Gait Gainz

Milestone 7

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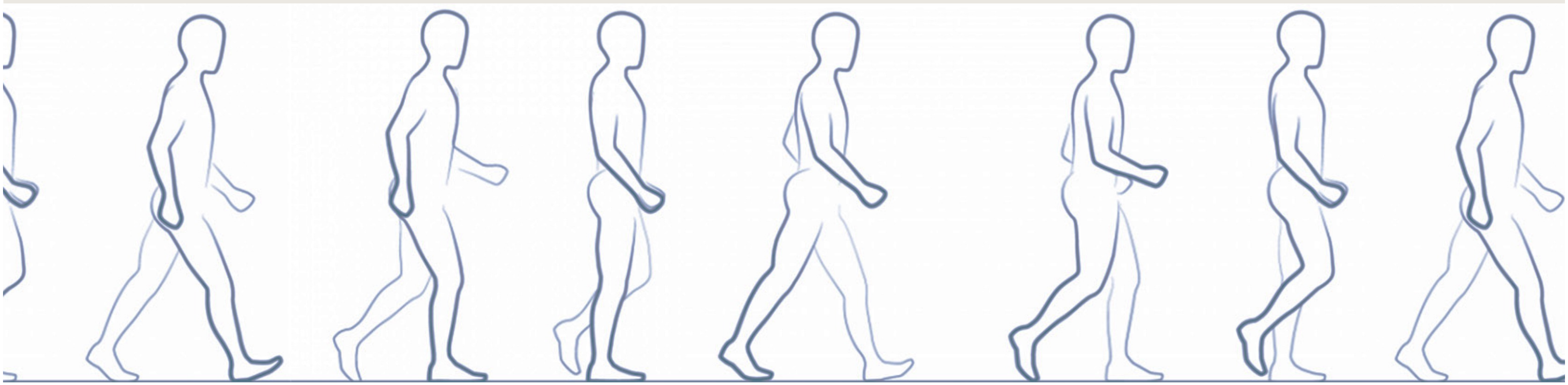
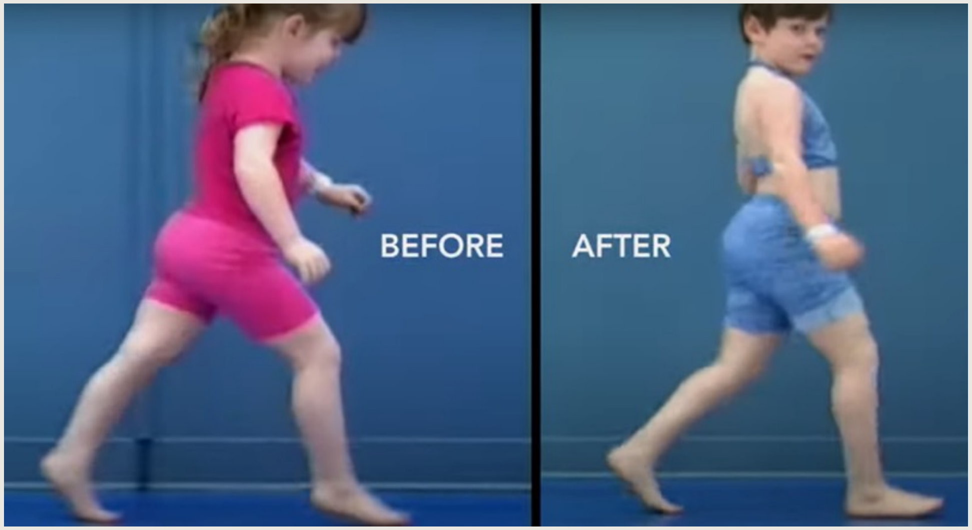


The Challenge

- 4 per 1000 children have Cerebral palsy, with up to 99% have equinus foot [2]
- Orthopaedic muscle or tendon lengthening surgery
- Post-operation, CP patients undergo physical therapy to relearn walking
- To assess improvement the change in gait pattern needs to be monitored



[3]

