Kepros Posture Training Device

DEC1605

The Team

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General Info of the Device

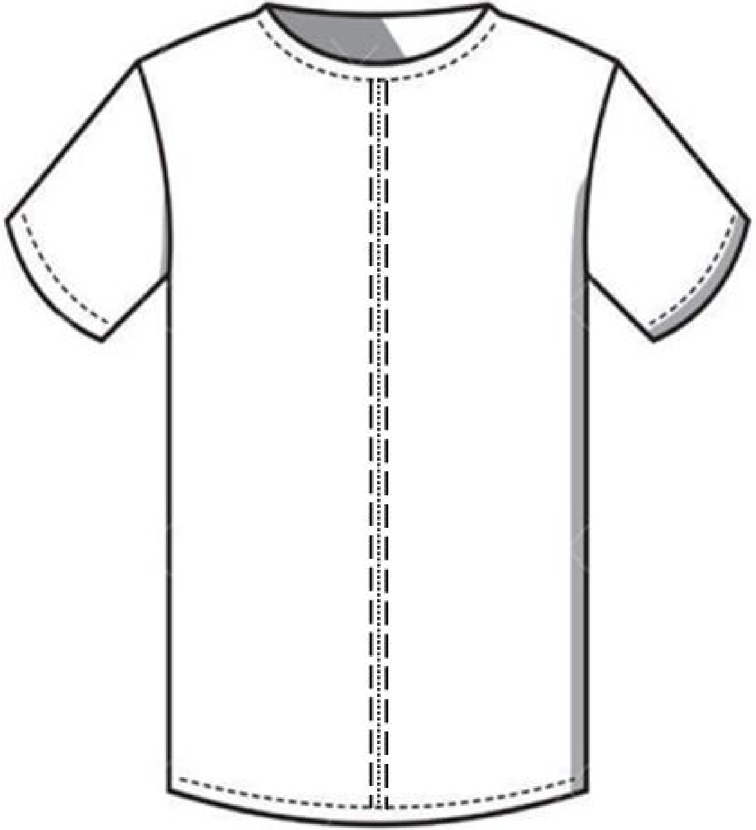
What: A wearable shirt that measures user posture over a specified time period

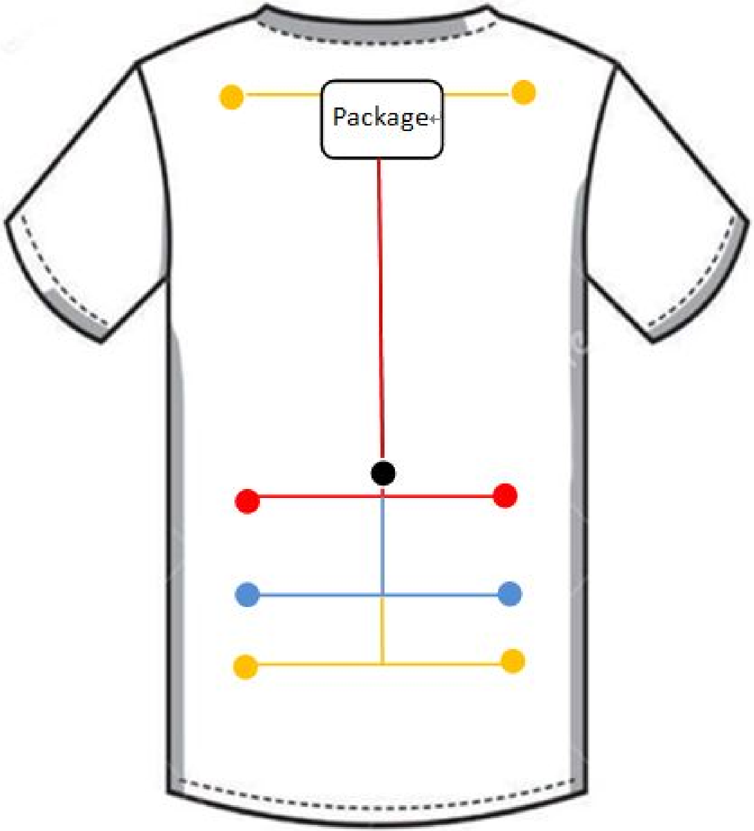
Users: Patients of Physical Therapists (athletes, anyone with back pain)

