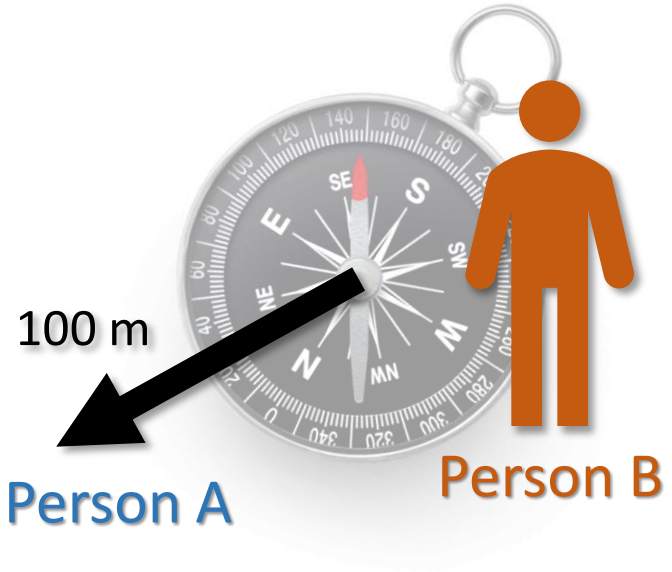
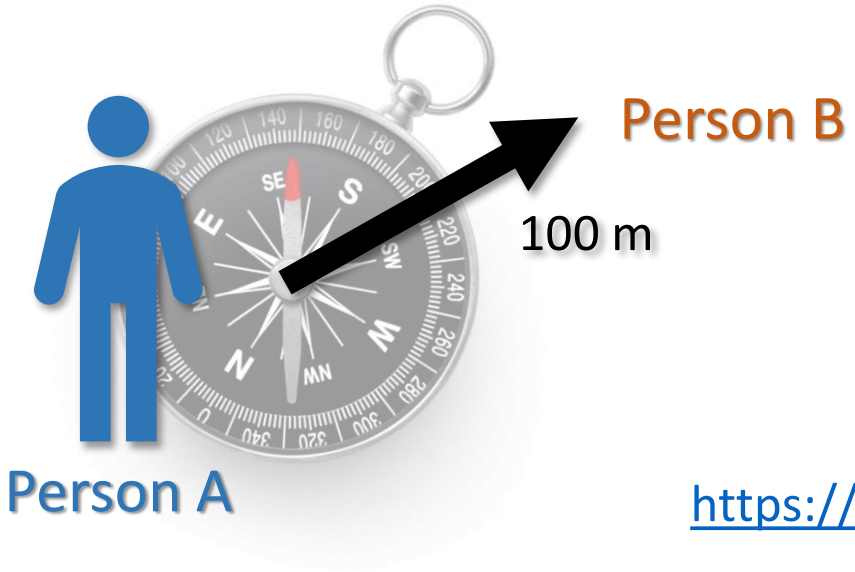
Find Each Other Compass

- Compass pointing to another person
- Useful for team sports like Airsoft on large outdoor fields

