Virtual Gloves Project with Flex / Force and Pressure Capabilities

- **Final Video:** https://drive.google.com/file/d/1Nbzjs-9L2LU9vQgTDTiS72lKytQIpyff/view

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Introduction:

1. Statement of Purpose:

The design purpose of our project was to create a virtual keyboard using flex sensors, force sensors, and vibration motors. The keyboard would replace the physical keyboard and allow users to type numbers and letters on any surface. It would only depend on muscle movement and finger pressure. The device would only require a small surface area for applying pressure in the force resistors and allow for usage across different devices. Since the gloves do not depend on finger location such as in physical Bluetooth keyboards available, the settings would depend on muscle memory of numbers and letters. The problem this solves is the need for a physical keyboard, and it assists us in making the difference in typing skills across all devices unified, which eliminates the need for muscle memory to re-program itself for different devices. What makes this unique is that it does not actually require a large smooth surface compared to virtual bluetooth keyboards available, and instead only needs a small area for precise bending of fingers.

This project is something we felt was exceptional as it encourages the digitalization and minimization of electronic devices, something that is currently crucial. For this project, we all collectively researched into the new technologies that make electronics smarter and found that the one common problem across digital devices is the difference in their screen sizes and thereby their keyboards. The transition for users between phones and even larger devices such as laptops is not smooth; it requires a certain amount of effort that can be eradicated via these gloves. Some projects similar to this that we were looking at were the creation of a miniature CNC machine, one that could create miniature parts, but the difference is that the need for a pair of virtual gloves outweighed the need for the creation of a CNC machine, and that these gloves were more likely to be successful than the CNC machine.

2. Initial Ideas:

At the start, our idea was to create a pair of gloves that a person can use as a keyboard for any device - where a person could move their fingers the system would output the desired characters. We started by thinking about hand movements and bending the fingers to certain angles/positions to detect whether someone is just resting their finger or has actually started to type. We knew that we had to use a flex sensor to detect the angle of the bend, but we also needed something to register a “press”, so we thought of using a force sensitive resistor to determine actuation force. Finally, we realized that when you type on a keyboard, you usually get feedback, whether it is feeling the keycap bottom out at the end of travel (like mechanical keyboards), or some sort of haptic feedback (smartphones, smartwatches, etc.). We felt like the best implementation for a glove was the haptic path, and that small vibration motors could be attached to the wrist so a user can feel the system acknowledge that a key was pressed.

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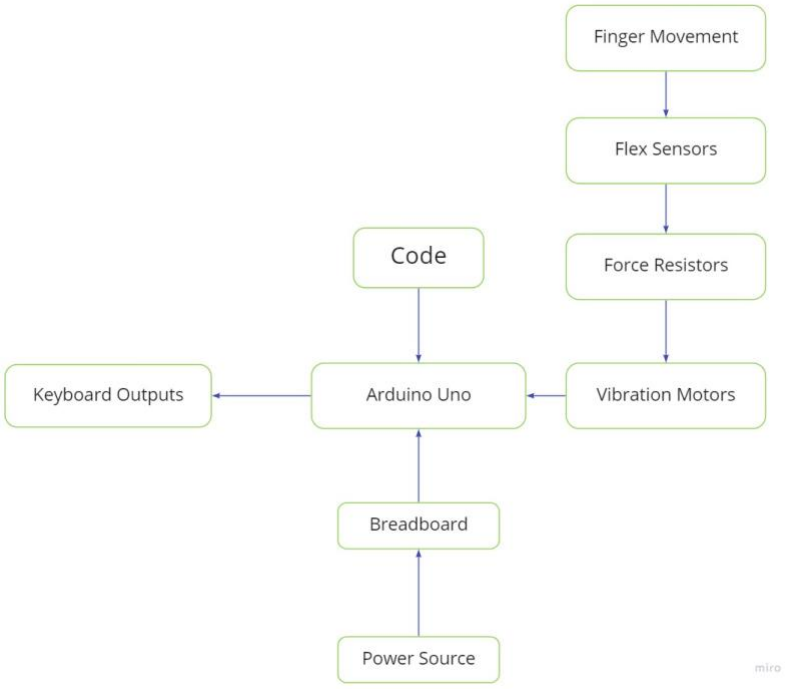

Figure #1: Block Diagram of system functionality. The Arduino Code and Finger Movement served as the original inputs and through the sensors and power would output keyboard values.