Customer: Physical therapists

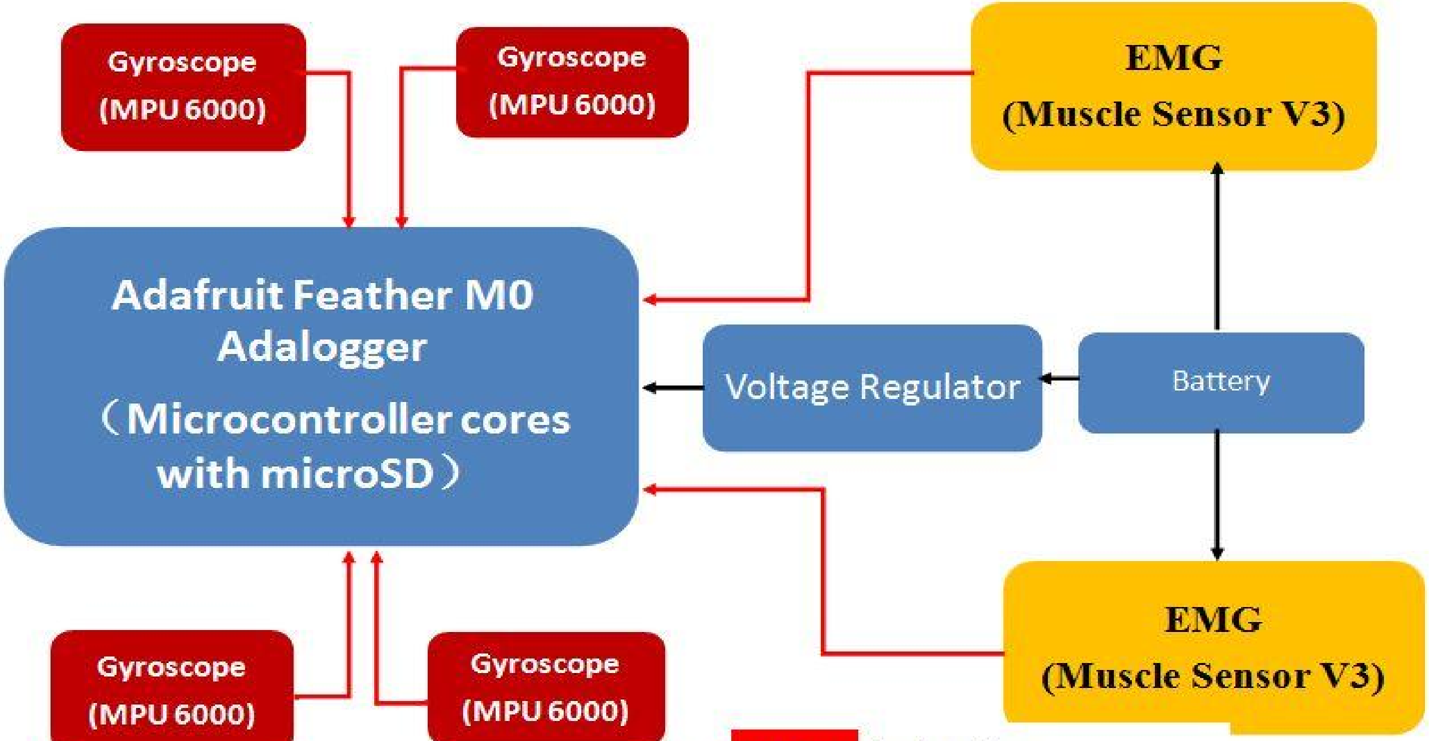
Why: Gather data unattainable in the current market

