SENSORS AND ACTUATORS

PROJECT REPORT

PIEZOELECTRIC SENSOR FOR GAIT ANALYSIS

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What is gait analysis?

Gait analysis is the study of human gait, or how people walk and run. It entails watching, measuring, and evaluating how different body parts move throughout the gait cycle, which is the series of motions that take place from one foot contact to the next.

Gait analysis can be done using a variety of techniques, such as pressure sensors, force plates, motion capture systems, video recording, and visual observation. Clinicians can identify areas of weakness or abnormality and create specialised treatments and rehabilitation programmes to improve function and lower the risk of pain or injury by analysing gait patterns.

The Experiment

Components Required

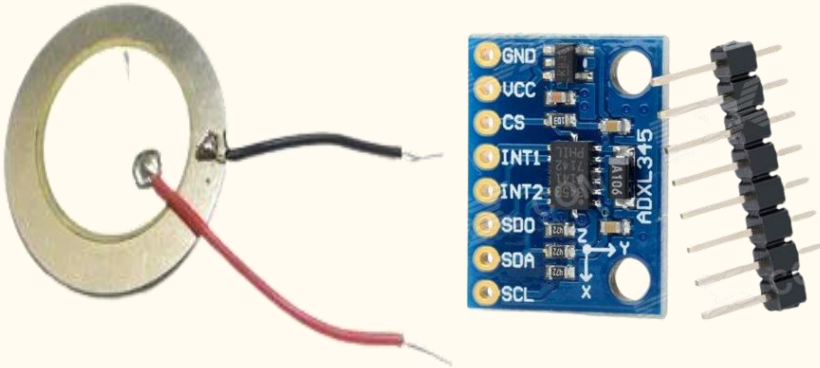
- Piezoelectric sensors - 4
- Mini Breadboard - 1
- Arduino UNO - 1
- Accelerometer ADXL 345 - 1
- Resistor - 1
- Jumper wires

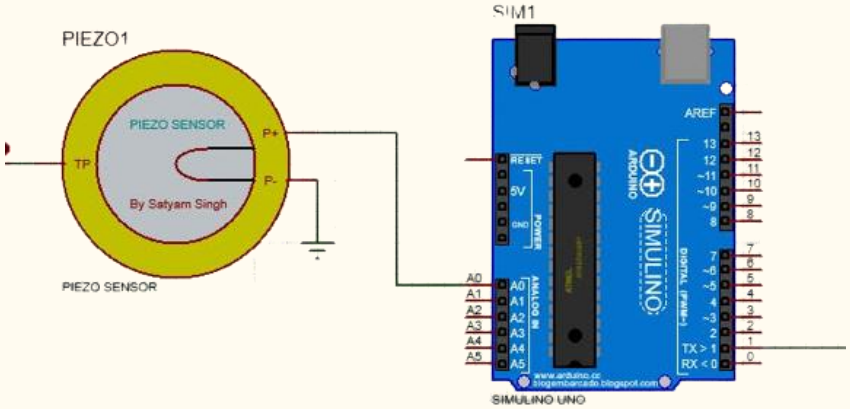
Procedure

1. Take the piezoelectric sensors and connect them in series in a set of two. Solder the outer rim and the inner part to jumper wires.

2. One pair is placed at the top part of insole near the toes while the other is placed at the lower part near the ankle.

3. Connect the sensor and arduino uno to the mini breadboard using jumper wires such that the rim of sensor is connected to the ground of arduino uno and the inner part is connected to A1 of arduino uno.