Design Criteria

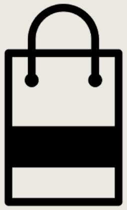
Comfortable

Device must comfortable to walk in and not impede patients typical gait

Sensitive to Changes

Device must be able to distinguish changes in gait patterns

Portable



Device must be minimal, lightweight and easy to remove

Design Constraints

Number of sensors

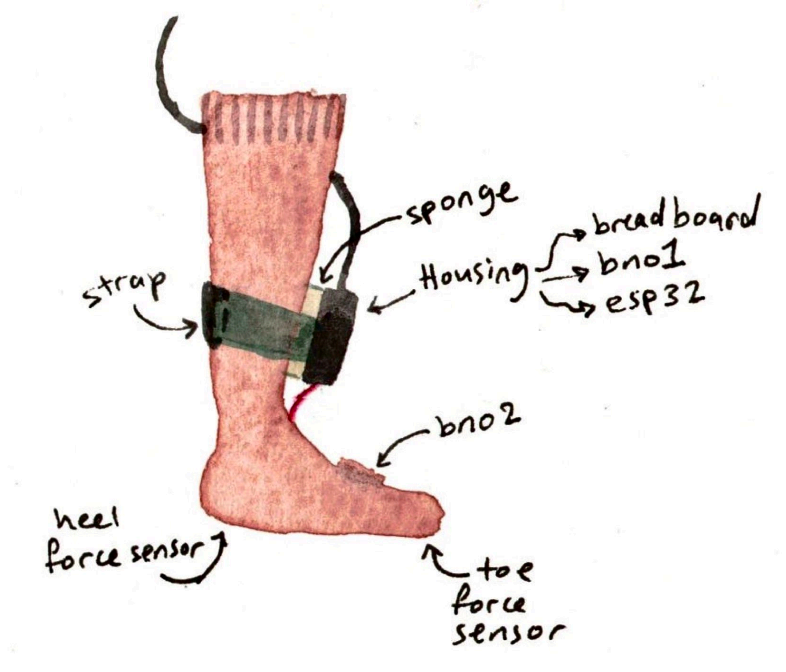
The maximum number of sensors that can be connect to the Arduino is 4.

Costs

The cost of manufacturing and the materials of the device must not surpass 400 dollars.

Size

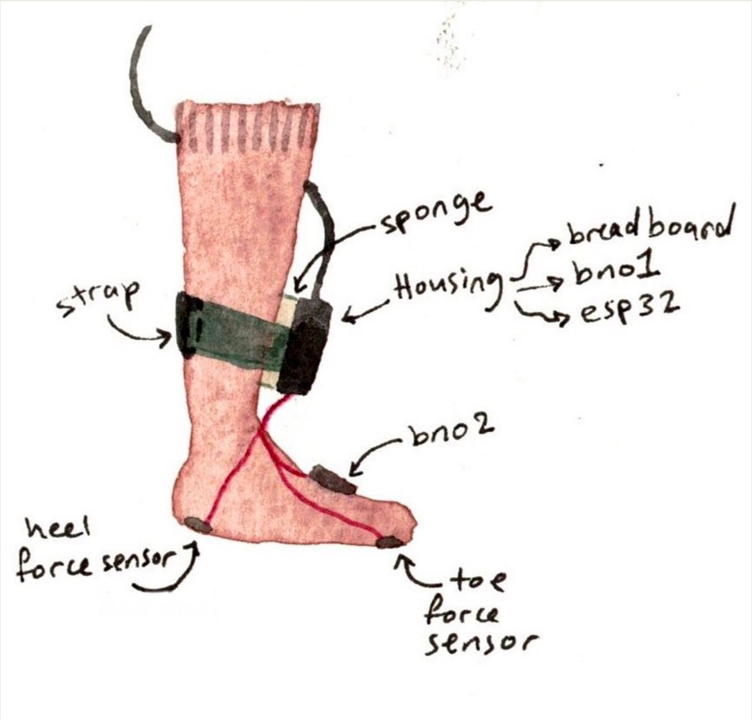
The size of the breadboard can be bulky.