General Design





Block Diagram



- 🟥 Red line is data line
- ■ Black line is power line

Sensors

- **Muscle Sensor V3 (EMG)**

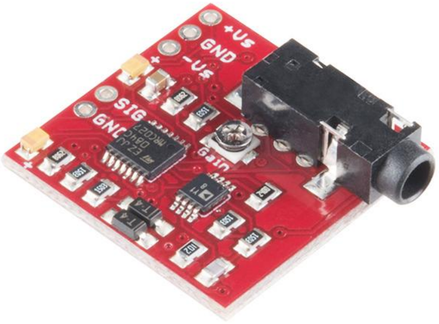
  Measure muscle activities by

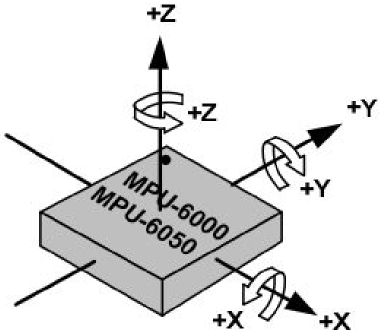
  detecting its electric potential

- **MPU 6000**

  3-axis accelerometer

  3-axis gyroscope



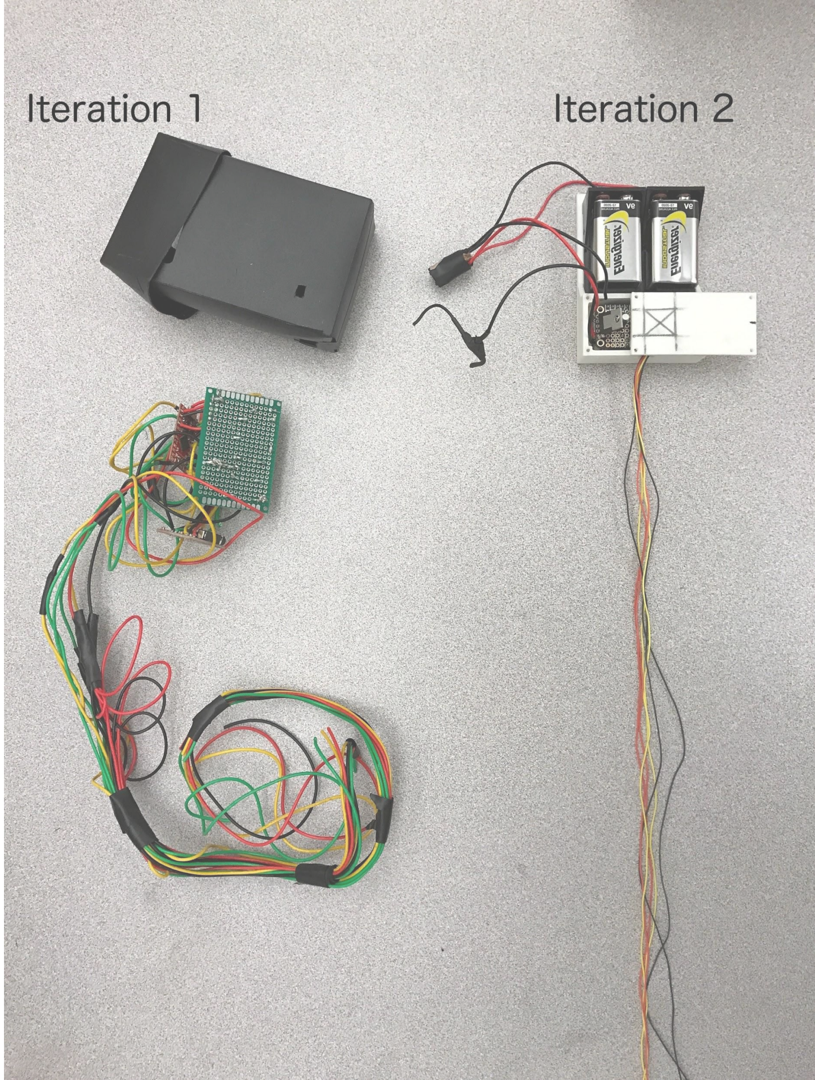


Problem: Big and Clunky

Issue: The capstone was a bunch of breadboards and wires haphazardly stored in a card game deck box.

Reason: Working with the large box on the hip would interfere with measurements

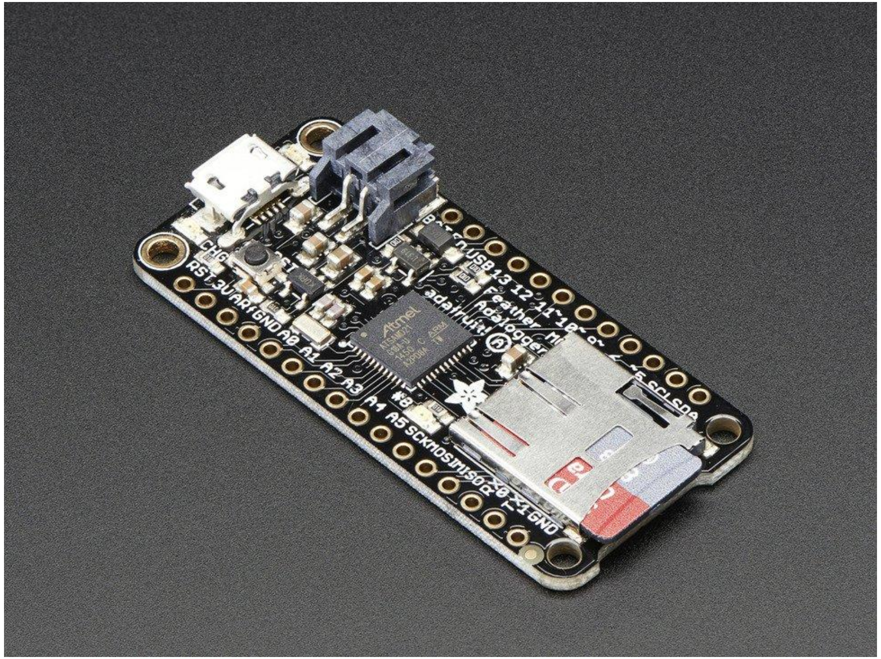
Solution: Rework the wiring harness and microcontroller to fit in a smaller more manageable space



The Brain

The Adalogger M0

-Higher clock speed
-Variable analog pins
-Integrated SD reader



Problem: Adapting the New to the Old

Issue: Getting familiar with the ins and out of the new and old hardware

Reason: Getting functionality for final product

Solution: Hard work and lots of determination

Software we are using

Arduino IDE

- Using Arduino Language and libraries to make the Adafruit board compatible
- Using 2 I2C buses to read from 4 sensors

Eclipse

- Java Code, Runs Arduino Code
- Swing for GUI
- Library to read from Arduino’s Serial, Saving Data to microSD card

Where we are currently

Reading data from 4 sensors simultaneously

Inconsistent readings, address not always recognized

Reading values from the EMG powered from battery connect to the bicep and back muscle