3. Results:

In the end, we were unfortunately unable to achieve all the goals that we had set at the start. We were only able to use two fingers and were relegated to using binary instead of actual ASCII characters. We also had to skip the vibration motors, as that was an auxiliary component that was not critical to the main design. Despite setbacks, we were able to successfully set up a system on a glove - using an Arduino, a breadboard, a flex sensor, and a FSR - which activates upon touch and can output 2 different "letters" or signals depending on how bent a finger is (e.g. binary 0's and 1's).

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Design

1. Design Details:

The user would start off in resting position without flexing the finger or applying pressure at the tip. When the flex sensor was flexed in a certain position, the resistance would increase and the voltage reading across the flex sensor would be measured. This value would then be mapped in the program and established within which range of position values it was. In the case of the force sensing resistor, the resistance associated with this sensor would decrease and the voltage reading across the sensor was taken. The value would then be mapped in the program and the range of values it fell into would be established. According to both the input from force sensing resistor (A0 input) and flex sensor (A1), the value intended by the value would be printed in the Arduino Serial Monitor.

2. System overview:

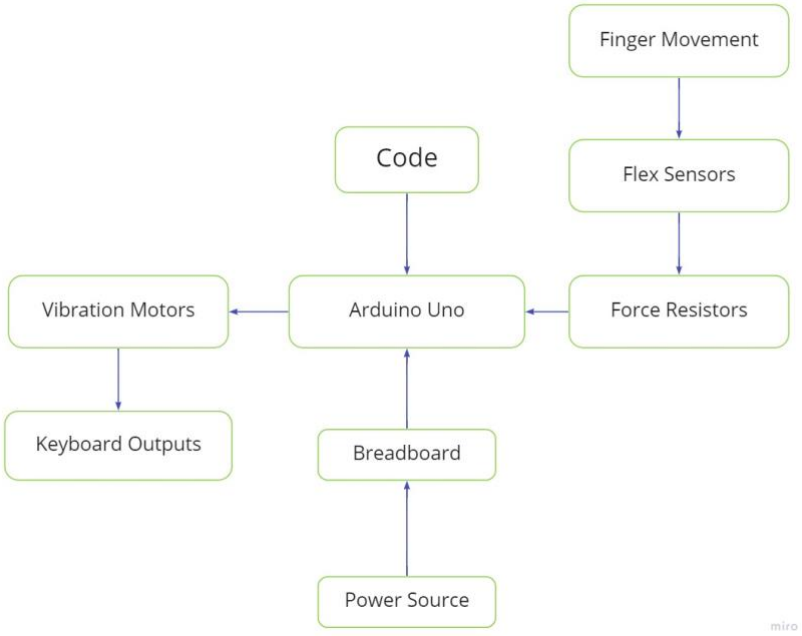

Figure #2: Modified Block Diagram for virtual glove system.

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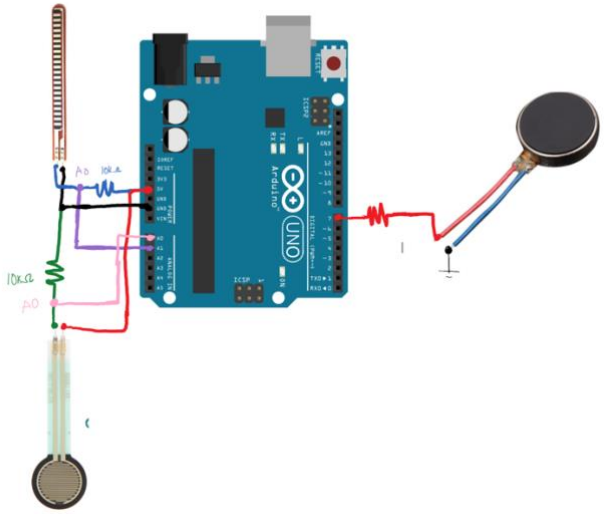

Figure #3: Physical Diagram for one-finger setup that would generate 2 values on the Virtual Keyboard.

