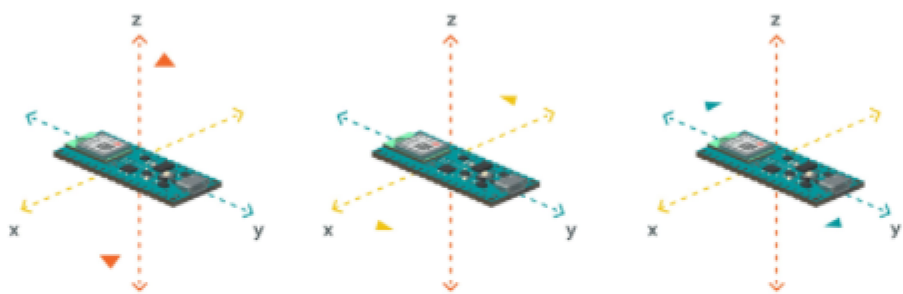
LAB4 - Jake Reilly
Team 7
IMU data collected collectively
IMU used: LSM9DS1
MCU used: Arduino Nano 33 BLE Sense

www.github.com/jathrei/180DA-WarmUp

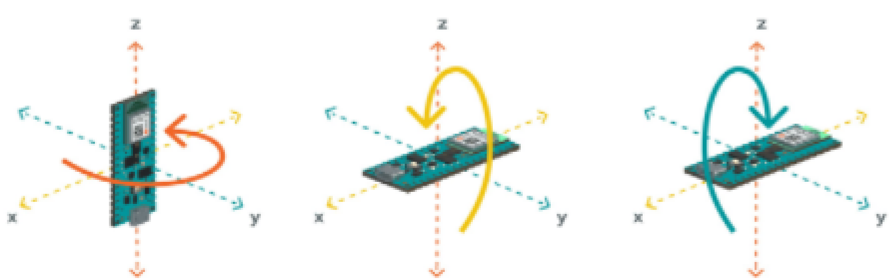
Part 1: Accelerometer Axes
(https://doc.arduino.cc/tutorials/nano-33-ble/imu_accelerometer)

For reference, the microusb is the front. The front is +y axis while back is -y axis. In the X plane, the right side is +x axis and left side is -x axis. Up is +z down is -z.



Gyroscope Axes
(https://docs.arduino.cc/tutorials/nano-33-ble-sense/imu_gyroscope)

Flat (with microusb in front as reference), rotating clockwise is +z and counter clockwise is -z (yaw). Rolling clockwise is +x and counterclockwise is -x. Pitch clockwise is +y and counterclockwise is -y.



When idle, the gravity acceleration is still present. Lifting upwards yields a higher gravity acceleration and downwards lessons the number.

Part 2: When idle, the following data stream is printed.

COM5

Send

aX	aY	aZ	gX (roll)	gY (pitch)	gZ (yaw)
-0.03	0.01	0.99	2.50	[illegible]	0.12
-0.03	0.01	0.99	2.26	1.40	0.12
-0.03	0.01	0.99	1.95	1.59	0.12
-0.03	0.01	0.99	1.59	1.65	0.12
-0.03	0.01	0.99	1.59	1.59	0.18
-0.03	0.01	0.99	1.40	1.34	0.18
-0.03	0.01	0.98	1.28	1.10	0.18
-0.03	0.01	0.97	1.65	0.61	0.00
-0.03	0.01	0.97	1.71	0.24	-0.06
-0.02	0.00	0.98	1.83	0.24	0.06
-0.02	0.00	0.98	1.89	0.24	0.00
-0.03	0.00	0.98	1.71	0.12	0.06
-0.03	0.00	0.98	1.77	0.00	0.00
-0.03	0.01	0.98	1.95	0.12	0.24
-0.04	0.01	0.99	1.77	0.31	0.06

Autoscroll Show timestamp Newline 115200 baud Clear output

As you can see, the acceleration for the z axis is roughly 0.98, which represents the gravity component. The other values, when idle, are close to 0 with a slight threshold due to drift. Compared to the acceleration components, the gyroscopic components are more affected by drift.

The following data (next page) characterizes the confusion matrix and compares the idle and non idle and their respective expected and predictive values. A good threshold for the expected is to account for the drifting values when idle.