Converting Data to Angles

Testing angular data with our measured data

Demo

Understandable Angle Readings

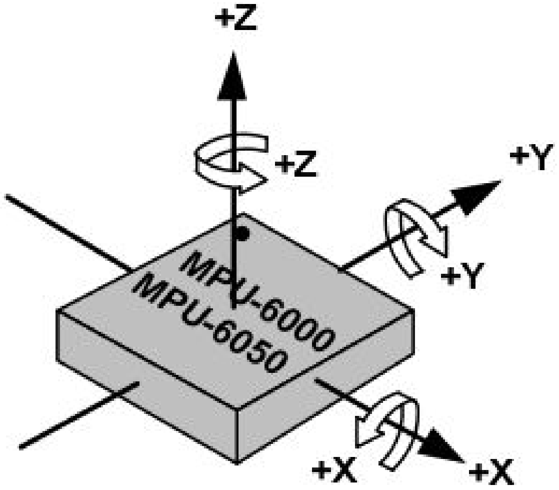
- 3-axis accelerometer

  Acceleration component

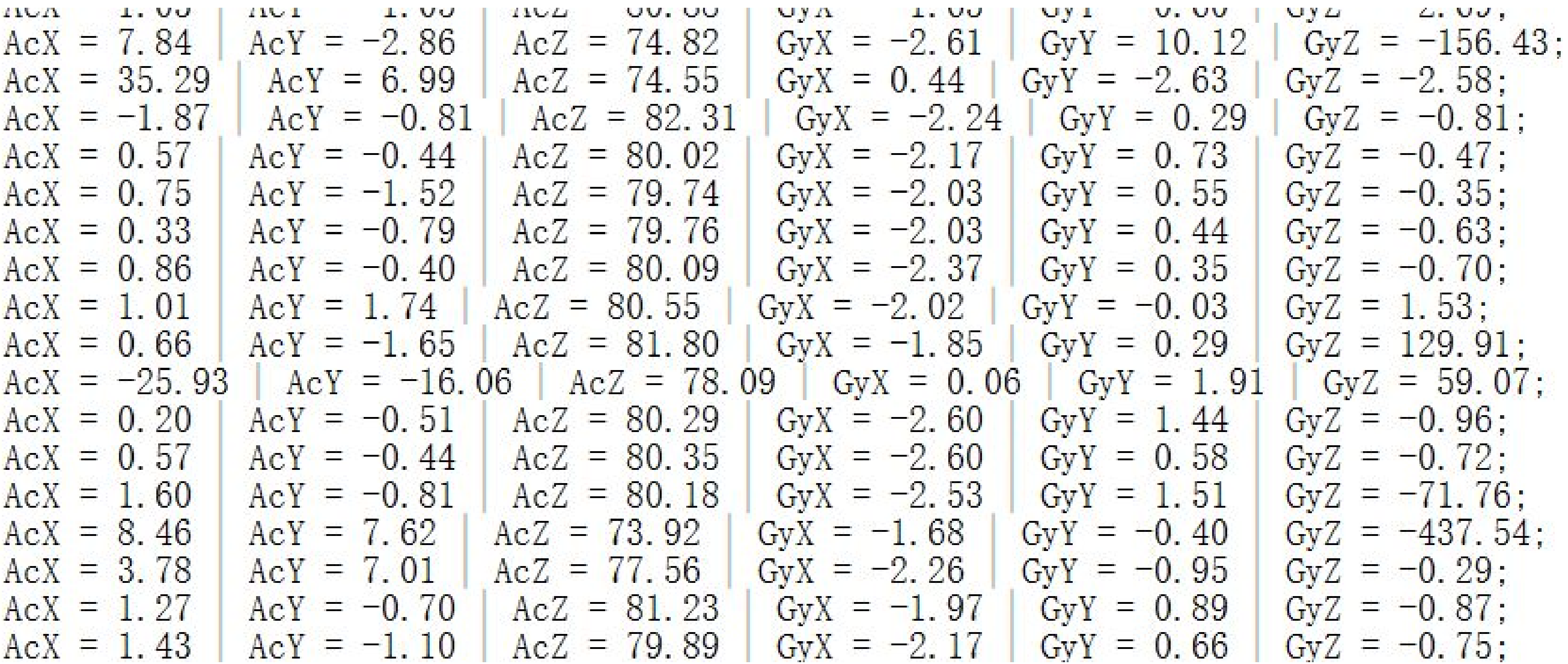
  due to gravity

- 3-axis gyroscope

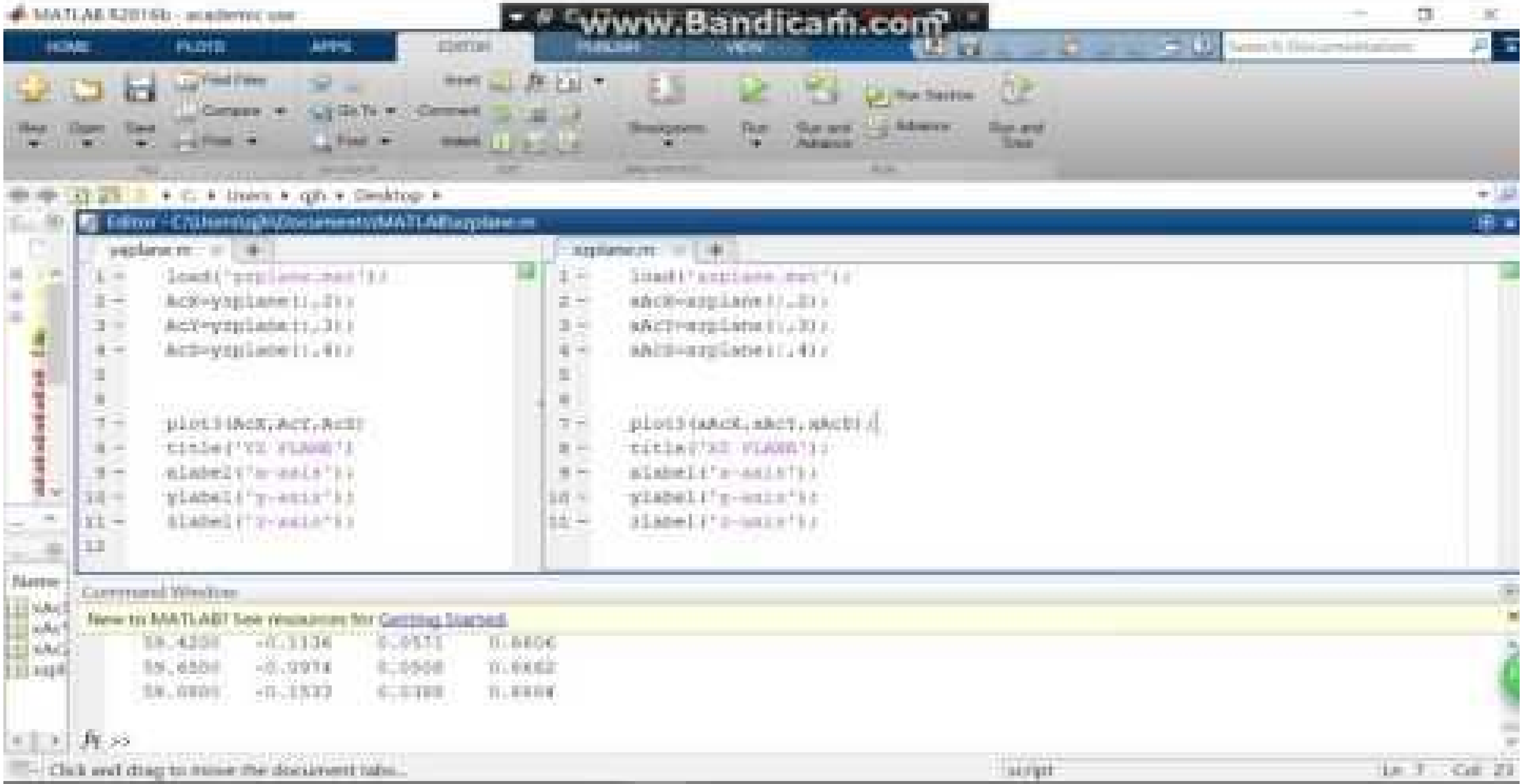
  angular velocity



Understandable Angle Readings



```
AcX = 7.84 | AcY = -2.86 | AcZ = 74.82 | GyX = -2.61 | GyY = 10.12 | GyZ = -156.43;
AcX = 35.29 | AcY = 6.99 | AcZ = 74.55 | GyX = 0.44 | GyY = -2.63 | GyZ = -2.58;
AcX = -1.87 | AcY = -0.81 | AcZ = 82.31 | GyX = -2.24 | GyY = 0.29 | GyZ = -0.81;
AcX = 0.57 | AcY = -0.44 | AcZ = 80.02 | GyX = -2.17 | GyY = 0.73 | GyZ = -0.47;
AcX = 0.75 | AcY = -1.52 | AcZ = 79.74 | GyX = -2.03 | GyY = 0.55 | GyZ = -0.35;
AcX = 0.33 | AcY = -0.79 | AcZ = 79.76 | GyX = -2.03 | GyY = 0.44 | GyZ = -0.63;
AcX = 0.86 | AcY = -0.40 | AcZ = 80.09 | GyX = -2.37 | GyY = 0.35 | GyZ = -0.70;
AcX = 1.01 | AcY = 1.74 | AcZ = 80.55 | GyX = -2.02 | GyY = -0.03 | GyZ = 1.53;
