Glove Controller

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Summary:

For our project we plan to design a controller that can track hand movements and translate these hand movements into virtual reality. We will need to design a circuit that can sense angles from finger joints and output raw data. The system will relay this information through a Universal Serial Bus. Using USB will allow for the controller to be more universally accepted among video game consoles, personal computers, or any device that will accept it. The system will be built using an Teensy Board (this board is smaller but can use Arduino code) that will interpret input signals from the glove and translate these inputs to the computer program. We will be using a common gardening glove, because of its durability and does not restrict the movement of the fingers. Attached to the glove will be flex resistors, one for each joint in the finger. The idea is that we will measure the voltage difference the flex resistors are causing as the fingers bend and cause the resistance in the circuit to decrease allowing for a different voltage drop. This difference in the voltage drop will be reported to the Teensy Board and the board will convert this analog information into digital and relay it through the serial port.

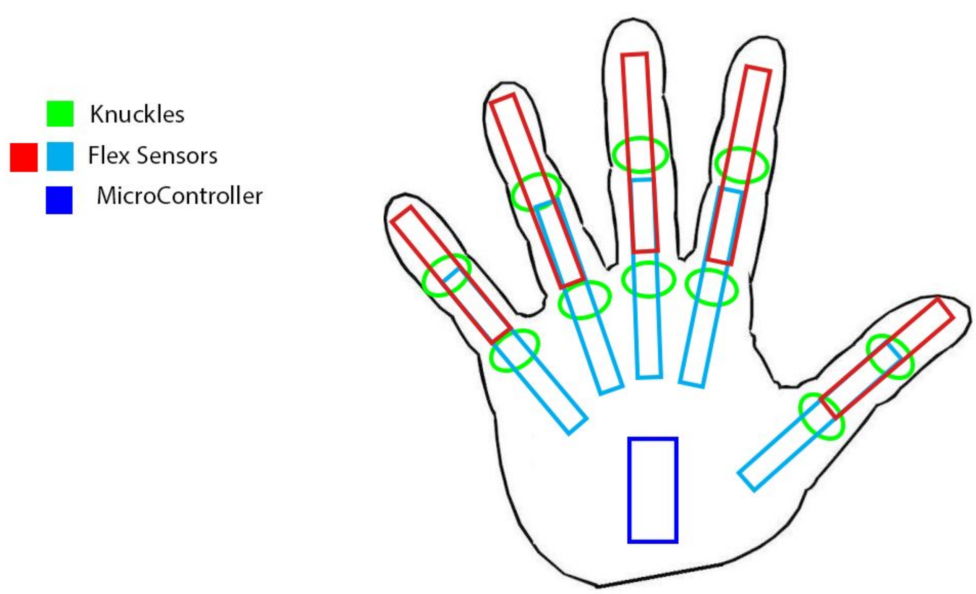

Figure 1: The Flex Sensors will lay on top of each knuckle and will sense how far a finger joint is bent.

Report:

We used flex resistors and tested their resistance and found the optimal resistance for the reference resistor seen in Equation (1). After finding the optimal resistance for each flex resistor we averaged the optimal reference resistors and found that a $41.3k\Omega$ resistor will give us the greatest difference in voltage drops. We chose to use a Teensy board over the Arduino because the Teensy board is smaller, flatter, and has more pins (21 analog) for analog to digital conversions. Additionally, the Teensy board can be programmed with Arduino sketches which we are familiar with from past Open Option Projects. The flex resistors were decided on over potentiometers because the flex resistors are smaller and can mimic how a finger moves.