Our Approach

- Using 4 sensors we will measure average range of motion during walking and detect the presence of heel strike during gait
- 2 BNO055 orientation sensors measure angle of ankle joint
- 2 force sensitive sensors track weight transfer from heal to toe

(Inside look)



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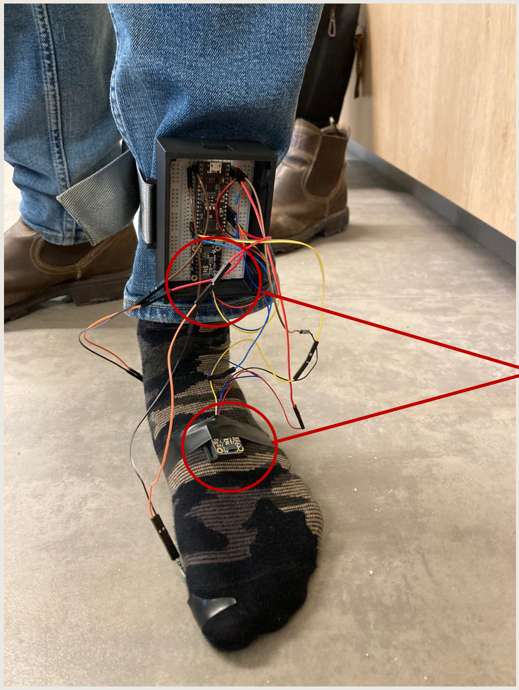
Initial Prototype



Current Prototype

Meeting Design Constraints and Criteria

Comfortable

Adjustable nature of the device is to optimize user comfort.

Sensitive to Changes

Sensors used provide a varied range of data depending on gait.

Portable

Device is easy to take on and off, and has minimal impact on gait.

Number of sensors

We utilized 4 total sensors, matching the Arduinos limit.