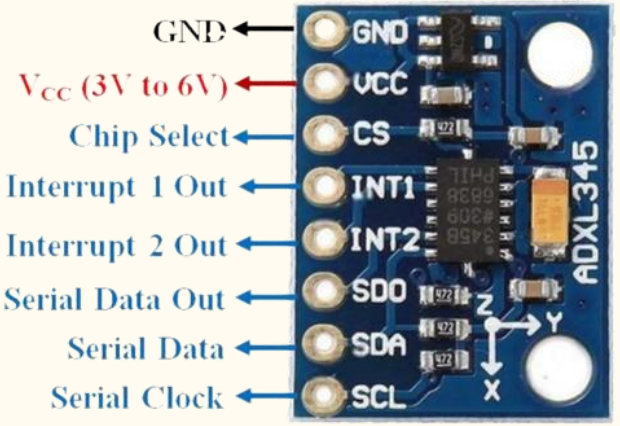


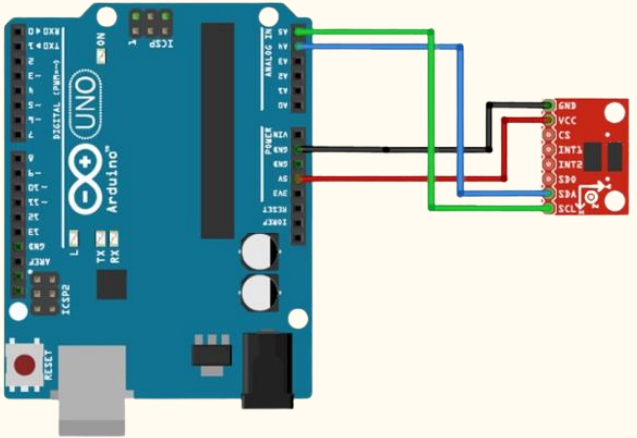


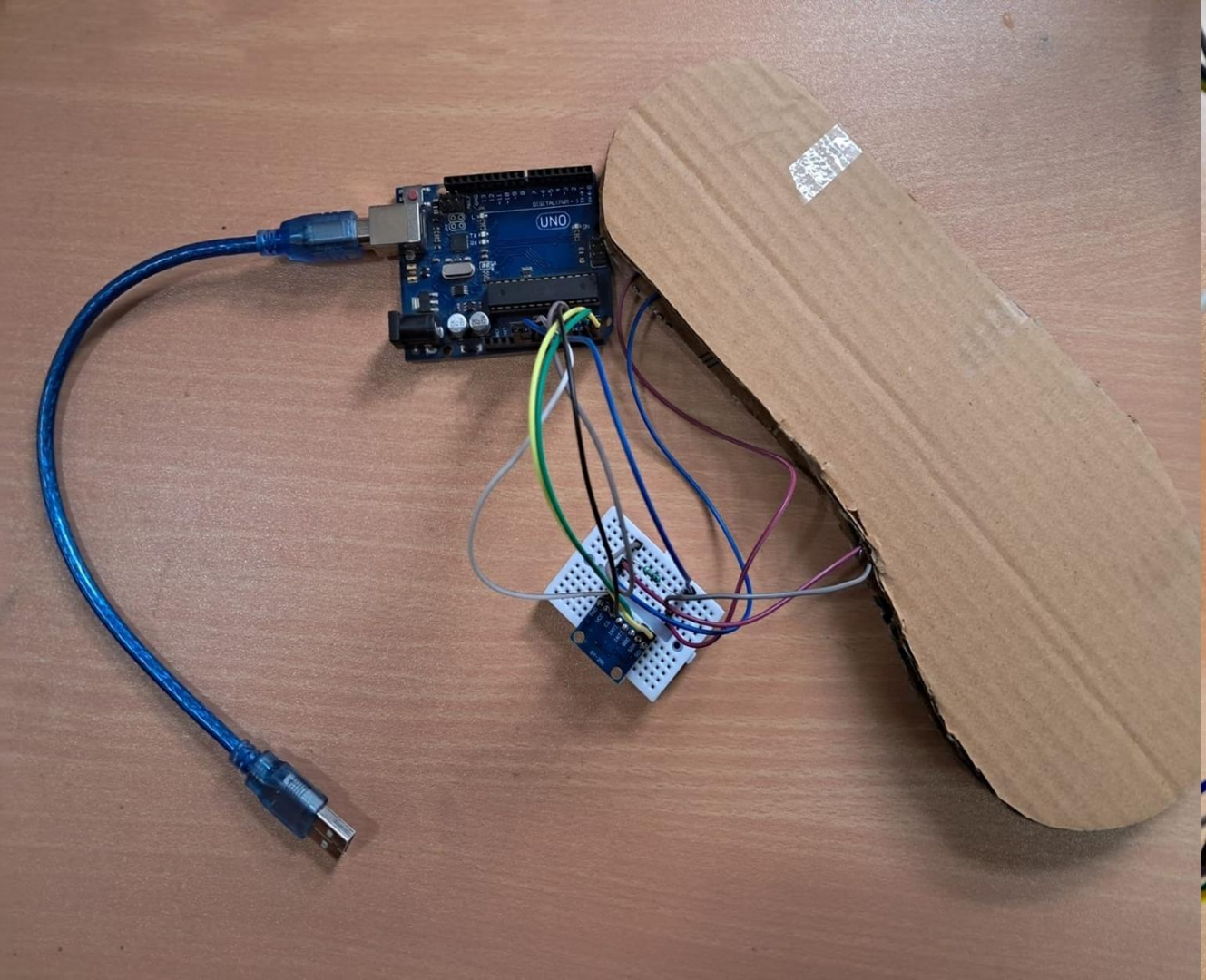
4. Fix accelerometer ADXL 345 in mini breadboard and connect its ground , vcc, SDA and SCL to ground , 5V , A4 and A5 respectively.