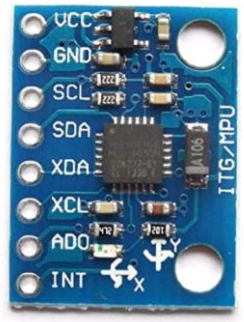


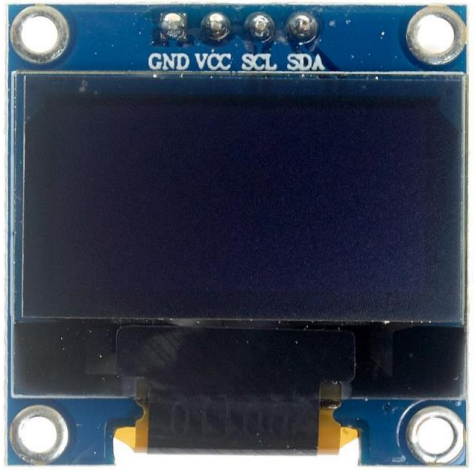


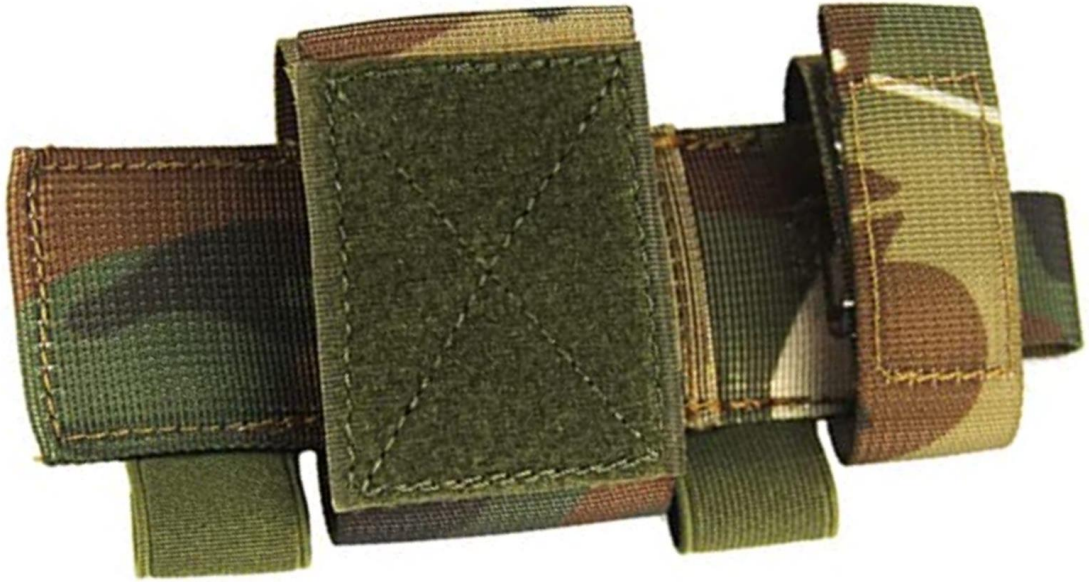
https://github.com/ClaudeMarais/FindEachOtherCompass_ESP32-C3

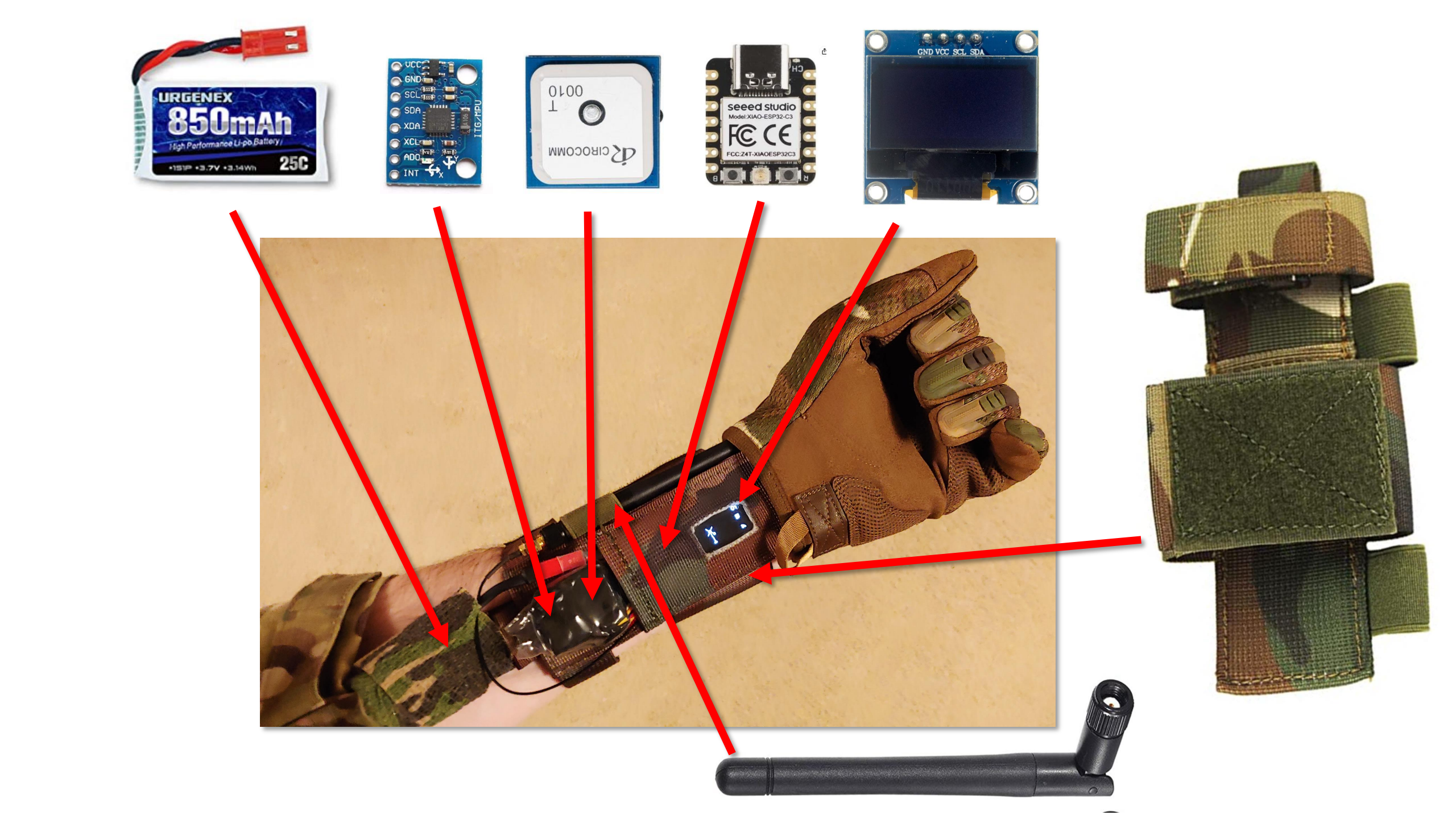
Equipment

- XIAO ESP32-C3
- BN-880 GPS, which includes
- HMC5883 Magnetometer
- MPU6050 Accelerometer
- SSD1306 OLED Display
- External antenna
- Buzzer
- Battery
- Molle Tourniquet Pouch