AcX = 0.66 | AcY = -1.65 | AcZ = 81.80 | GyX = -1.85 | GyY = 0.29 | GyZ = 129.91;
AcX = -25.93 | AcY = -16.06 | AcZ = 78.09 | GyX = 0.06 | GyY = 1.91 | GyZ = 59.07;
AcX = 0.20 | AcY = -0.51 | AcZ = 80.29 | GyX = -2.60 | GyY = 1.44 | GyZ = -0.96;
AcX = 0.57 | AcY = -0.44 | AcZ = 80.35 | GyX = -2.60 | GyY = 0.58 | GyZ = -0.72;
AcX = 1.60 | AcY = -0.81 | AcZ = 80.18 | GyX = -2.53 | GyY = 1.51 | GyZ = -71.76;
AcX = 8.46 | AcY = 7.62 | AcZ = 73.92 | GyX = -1.68 | GyY = -0.40 | GyZ = -437.54;
AcX = 3.78 | AcY = 7.01 | AcZ = 77.56 | GyX = -2.26 | GyY = -0.95 | GyZ = -0.29;
AcX = 1.27 | AcY = -0.70 | AcZ = 81.23 | GyX = -1.97 | GyY = 0.89 | GyZ = -0.87;
AcX = 1.43 | AcY = -1.10 | AcZ = 79.89 | GyX = -2.17 | GyY = 0.66 | GyZ = -0.75;
```



```
load('yzplane.mat');
AcX=yzplane(:,2);
AcY=yzplane(:,3);
AcZ=yzplane(:,4);


plot3(AcX,AcY,AcZ)
title('YZ PLANE')
xlabel('x-axis');
ylabel('y-axis');
zlabel('z-axis');
```

```
load('xzplane.mat');
aAcX=xzplane(:,2);
aAcY=xzplane(:,3);
aAcZ=xzplane(:,4);


plot3(aAcX,aAcY,aAcZ);
title('XZ PLANE');
xlabel('x-axis');
ylabel('y-axis');
zlabel('z-axis');
```