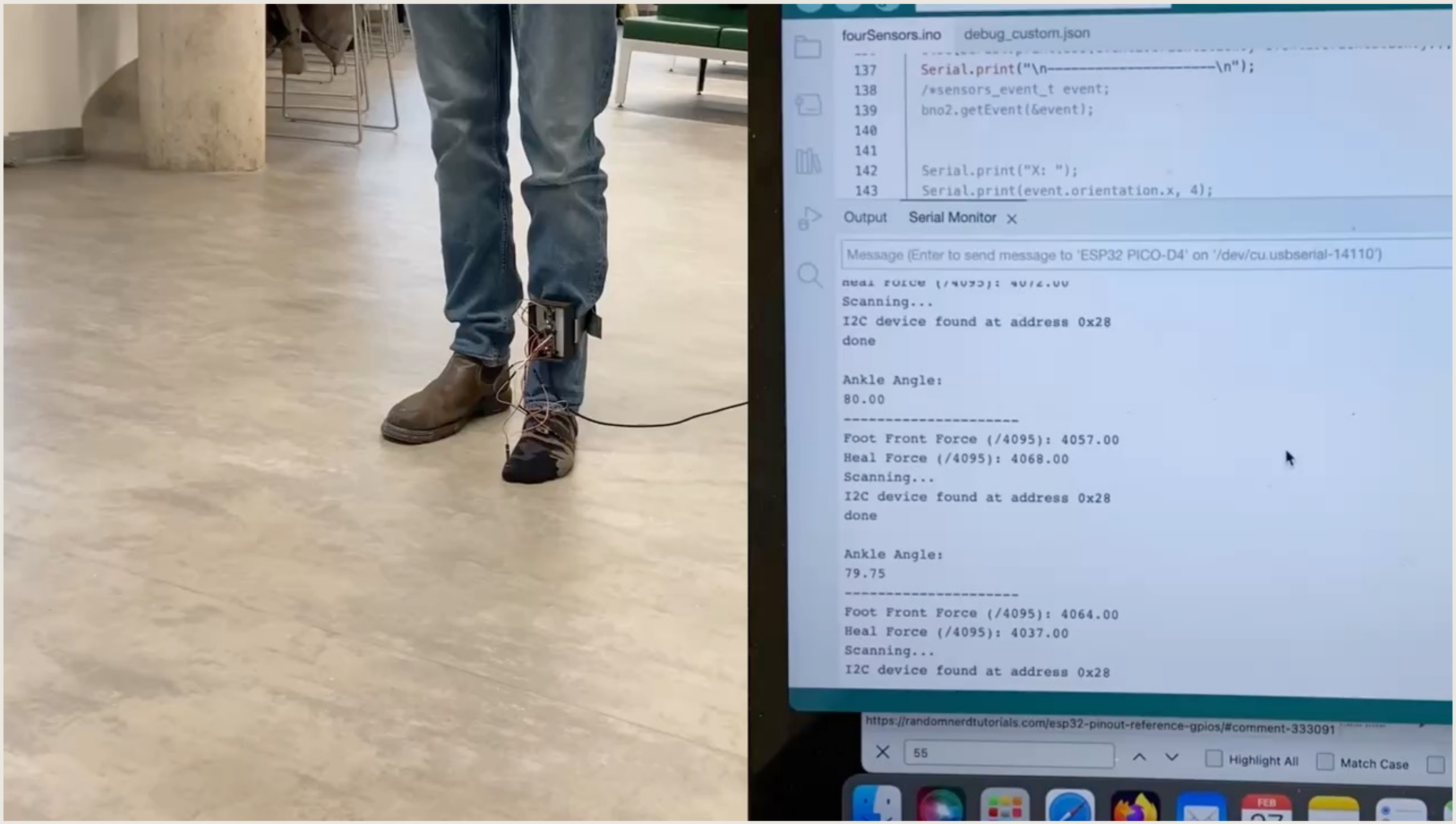
Costs

Summing the bill of materials, we totalled 122 CAD.

Size

Breadboard is placed in an unobtrusive area to mitigate size issues.

Demo


fourSensors.ino
debug_custom.json
Serial.print("\n--------------------\n");
/*sensors_event_t event;
bno2.getEvent(&event);
Serial.print("X: ");
Serial.print(event.orientation.x, 4);
Output
Serial Monitor
Message (Enter to send message to 'ESP32 PICO-D4' on '/dev/cu.usbserial-14110')
Scanning...
I2C device found at address 0x28
done
Ankle Angle:
80.00

Foot Front Force (/4095): 4057.00
Heal Force (/4095): 4068.00
Scanning...
I2C device found at address 0x28
done
Ankle Angle:
79.75

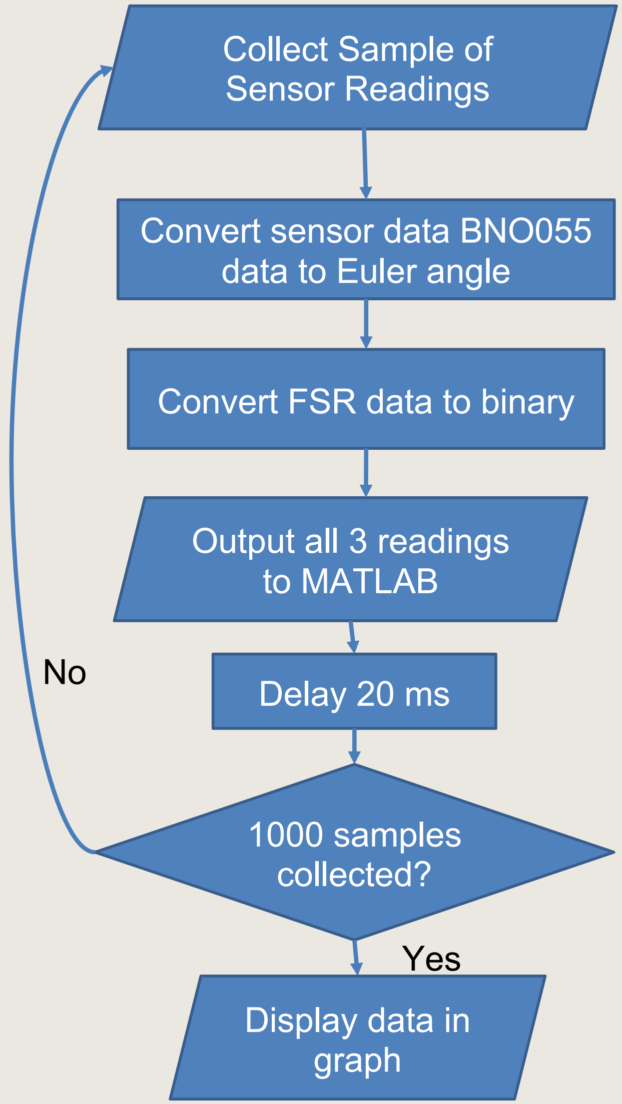
Foot Front Force (/4095): 4064.00
Heal Force (/4095): 4037.00
Scanning...
I2C device found at address 0x28
Highlight All
Match Case

