 1 meter.

- Verification passed, but the measurements fluctuate constantly within .5 m/s²

Gyroscopic sensor reflects correct orientation to within 5 degrees per second and reflects correct direction.

- Verification: Tilt the tag 90 degrees in one second to ensure measurement is within 5 degrees per second in the correct orientation.

- Verification passed with fluctuating measurements

Data is sent back to the computer via Bluetooth.

- Verification: Perform the above verifications with the tag communicating with the computer wirelessly, and ensure the results stay the same.

- Verification passed.

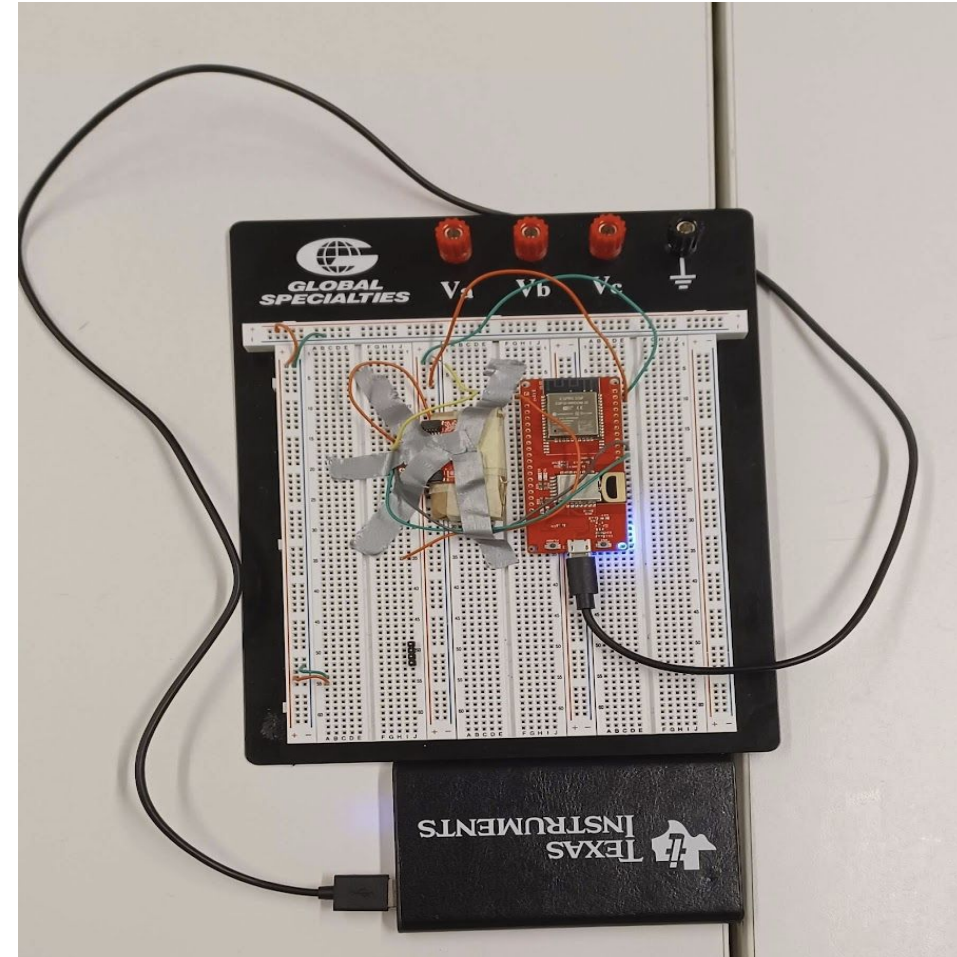## Data can be processed and visualized on the computer screen

- Verification: Ensure that the calculated location, acceleration, and rotation are displayed in Python visualization