3. Parts:

- 2 Vibration Motors: 2pcs 5.0v Vibrating Vibration Motor DC Motor for Arduino DIY Projects [$5.12]
- 4 10kΩ Resistors [inventory]
- 2 LEDs [inventory]
- 4 Sparkfun Flex Sensors: 4.5 Inch Flex Sensor 10-40K Ohms [$16*4]
- 4 Force Sensitive Resistors :Force sensing resistors, 0.5 inch, circle, 1oz - 22lb, flexible [$4.17*4]
- 1 Pair of Double-lined Gloves[$25]
- 1 Arduino: Arduino Uno R3 [inventory]
- 1 Breadboard [inventory]
- 1 Prototyping shield: Adafruit Proto Shield for arduino projects [$10 (optional)]

4. Problems and Challenges:

One of the obstacles that we ran into was getting the sensors on the glove and getting 3 different values for the flex sensor. It was also challenging as using tape to stick the flex sensor restricted movement. We tried to use string, but this was not strong enough. We only had 2 flex sensors because of its price and therefore we weren't able to create a full keyboard. The vibration motors gave a bigger response for each character than we wanted even after increasing the resistance and delay. The glove was very thick and restricted movement even without the flex sensor attached on the fingers. In addition, we struggled with adjusting the values of the FSR and Flex Sensor to make it viable.

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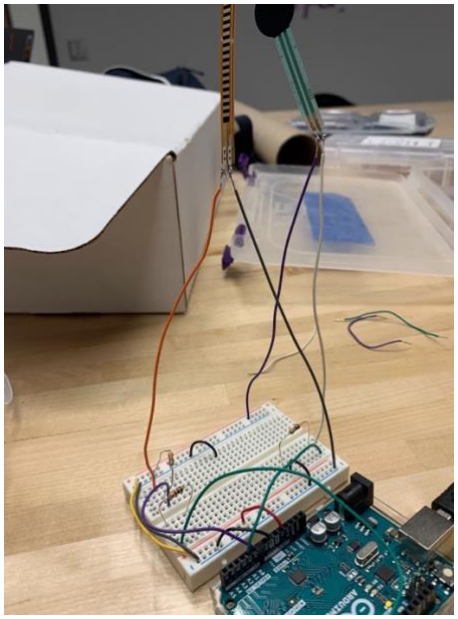

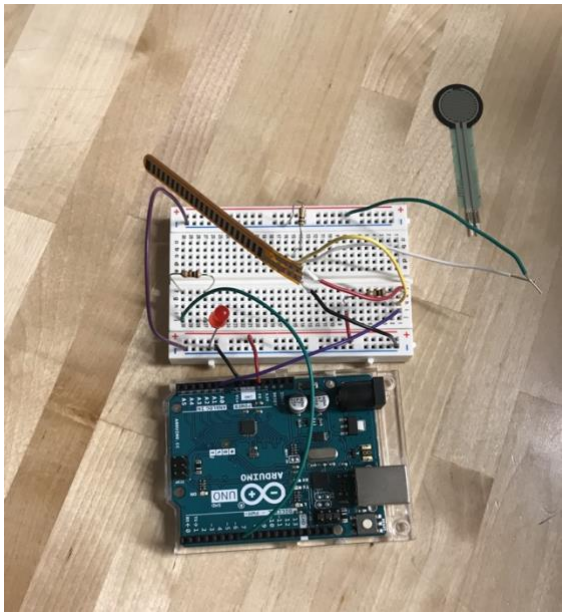

Figure #4: Breadboard and Arduino Connections to Sensors for Glove as implemented.