Required Inputs/Variables

- Sampling Rate: 50 Hz
- Start Button: Determines when to commence collecting 1000 samples
- Pre-set calibration Angle: 10 degrees, can be adjusted
- Readings from 2 BNO055 sensors at sampling frequency
- Readings from 2 FSRs at sampling frequency

Data Processing

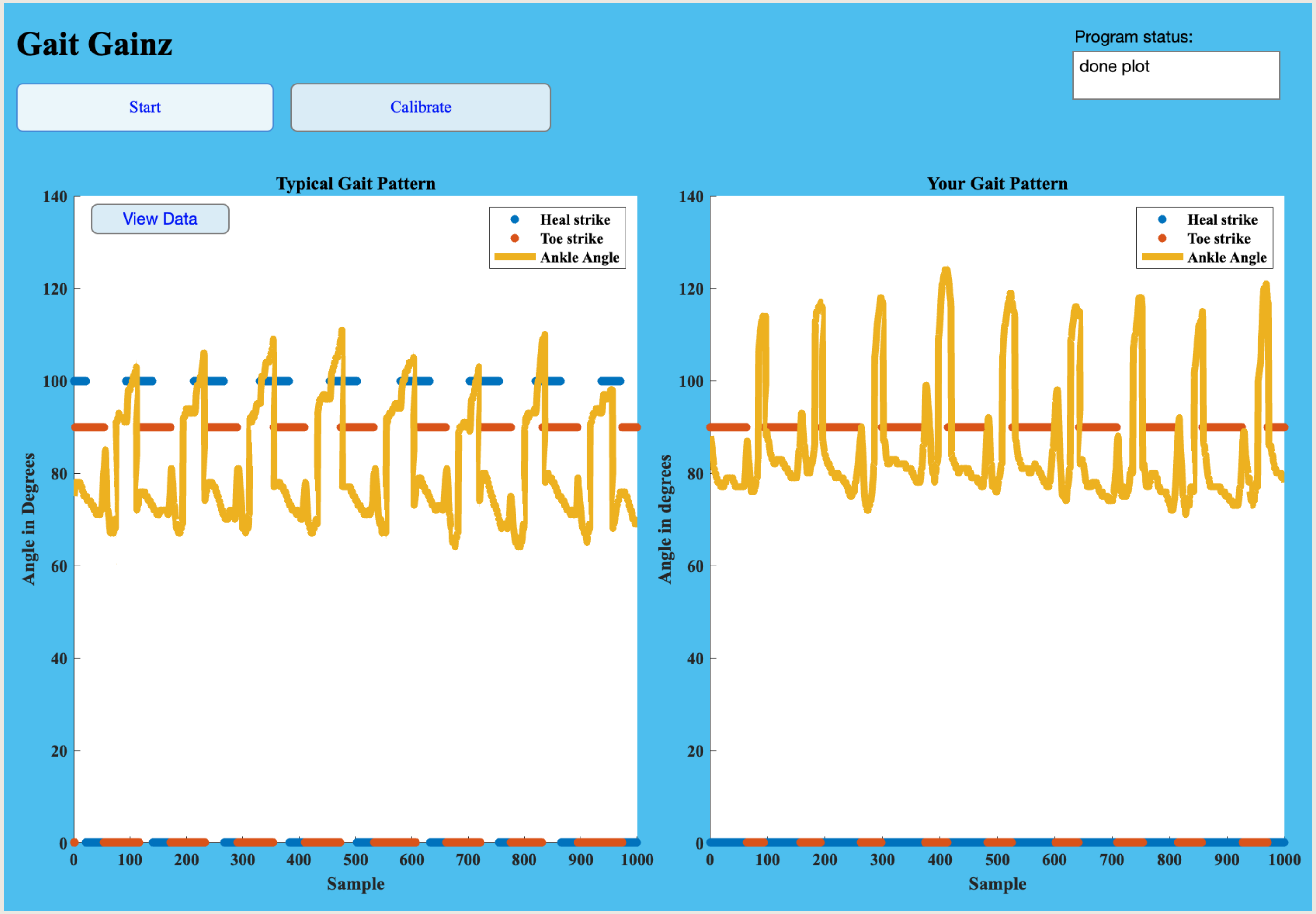
- Readings from sensor will be taken and output in an understandable way by our algorithm
- $angle$: Refer to next slide for formula
- Threshold for FSR: >3095 is interpreted as 0, <3095 is interpreted as 1
- Filter: Built in low-pass filter