URGENEX
850mAh
High Performance Li-po Battery
1S1P 3.7V 3.14Wh
25C
VCC
GND
SCL
SDA
XDA
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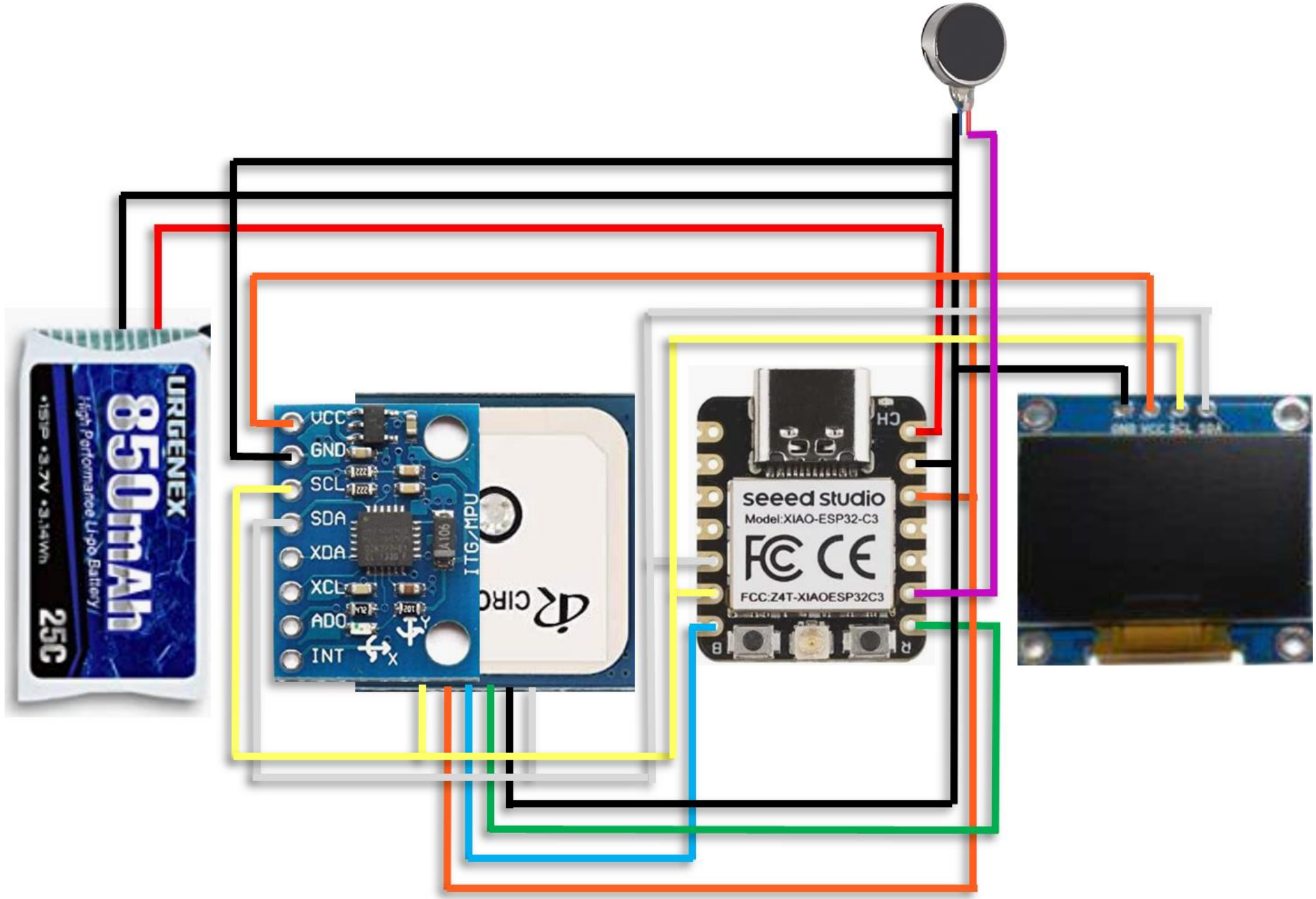
Model:XIAO-ESP32-C3