5. Future Plans

We plan to finish this project by using 3 characters for each finger and thumbs and therefore being able to type all possible words using the glove. This would involve taking input from all the fingers simultaneously with Arduino and sending voltage across the motors receiving input from finger movement. Decreasing breadboard side or finding an alternate solution would allow more flexibility for the glove. Also, replacing the glove for a thinner glove would make the flex sensor more sensitive and pick up finger movements better.

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Project Implementation:

1. Arduino Code

Finger with 3 Keyboard Values

```
int fsrPin = 1
//the FSR and 10K pulldown are connected to a0
int fsrReading
const int motorpin = 7
const int flexPin = A0
void setup() {
   // put your setup code here, to run once:
   Serial.begin(9600)
   pinMode(7, OUTPUT)
}
void loop() {
   // put your main code here, to run repeatedly:
   int flexValue
   flexValue = analogRead(flexPin)
   fsrReading = analogRead(fsrPin)
   if (flexValue > 890 & & fsrReading > 200)
   {
      Serial.println("U")
      digitalWrite(motorpin, HIGH)
      delay(1000)
   }
   else if (flexValue < 890 & & flexValue > 810 & & fsrReading > 200)
   {
      Serial.println("J")
      digitalWrite(motorpin, HIGH)
      delay(1000)
```

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```
  }
  else
  digitalWrite(motorpin, LOW)
  else if (flexValue < 810 fsrReading > 200)
  {
     Serial.println("N")
     digitalWrite(motorpin, HIGH)
     delay(1000)
  }
  else
  digitalWrite(motorpin, LOW)
  delay(1000)
}
```

Finger with binary values

```
int fsrPin = 0
// the FSR and 10K pulldown are connected to a0
int fsrReading
const int motorpin = 7
const int flexPin = A1


void setup() {
   // put your setup code here, to run once:
   Serial.begin(9600)
   pinMode(7, OUTPUT)
}
void loop() {
   // put your main code here, to run repeatedly:
```

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```
  int flexValue
  flexValue = analogRead(flexPin)
  fsrReading = analogRead(fsrPin)
  / *Serial.print("Sensors:\n")
  Serial.print("FSR:\n")
  Serial.print(fsrReading)
  Serial.print("\n")
  Serial.print("Flex:\n")
  Serial.print(flexValue)
  Serial.print("\n")
  * /
  if(flexValue < 790 & & fsrReading > 0)
  {
     Serial.print("Binary 1\n")
     digitalWrite(motorpin, HIGH)
     delay(150)
  }
  if(flexValue > 810 & & fsrReading > 0)
  {
     Serial.print("Binary 0\n")
     digitalWrite(motorpin, HIGH)
     delay(150)
  }
  delay(200)
}
```