Data Processing

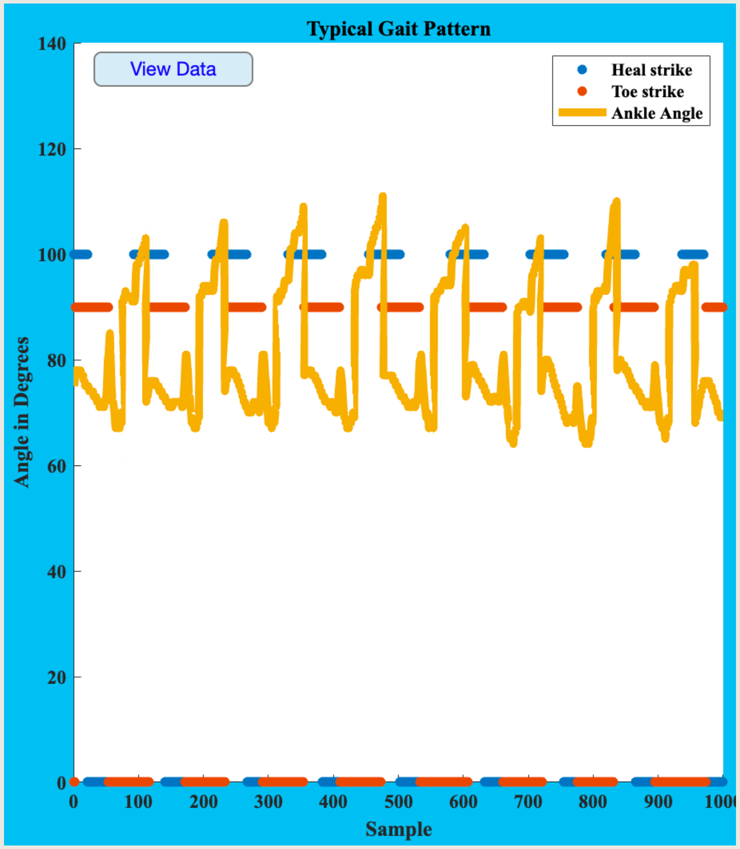
```
if(abs(event2.orientation.z)<90){angle=abs(abs(event2.orientation.y+event1.orientation.y)-patientFootAngle-180);}
else{angle=abs(abs(180-event2.orientation.y+event1.orientation.y)-patientFootAngle-180);}
```

User Interface



Data Analysis

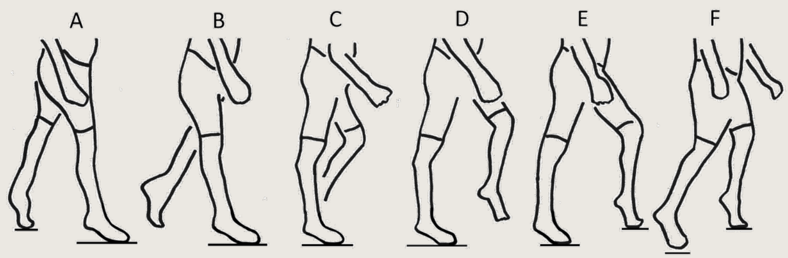
- BNO055 sensor data is used to make a plot of joint angle throughout gait
- FSRs determine angle that heal and toe strikes occur and can be overlayed on plot
- Angle measurements throughout gait can be exported to MATLAB for further analysis by physician

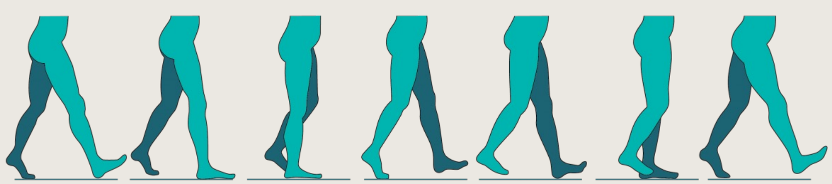


Sample of output graph

Validation Plan

- Compare 2 distinct gait patterns to determine if device can distinguish differences