FCC:Z4T-XIAOESP32C3
GND VCC SCL SDA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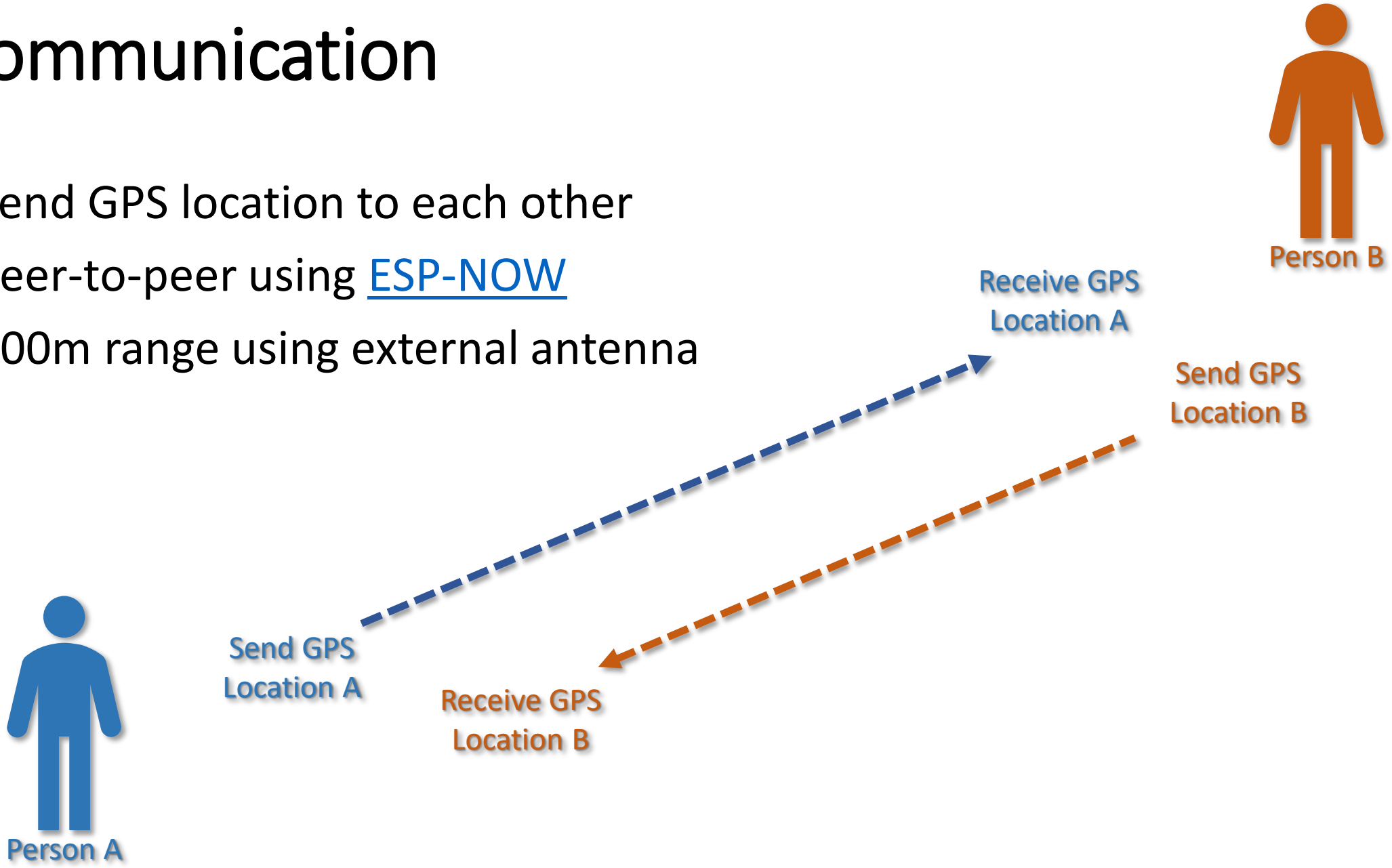
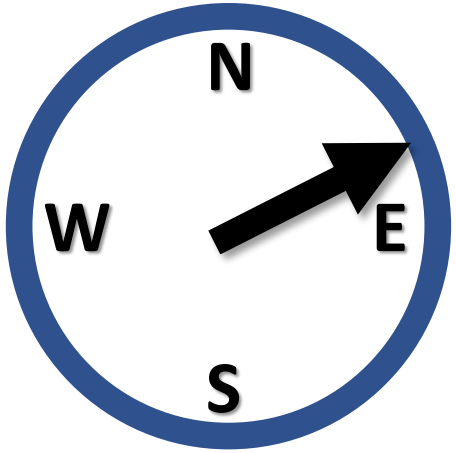
Communication