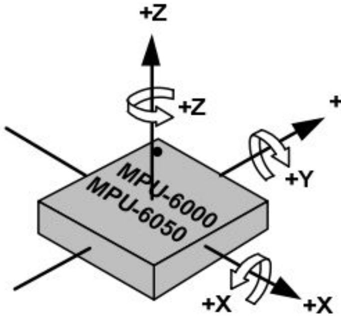
```
   59.4200   -0.1136    0.0511    0.8606
   59.6200   -0.0974    0.0508    0.8662
   59.0800   -0.1533    0.0388    0.8888

fx >>
```

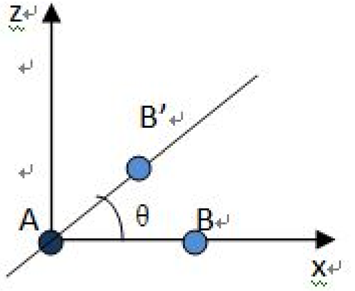
Understandable Angle Readings

- 3-axis accelerometer

    xz-plane measurement

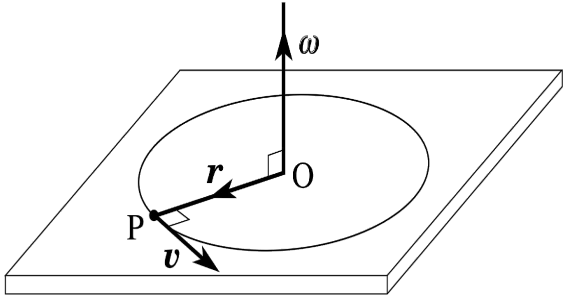
    yz-plane measurement





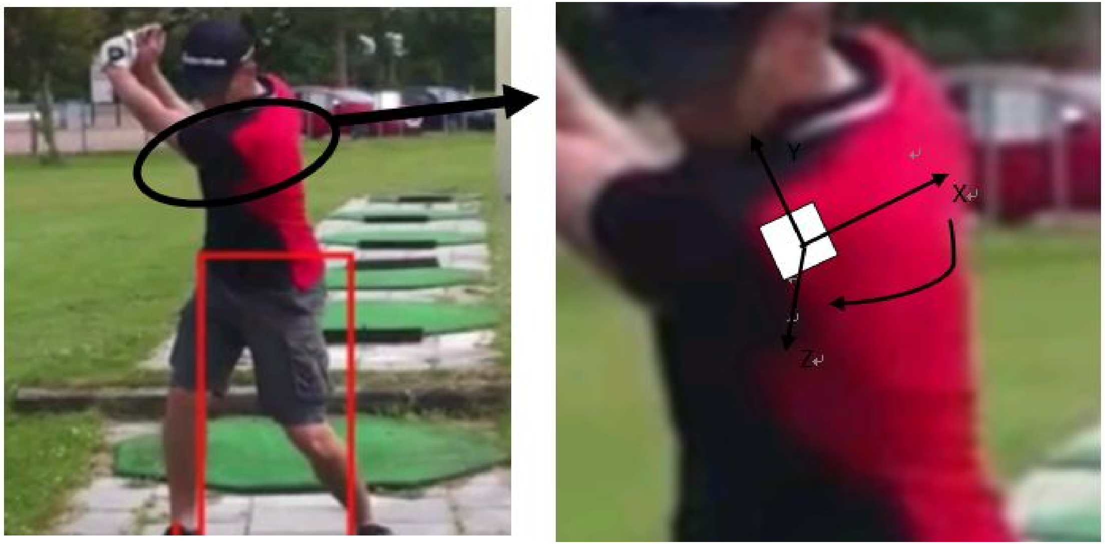
- 3-axis gyroscope (angular velocity)