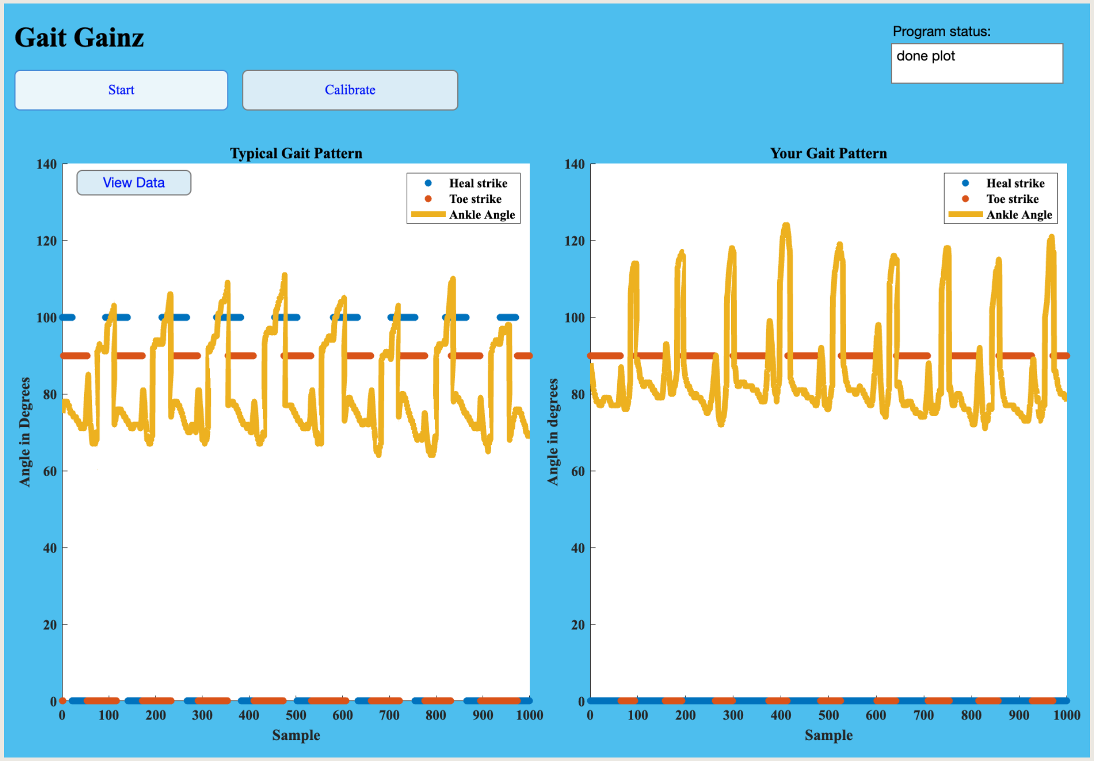


- Confirm angles measured by device match manually measured angles

[3,4,5]

Performance Test Results

- System expresses equine gait in two ways:
- The lack of heel strikes (force sensors)
- Higher minima of ankle angles (BNO055 sensors)



Results & Conclusion

Accomplished Goal

Device can distinguish irregularities between typical and equinus gait

Patient Oriented

Our device helps users to develop skills that will improve their quality of life

Next Steps

Develop further analysis tools, to identify phases of gait and implement Bluetooth connection

Bill of Materials

Item	Cost	Acquisition Cost (Tax, Shipping)	Source
1 ESP32-PICO-KIT V4	1 x $17.54	$2.28	Amazon
2 BNO055 sensor	2 x $29.32	$15.62	Digikey
2 Force sensing resistors	2 x $6.37	$1.51	Amazon
1 Breadboard	1 x $5.20	$0.67	Next Gen Guitars
20 Jumper wires	20 x $0.14	$1.35	Amazon
2 10k Ohm resistors	2 x $0.10	$0.01	Amazon
Straps	$1.43	$0.19	Ali Express
3D Printing	$2.33	$0.30	Amazon
Total	$100.88	21.93	$122.81

Additional Costs

Item	Cost
Design Studio Tools	N/A
3D printer	$10 x 2 hours
Computer	$10 x 30 hours
Total	$320

References

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[3] Gait analysis helps children with Cerebral Palsy Keep pace (no date) *Braceworks Custom Orthotics*. Available at: https://braceworks.ca/2017/02/03/devices/lower-limbs/afo/gait-analysis-helps-children-with-cerebral-palsy-keep-pace/ (Accessed: February 28, 2023).

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