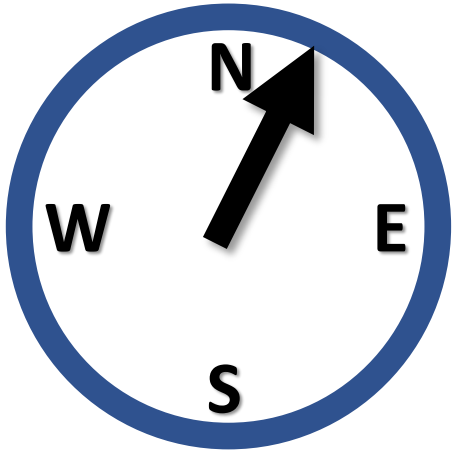
- Send GPS location to each other
- Peer-to-peer using ESP-NOW
- 100m range using external antenna



Calibrate magnetometer

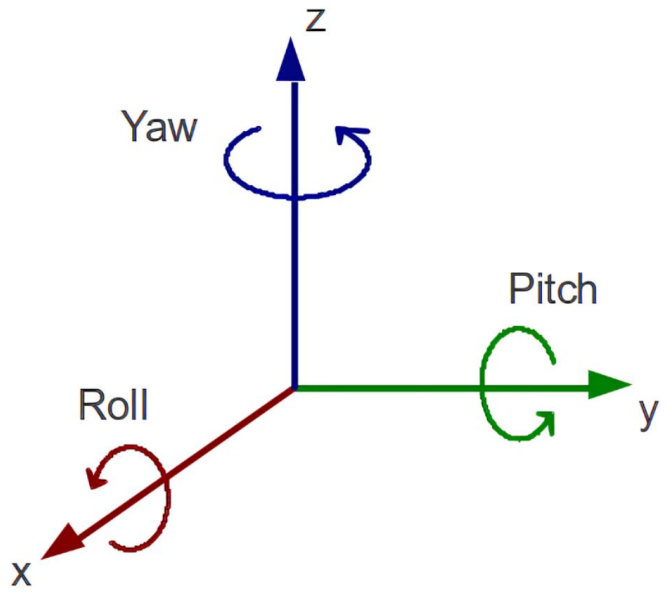
- Magnetometer 100% unreliable without calibration
- North pointing to all kinds of directions when in different orientations
- Calibrate after device is assembled to compensate for small magnetic interferences of components inside the device
- Calibration for each device is unique





Hard-iron calibration

- Finding calibration values
  - Rotate 360 degrees around each 3D axis
  - Record and save min/max magnetometer values
  - Can save these values to EPROM

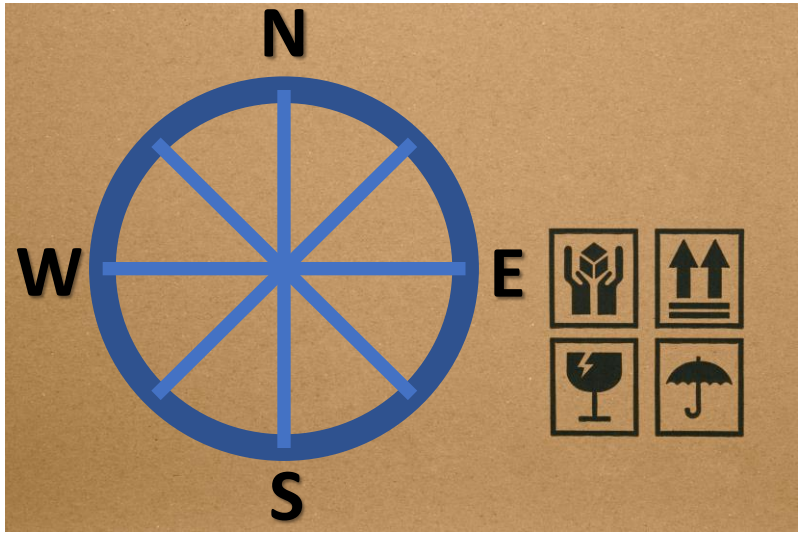


- Using calibration values
  - Offset new values with min/max values

```
mx = (mx - min.x) / (max.x - min.x) * 2.0 - 1.0;
my = (my - min.y) / (max.y - min.y) * 2.0 - 1.0;
mz = (mz - min.z) / (max.z - min.z) * 2.0 - 1.0;
```