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2. Testing

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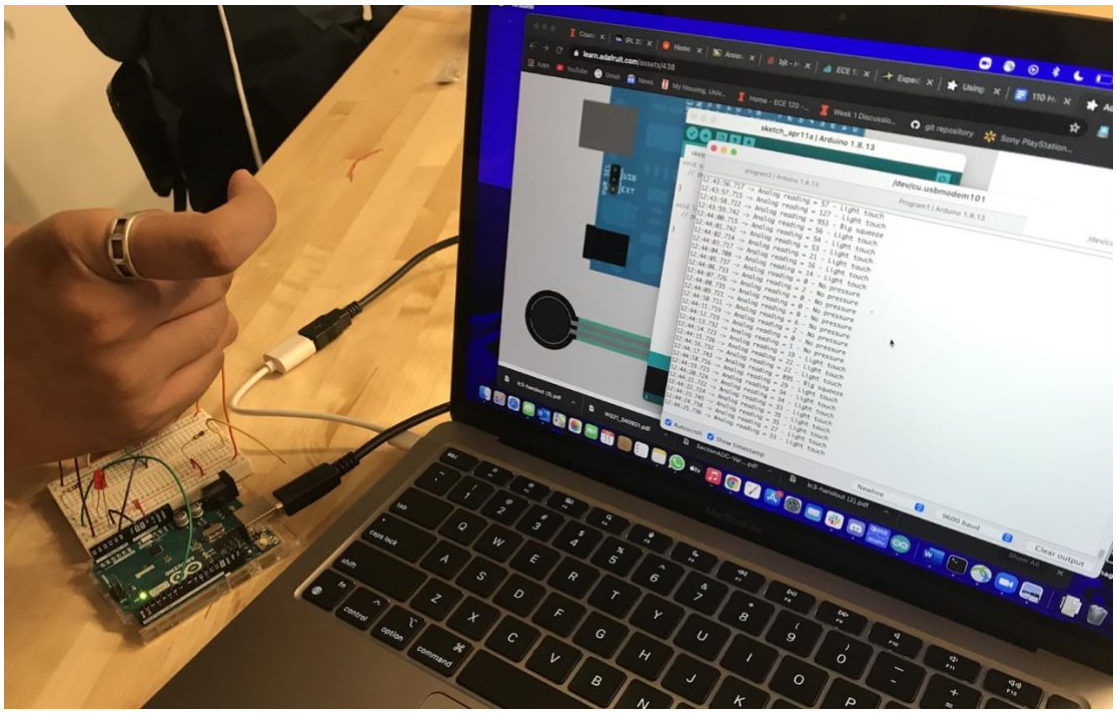

Figure #5: Testing of Flex Sensor Values in different positions using Arduino

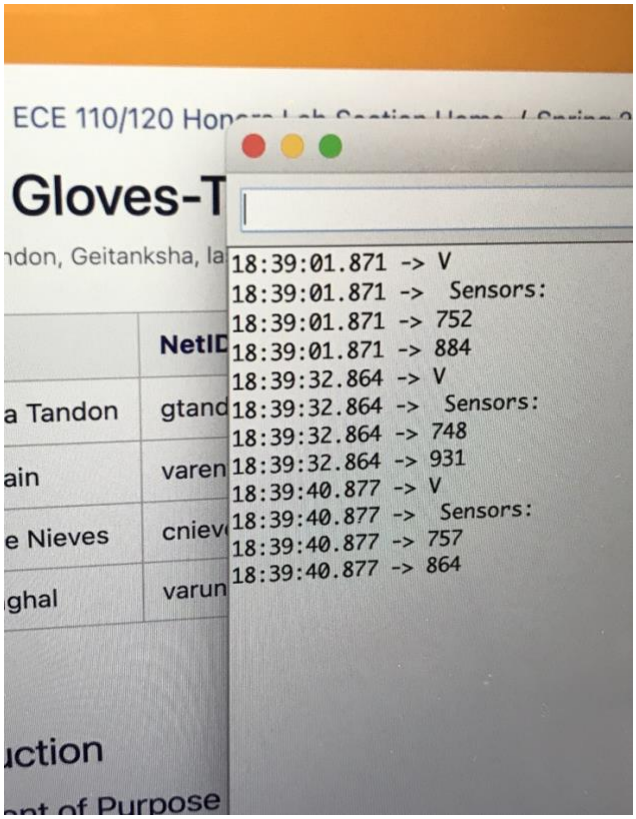

Figure #6: Readings Displayed in Serial Monitor and output corresponding to specific inputs

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References

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[3] About FSR: https://learn.adafruit.com/force-sensitive-resistor-fsr
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https://learn.adafruit.com/force-sensitive-resistor-fsr/using-an-fsr

[7] Diagram of FSR circuit: https://learn.adafruit.com/assets/434

[8] Flex sensor circuit (applied) picture

[9] Online diagram of Flex sensor circuit