Confusion Matrixes

idle

Expected | Predicted

idle | idle

1)

-0.07	-0.09	0.99	2.20	0.43	0.24
-0.07	-0.08	0.99	2.01	0.49	0.18
-0.06	-0.09	0.99	2.01	0.67	0.12
-0.06	-0.09	0.99	2.08	0.61	0.12
-0.06	-0.09	0.99	1.95	0.79	0.12
>-0.1	>-0.1	<1	<2	<1	<1

idle | idle

2)

-0.07	-0.07	0.99	1.95	0.49	0.06
-0.07	-0.07	0.99	1.71	0.37	0.06
-0.07	-0.07	0.99	1.89	0.43	0.00
-0.07	-0.07	0.99	1.77	0.49	0.12
-0.07	-0.07	0.99	1.77	0.37	0.06

idle | idle

-0.03	-0.07	0.99	1.95	0.49	0.06
-0.03	-0.06	0.99	1.95	0.49	0.06
-0.03	-0.06	0.99	2.08	0.61	-0.06
-0.03	-0.06	0.99	1.95	0.43	-0.06
-0.03	-0.06	0.99	2.01	0.49	-0.06

idle | idle

-0.03	-0.06	0.99	1.95	0.43	-0.06
-0.03	-0.06	0.99	2.01	0.49	-0.06

idle | idle

-0.03	-0.04	0.99	1.83	0.55	0.06
-0.03	-0.04	0.99	1.89	0.55	0.06
-0.03	-0.04	0.99	1.89	0.43	0.06
-0.03	-0.04	0.99	1.77	0.43	0.06
-0.03	-0.04	0.99	1.65	0.43	0.06

idle | idle

-0.03	-0.05	0.99	1.95	0.49	-0.06
-0.03	-0.05	0.99	2.01	0.49	-0.06
-0.03	-0.05	0.99	1.83	0.61	0.00
-0.03	-0.05	0.99	2.01	0.67	0.00
-0.03	-0.05	0.99	1.95	0.61	0.06

non-idle

Expected | Predicted

non idle — side to side — non idle

3.17	2.12	2.11	-156.74	-7.81	-96.86
2.27	1.64	2.13	-432.68	148.25	214.48
1.57	0.70	1.93	-599.91	311.28	467.53
1.14	-0.09	1.58	-687.13	413.51	596.19
0.74	-0.94	1.17	-693.48	411.44	619.57

non idle — going forward — non idle

-0.59	1.21	0.43	169.86	-135.31	419.80
0.18	3.37	0.84	111.57	-119.81	433.78
1.03	4.00	1.39	14.22	-112.30	447.39
1.87	4.00	1.76	-79.16	-47.67	458.01
2.29	4.00	1.36	-133.06	80.69	389.28

non idle — shaking — non idle

-1.42	0.47	0.95	0.31	-16.05	75.50
-1.42	0.46	1.01	27.53	-33.87	101.68
-1.45	0.49	1.05	40.47	-63.66	131.47
-1.44	0.39	1.07	47.18	-103.88	147.89
-1.42	0.21	1.20	46.75	-142.09	143.92

non idle — going upwards — non idle

non idle — going upwards — non idle

0.04	0.29	-0.04	98.88	114.44	-21.30
0.05	0.24	-0.36	93.51	116.46	-20.63
0.00	0.14	-0.70	82.40	114.32	-18.68
0.08	0.13	-0.95	60.97	99.98	-14.04
0.17	0.09	-1.05	45.84	72.57	-12.51

non idle — shaking — non idle

-2.76	2.55	-3.21	21.00	86.18	217.59
-2.66	3.40	-3.74	22.95	-27.40	104.68
-2.46	3.78	-3.75	-1.40	-131.04	-27.59
-2.36	3.55	-3.18	-58.53	-239.38	-146.42
-2.25	3.09	-2.12	-130.98	-351.38	-227.48

Part 3: Determine uppercut vs downwards

In the Z axis, I implemented code that determines whether the sampled data was positive or negative acceleration in the Z axis. A positive acceleration was classified as an uppercut while a negative acceleration classified as a downwards spike.
(https://docs.arduino.cc/tutorials/nano-33-ble-sense/get-started-with-machine-learning)
The IMU data is assumed to be idle unless threshold acceleration is passed.

```
-1.658,-0.107,-2.821,-72.937,-214.905,131.470
Downwards Spike!

-1.361,0.363,-2.207,146.423,-628.540,126.831
Downwards Spike!
```

```
-2.558,0.059,2.856,188.171,-1093.689,-214.783
Uppercut!

-0.991,-0.312,3.427,155.212,-869.812,-293.579
Uppercut!

-1.082,-0.672,2.682,-35.645,-537.720,-130.676
Uppercut!
```

Part 4: Utilizing a decision tree —-> Action (x acceleration, y acceleration, z acceleration)
Downwards spike is there all negative (-, -, -)
Uppercut is all accelerations positive (+, +, +)
A circular motion contributes depends on the individual combination, but as a clockwise example→> (+, -, +)

To ensure the decision tree accounted for drift or false readings, the first few samples were compared to determine the direction of acceleration.

Difficulty – The difficulty depended largely on the actions. Since the actions used in our lab group were quite simple, we developed a simple model. More complex actions would require a more indepth decision tree.

Part 5: Uploaded to github www.github.com/jathrei/180DA-WarmUp