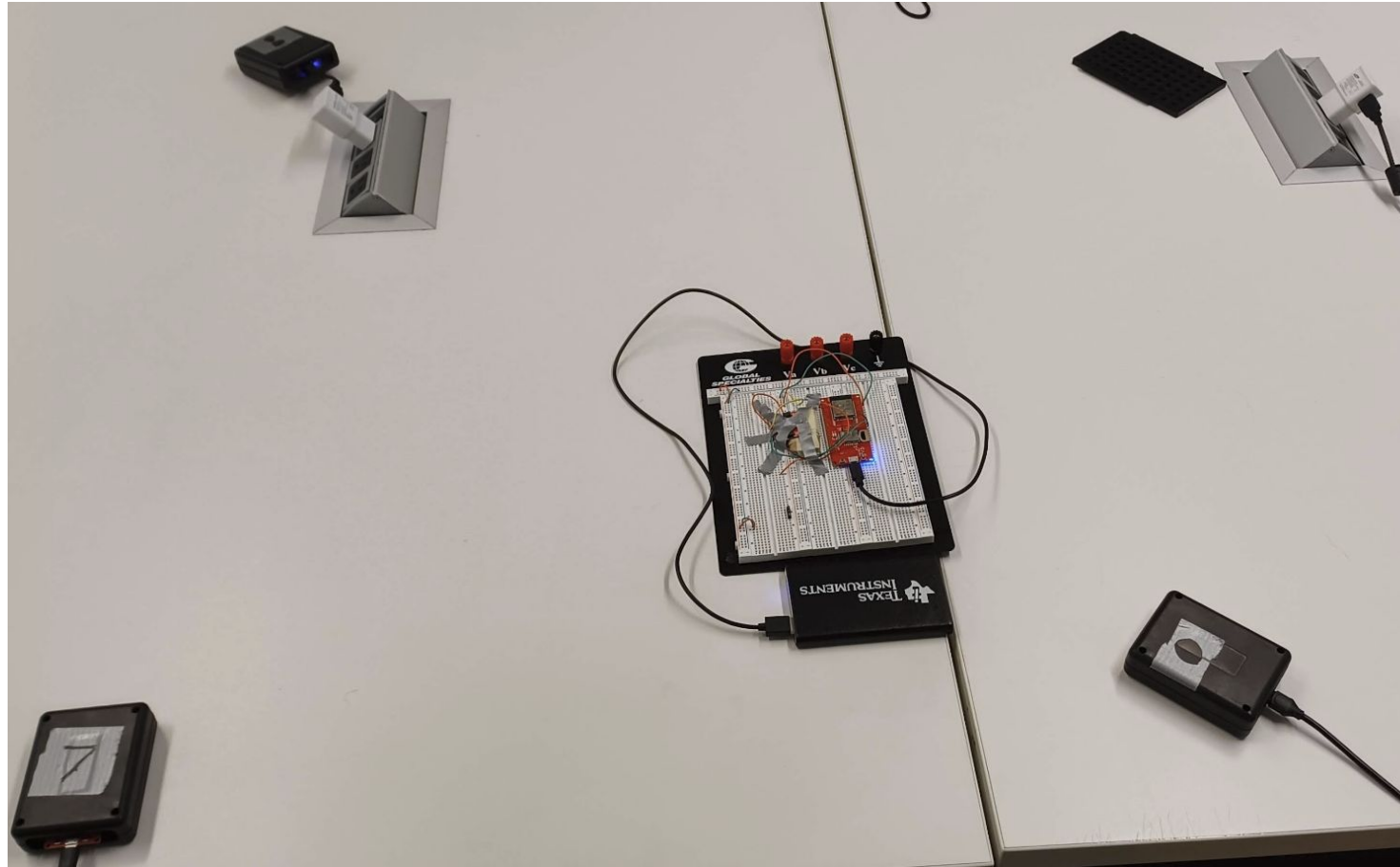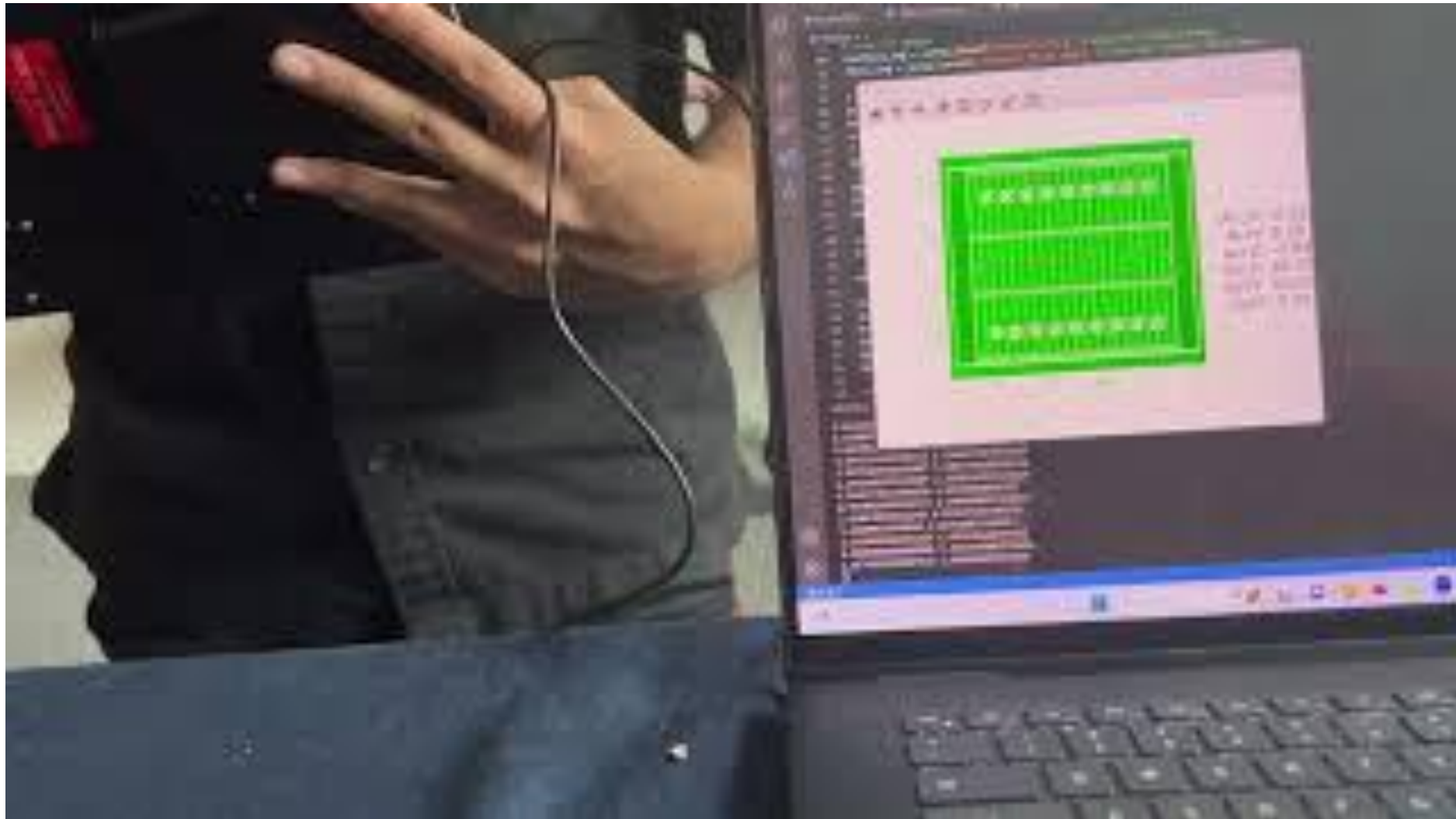- Changed from original design

- Verification passed

Demo & Build

Anchor

Tag

Setup

Conclusions

Conclusions

Accomplishments

- Location tracking accurate to within 30 cm, or the length of a football

- Accurate IMU for our purposes, showing when the device is moving in any direction and when it is not

- Able to transmit data via Bluetooth, which is important during a game because a football should be completely wireless

Issues

- Location tracking only works within 7.5 m, so device has to be scaled for outdoor accuracy

- Fluctuation in data

- Barometric sensor not implemented

- PCB order delay, so we had to order new development boards to work on breadboard

Conclusions

What We Would Do Differently

- Order parts better suited for breadboarding
  - Castellated vias

- Use the accelerometer in conjunction with DW1000 to get more accurate location

- Use a ten-axis IMU

- Make sure our PCB comes in on time

Future Works

Extended Implementations
- Refined PCB design
- PCB Enclosure within football
- Include Barometer metrics for pressure sensing
- Add rechargeable battery to football

Memory Storage and Application
- Could include tag based game play and assign metrics with player
- Convert PC program into a mobile application to allow for easier access

Thank You
Questions?
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