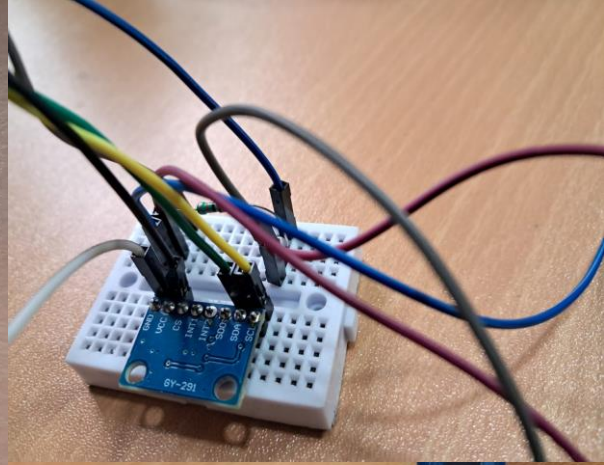
5. Prepare the mini breadboard and code according to the required output.

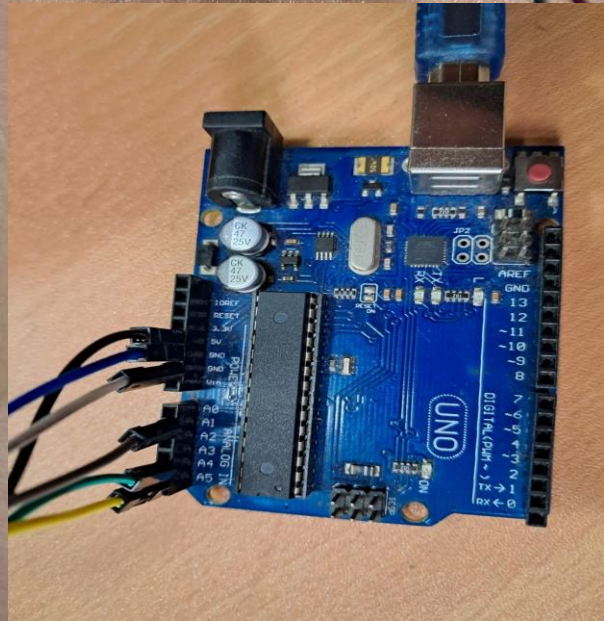
6. Select board and port in laptop for arduino uno, then verify and upload the code and get the output and graphical readings.