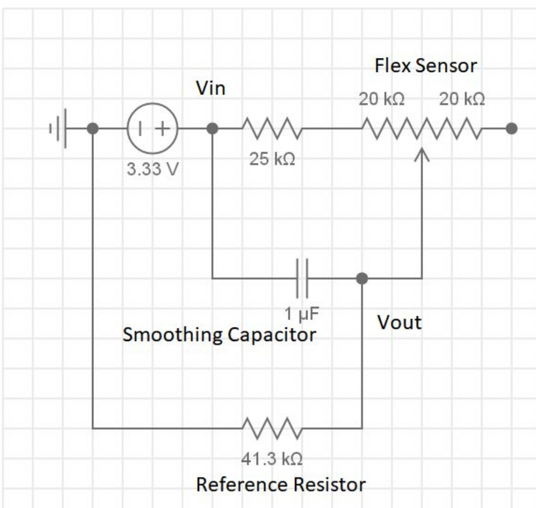

Figure 2: Circuit Schematic

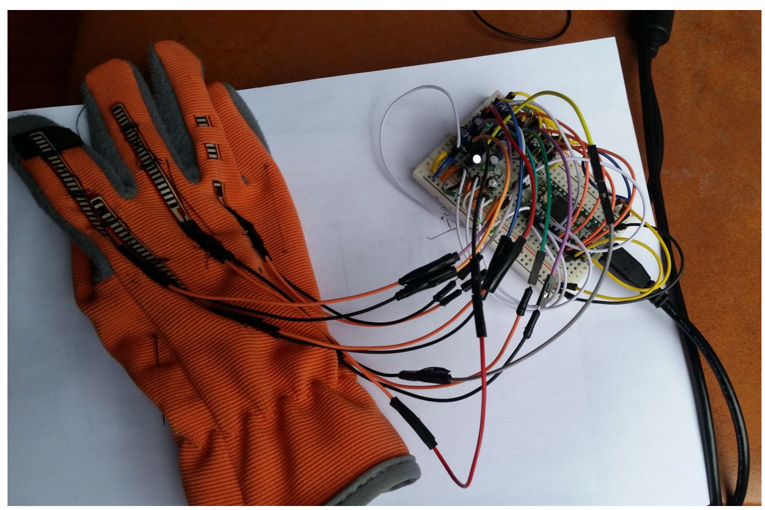

Figure 3: Completed glove and circuit

Choosing Reference Resistor:

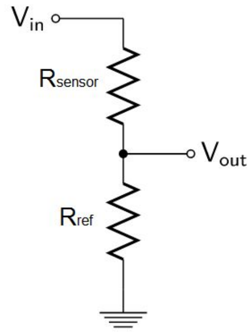

Figure 4: We chose a reference resistor to maximize resolution

To choose our reference resistor for our sensors, we came up with Equation (1). We want a resistor that maximizes our voltage range that we can output to the microcontroller. With a bigger voltage range, we can get a higher resolution with our analog to digital conversion. We will call the output voltage range ΔV.

$$\Delta V = V_{max} - V_{min}$$

To find V_{max} and V_{min}, we calculate the voltage divider with R_{max} as the maximum resistance of the sensor and R_{min} as the minimum.

$$V_{max} = V_{in} \cdot \frac{R_{ref}}{R_{ref}+R_{min}} \qquad V_{min} = V_{in} \cdot \frac{R_{ref}}{R_{ref}+R_{max}}$$

$$\Delta V = (V_{in} \cdot \frac{R_{ref}}{R_{ref}+R_{min}}) - (V_{in} \cdot \frac{R_{ref}}{R_{ref}+R_{max}})$$

Calculus optimization problem: we can take the derivative of ΔV with respect to R_{ref} and set that equal to 0 to find the R_{ref} at which ΔV is maximum.

$$\frac{d\Delta V}{dR_{ref}} = 0 = (V_{in} \cdot \frac{R_{min}}{(R_{ref}+R_{min})^2}) - (V_{in} \cdot \frac{R_{max}}{(R_{ref}+R_{max})^2})$$

Solve for R_{ref}

(1) $$R_{ref} = \sqrt{R_{min} \cdot R_{max}}$$

With this value, we can find a reference resistor to find the biggest voltage output range for our sensor.