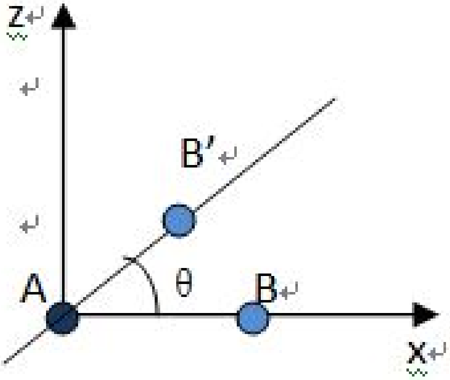
    xy-plane measurement



Angle Calculation Formula

Accelerometer

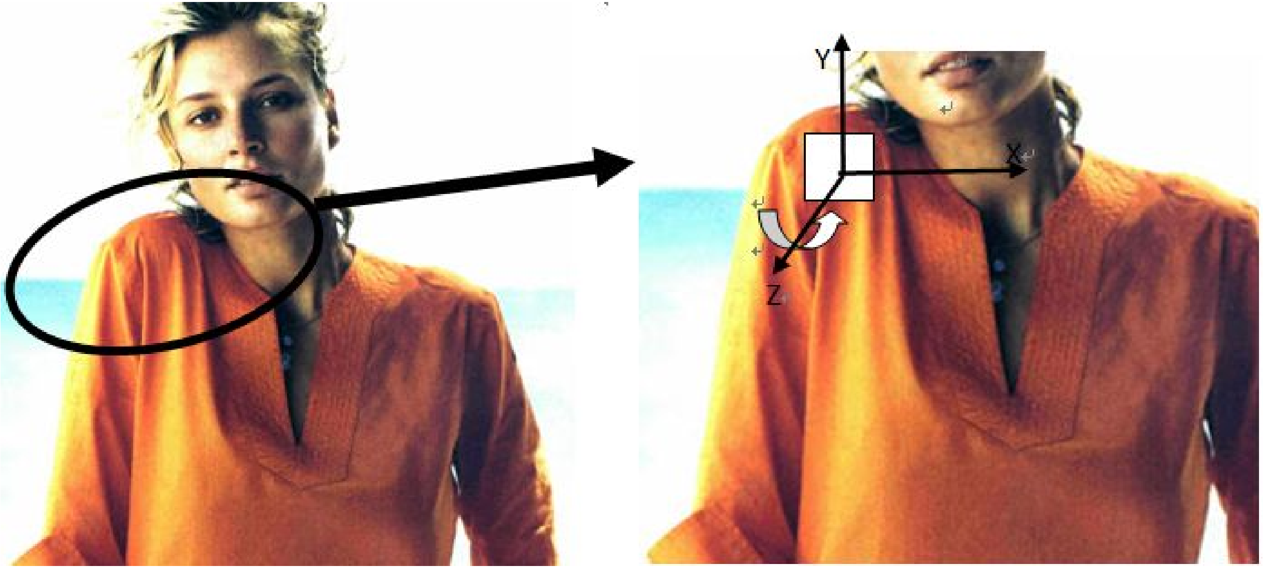


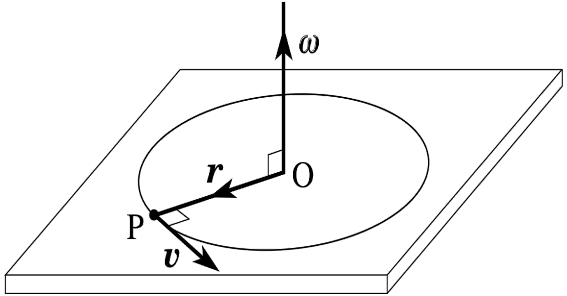


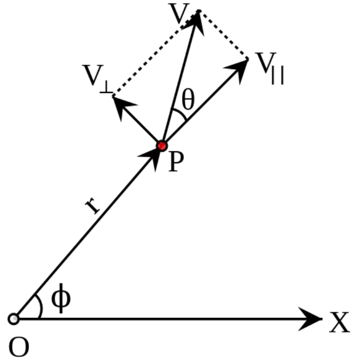
$$\theta = \tan^{-1}(AcX_{B'-B} / AcZ_{B'-B})$$

Angle Calculation Formula

Gyroscope







$$\emptyset = \int_{t1}^{t2} \omega \, dt$$

Test Plan: Custom Agile Methodology

- **Hardware:**
    a. **Phase One -** Proof of design concept
    b. **Phase Two -** Optimization of design
    c. **Phase Three -** Integration with device
- **Software:**
    a. **Phase One -** Proof of design concept
    b. **Phase Two -** Optimization of design
    c. **Phase Three -** Integration with device
- **Prototype:**
    a. **Phase 1 -** Collaboration of components
    b. **Phase 2 -** Optimization of prototype device

Questions and Wrap Up

Costs

Gyroscope/Accelerometer (MPU): $50.00 each (4 total)