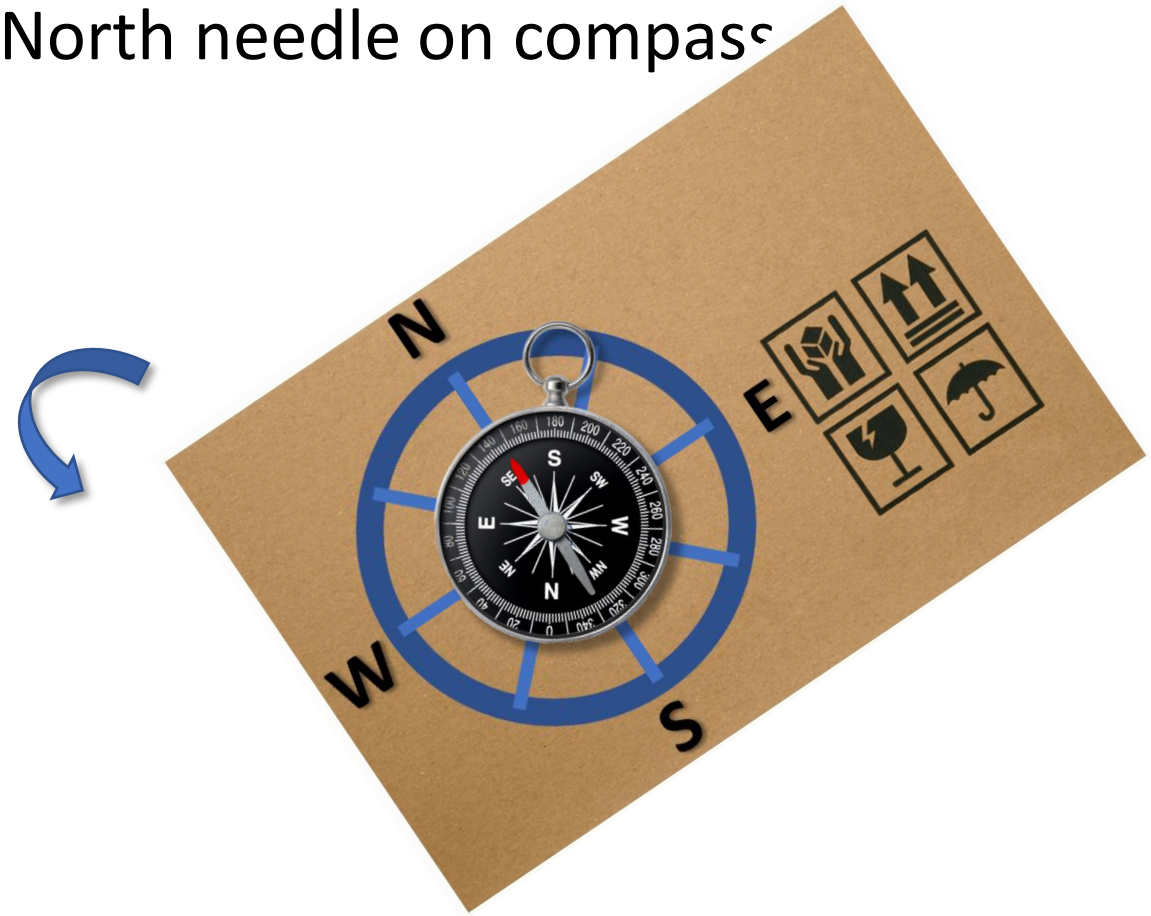
Soft-iron calibration

- My own method
- Need
  - Real compass
  - Cardboard box to ensure no magnetic interference
  - Draw 8 precise markings on cardboard box indicating 8 compass directions
  - Show magnetometer degrees on OLED display



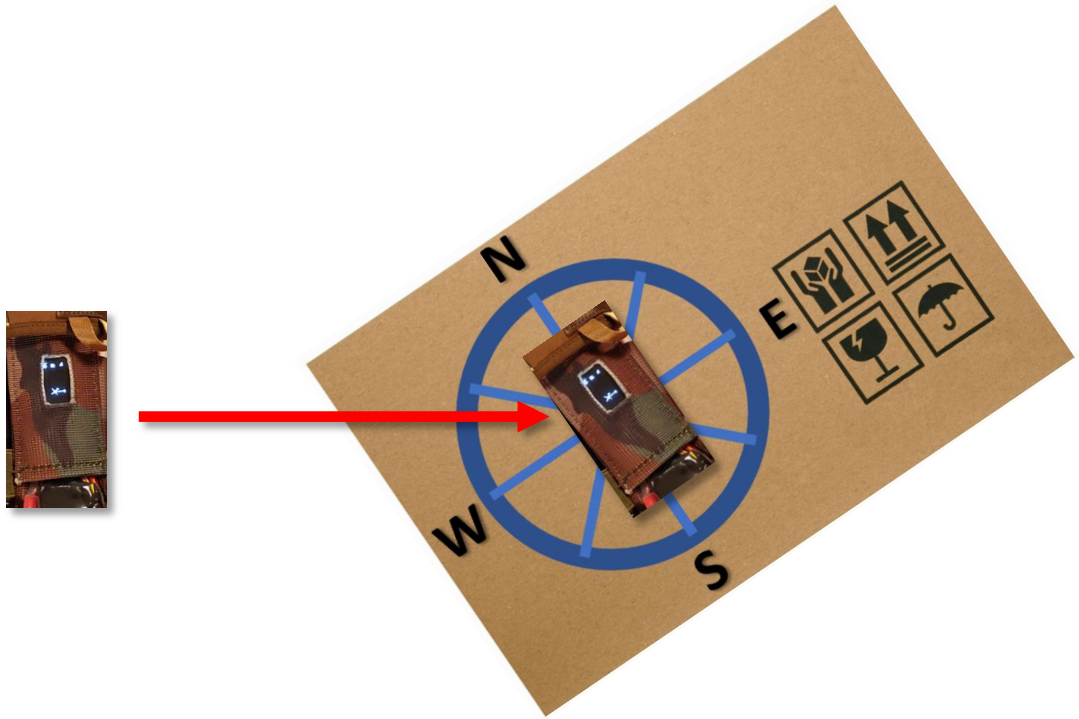
Step 1 – Establish ground truth North

- Place real compass on box
- Rotate box so North on box points to North needle on compass
- Secure box position