UNO


GY-291

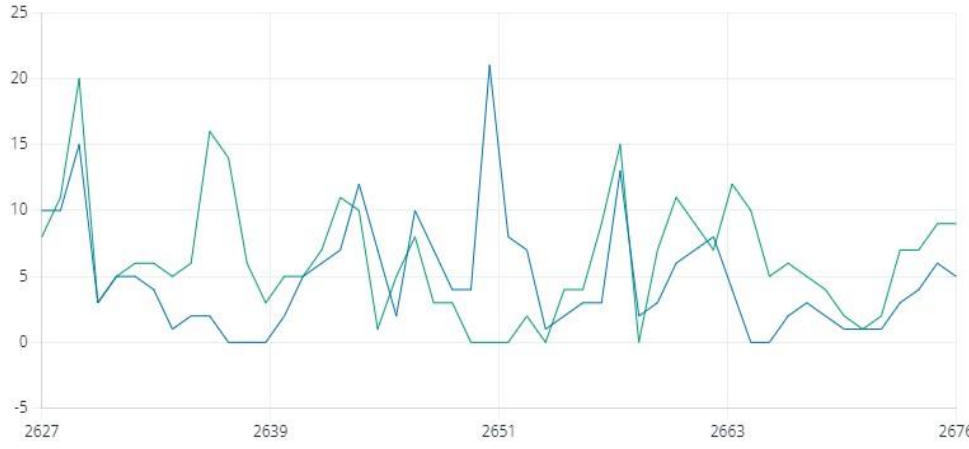

UNO
AREF
GND
13
12
~11
~10
~9
8
7
~6
~5
4
~3
2
TX→1
RX←0
DIGITAL (PWM~)
POWER
ANALOG IN
IOREF
RESET
3.3V
5V
GND
Vin
A0
A1
A2
A3
A4
A5

CODE AND OUTPUT

```ino
#include <Wire.h>
int ADXL345 = 0x53;
int X_out, Y_out, Z_out;

void setup() {
  Serial.begin(9600);
  Wire.begin();
  Wire.beginTransmission(ADXL345);
  Wire.write(0x2D); //talk to POWER_CTL Register - 0x2D
  Wire.write(8); // Bit D3 High for measuring enable (8dec -> 0000 1000 binary)
  Wire.endTransmission();
  delay(10);
  Serial.begin(9600);//enable serial monitor
  for (byte a = 2; a <= 6; a++) {
    pinMode(a, OUTPUT);
  }
  for (byte b = 2; b <= 6; b++) {
    pinMode(b, OUTPUT);
  }
}

void loop() {
  Wire.beginTransmission(ADXL345);
  Wire.write(0x32);
  Wire.endTransmission(false);
  Wire.requestFrom(ADXL345, 6, true);
  X_out = ( Wire.read() | Wire.read() << 8);
  Y_out = ( Wire.read() | Wire.read() << 8);
  Z_out = ( Wire.read() | Wire.read() << 8);
  Serial.print(X_out);
  Serial.print(" ");
  Serial.print(Y_out);
  Serial.print(" ");
  Serial.println(Z_out);
  delay(100);
  int value1 = analogRead(A1);
  Serial.print(value1);
  //print serial monitor
  for (int a = 1; a <= 5; a++) {
    if (value1 > a * 10) {
      digitalWrite(a + 1, HIGH);
    } else {
      digitalWrite(a + 1, LOW);
    }
    delay(10);
  }
    int value2= analogRead(A1);//read analog value and put in to the variable
    Serial.print(" | ");
    Serial.print(value2);
    Serial.println();
for (int b = 1; b <= 5; b++) {
    if (value2 > b * 10) {
      digitalWrite(b + 1, HIGH);
    } else {
      digitalWrite(b + 1, LOW);
    }
    delay(10);
  }
}
```



Hypothesis

The effect of first releasing the sensor followed by the strike can be seen with a time delay. If only the time delay between strikes is considered, moving forward and backwards can be detected. If the magnitude of the strikes is as well considered, walking and running can be distinguished from each other.

Variables that may affect the outcome...

- Variability: Human gait is highly variable, and there is significant inter-individual variation in gait patterns. This can make it difficult to compare gait patterns across individuals or to establish normative values.
- Technical limitations: Different equipment and software systems can produce different results, making it difficult to compare data across studies.
- Complexity: Gait is a complex motion involving multiple joints and muscles. This complexity can make it difficult to isolate the contribution of specific factors to changes in gait patterns.

Conclusion

In this work, piezoelectric-based mechanical sensors were used to design an insole. The design options for piezoelectric insoles are expanded by the insole with clearly defined artificial cavities. Using 3D printing techniques, a field with enormous potential, it is possible to design more intricate structures. Custom insoles with movable local sensitivities can be created in this situation to accommodate various application fields. Another benefit of using piezoelectric sensors is the readout circuit, which is straightforward and made of inexpensive discrete components.