Three pad EMG: $45.00

Adalogger Board: $35.00

Wiring and Soldering: $5.00

Casing: $2.00

9V Batteries: $5.00

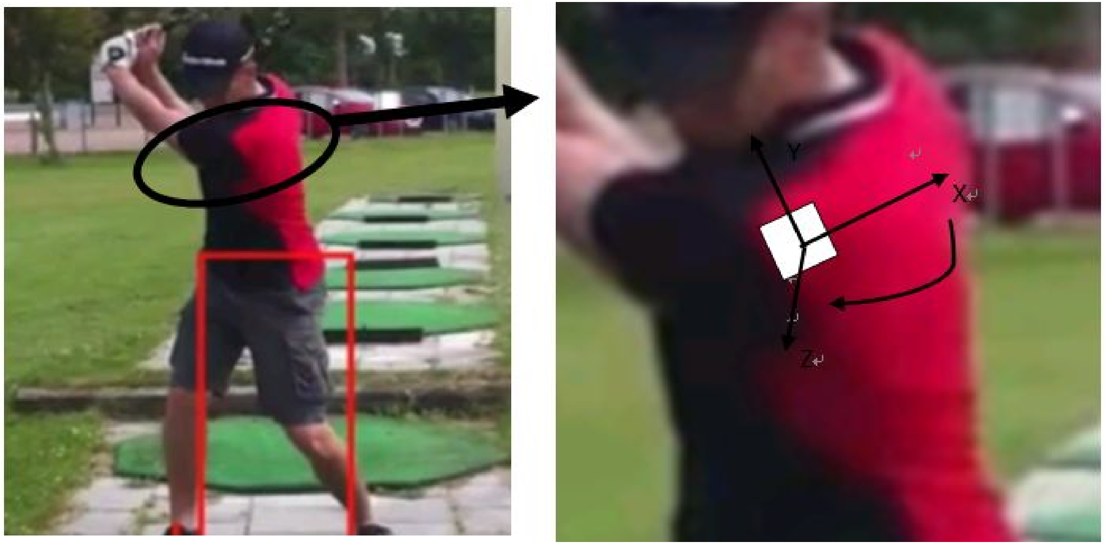
Shirt: $40.00

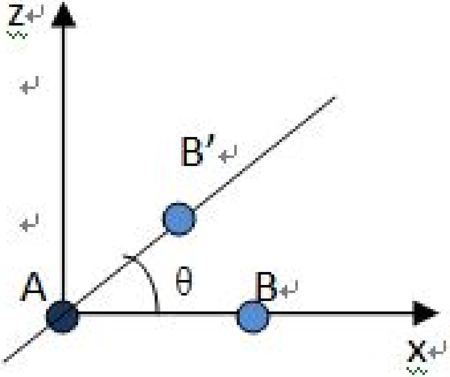
Conductive Adhesive Padding: $15.00

SD Card: $15.00

Angle Calculation Formula

Accelerometer

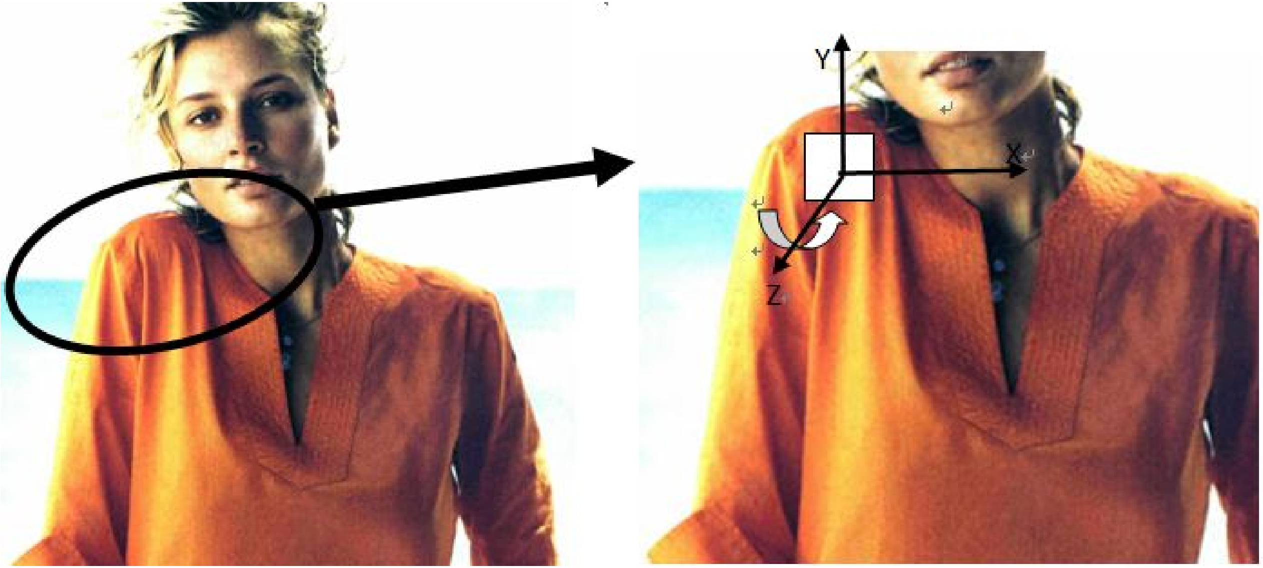


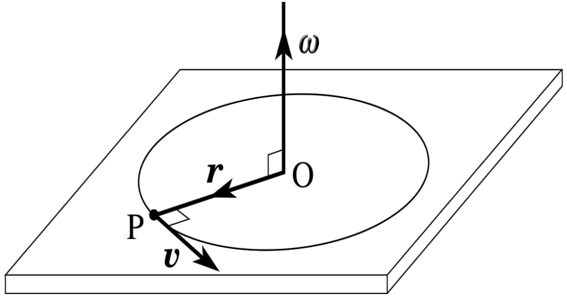


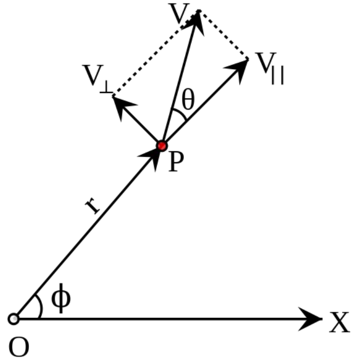
$$\theta = \tan^{-1}(AcX_B / AcZ_B)$$

Angle Calculation Formula

Gyroscope







$$\emptyset = \int_{t1}^{t2} \omega \, dt$$