Step 2 – Document North angle error

- Place device on North aligned box
- Device should show zero degrees when also pointing North
- Document what it actually shows



Example

Expected Angle	Actual Angle
0	**18**
45	
90	
135	
180	
225	
270	
315	

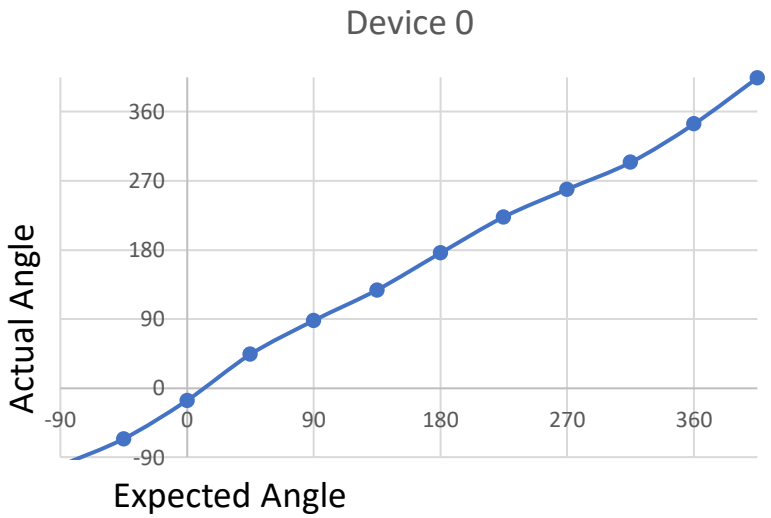
Step 3 – Document all angle errors

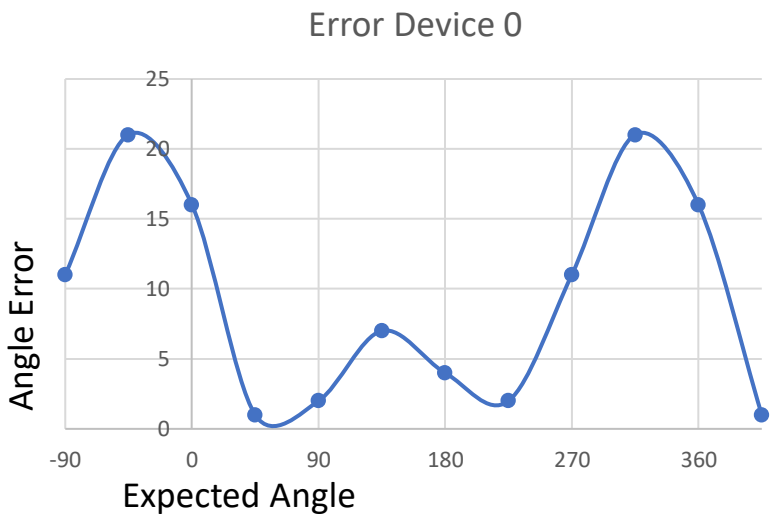
- Keep box North aligned and point device in other directions
- Document what it actually shows

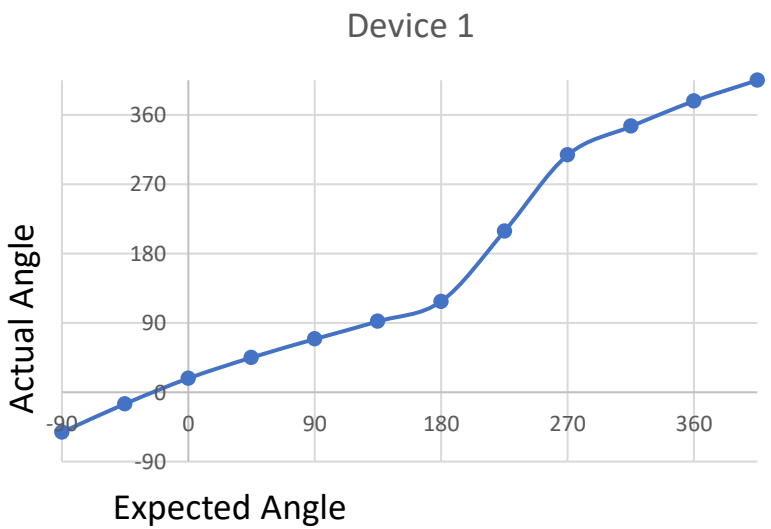
Example

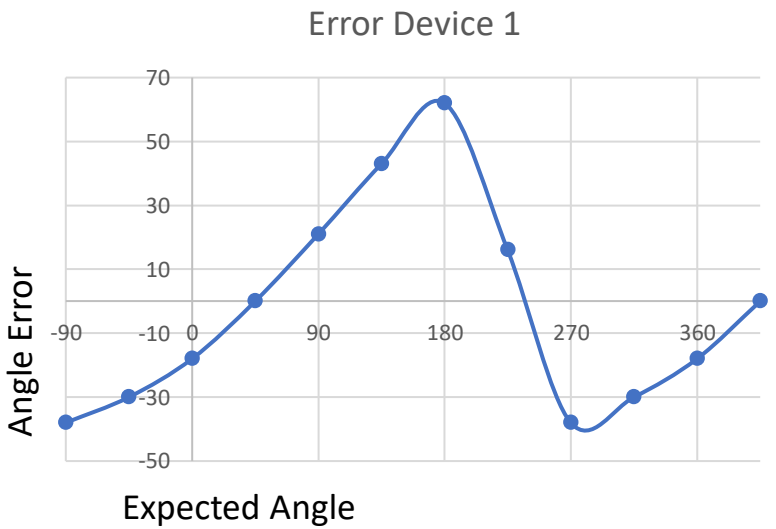
Expected Angle	Actual Angle
0	18
45	**45**
90	**69**
135	92
180	118
225	209
270	308
315	345

For fun, I plotted errors of two devices



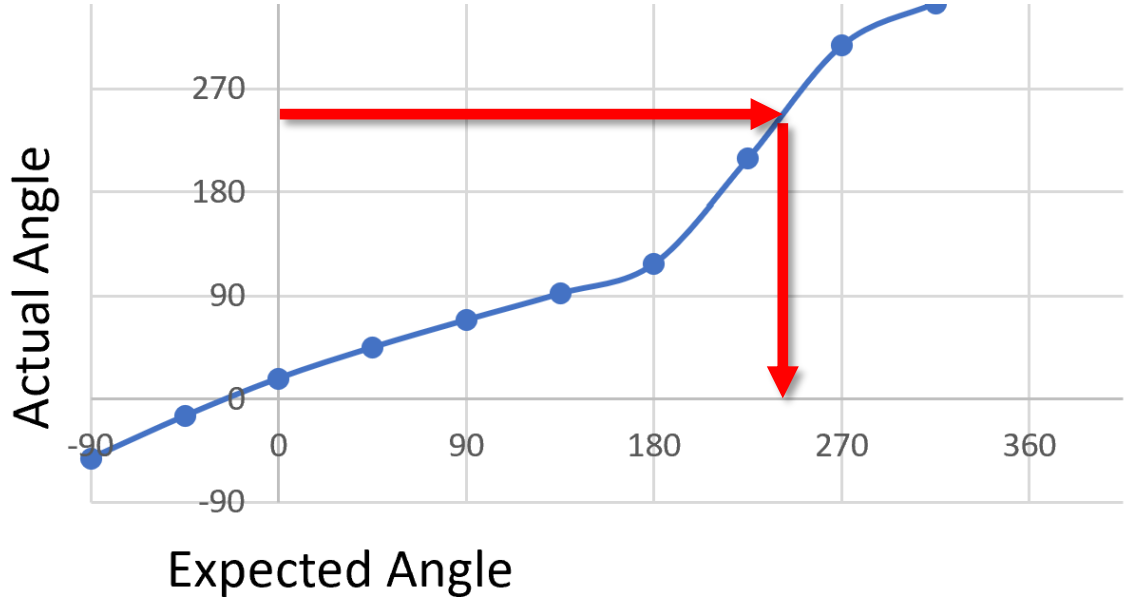






Step 4 – Use values at runtime

- Calc magnetometer angle
- Find the two “Actual Angles” where new angle lies between
- Calc interpolation factor using the two “Actual Angles”
- Interpolate “Expected Angles” to find correct calibrated angle



Example

- Magnetometer measures 57 degrees
- 57 is an uncalibrated “actual angle”
- 57 is 50% between “actual angles” 45 and 69
- “Actual angles” 45 and 69 correlates to “expected angles” 45 and 90
- 50% between “expected angles” 45 and 90 is 67.5
- Therefore, correct calibrated value is 67.5 degrees

Expected Angle	Actual Angle
0	18
45	45
90	69
135	92
180	118
225	209
270	308
315	345

Tilt corrected compass

- Compass requires to be held perfectly horizontal
- Tilted angles can give North up to 100 degrees off!
- Add tilt correction using accelerometer data
- Doesn’t work without magnetometer calibration

Used method from

https://github.com/pololu/lsm303-arduino/blob/master/LSM303.h

Battery lifetime

- Using small 850 mAh Lipo battery
- Originally only lasted 1.5 hours
- After optimizations lasting 3.5 hours

- Optimizations
  - Send GPS coordinates less frequently, e.g. only every 5 seconds
  - Do expensive calculations less frequently, e.g. pitch and roll every half second
  - Turn display off when at rotation angles larger than 30 degrees
  - Stop doing some calculations when display is off, e.g. sin/cos to draw needle
  - Disable output to Serial
  - Code cleanup, removing redundent lines of code