Testing Flex Sensors:

Flex Resistor	Bent Resistance	Un-Bent Resistance	Ideal Resistor	Theoretical Voltage Drop at max	Theoretical Voltage Drop at min	Voltage Output Range
#1	53545.45 ohms	33698.12 Ohms	42478.01 ohms	1.33V	1.67V	0.34V
#2	53545.45 ohms	32333.33 ohms	41608.93 ohms	1.31V	1.69V	0.38V
#3	59000 ohms	27991.11 ohms	40638.35 ohms	1.22V	1.78V	0.56V
#4	64217.39 ohms	29000 ohms	43154.42 ohms	1.21V	1.79V	0.58V
#5	49000 ohms	30914.89 ohms	38920.81 ohms	1.33V	1.67V	0.34V
Average	55861.66 ohms	30787.49 ohms	41360.10 ohms	1.28V	1.72V	0.44V

Table (1): Showing the range of values for each flex resistor

Description:

Each flex sensor was placed in series with a $1k\Omega$ resistor then we found the voltage drop over the flex resistor using a voltage divider equation. The flex resistor was then bent to approximately 90 degrees and the same process as before was used to find its bent resistance. The input voltage into the circuit was 3 volts and actual value for the $1k\Omega$ resistor was measured to be .998 but for convenience we assumed the system had an ideal source and resistor. The ideal resistor column values were calculated by Equation (1) . The theoretical voltage drops are measuring what the voltage will be at the node between the flex resistors and the ideal resistor, this was calculated using a voltage divider equation.

Scaling Function:

We have made Equation (2) to allow us to take any range of values as an input and proportionally scale the input value to any range of outputs of our choosing. "(OMax - OMin) / (IMax - IMin)" is the slope of the the line; change in output over the change in input. "(x - IMin)" is our input shifted by IMin. " + OMin" shifts the whole output up by OMin. Our input x will range from integer values 0 to 1023 (due to 10 bit ADC conversion). IMax and IMin for each finger joint will be updated as the hand moves around during calibration. Our final output value f(x) will be an angle that our 3D model will use to rotate its joints. OMax and OMin will be selected based on the beginning and ending angle of rotation on our 3D model. This equation is very important in the functionality of our hand as all 10 joints will need it to move exactly where they need to.

(2) $$f(x) = \frac{O_{Max} - O_{Min}}{I_{Max} - I_{Min}}(x - I_{Min}) + O_{Min} \ \{I_{Min} \leq x \leq I_{Max}\}$$

Conclusion:

The source of my (Lane) inspiration came from playing video games and being intrigued by how controllers interact with software quickly and accurately. This technology has a variety of applications and has the potential to help out people who sign language or security to safely defuse bombs. I am also hoping to apply my continuing knowledge from 202 and other ECE classes to this design and learn more about electrical/computer engineering. After reading "Ready Player One" I (David) was inspired to work with something that could have application with virtual reality. The book describes a world built around virtual reality and all the possibilities that virtual reality holds; and because of this I wanted to work with something related to virtual reality.

The testing that we performed was used to find the max and minimums of each flex resistor. We then mapped out all of these values in Table (1) and averaged out what the average minimum and maximum resistance of the flex resistors are. After finding these values we used an optimization equation to find an equation that would give use the best reference resistor. After using Equation_(1)_with the average values from the table we found that $41.3\text{k}\,\Omega$ would give our circuit the largest voltage drop. After the values for the components in the circuit had been chosen, Equation (2) was derived so that in the program the values of the voltage drop would be scaled so the 3-D model would represent an appropriate angle.

If we had a chance to do this project again we would look into alternate ways to mount the flex resistors onto the glove. Initially we tried to sew them on there but this resulted in a “bubbling” effect on the resistors; this caused the 3-D model read the hand as being bent constantly. We then attempted to weave these resistors in and out of the glove by cutting slits in the glove but this resulted in a short in the connections and we did not get accurate readouts for the voltage drop. A alternative approach that could have been taken would have been printing conductive material directly onto the fabric. Overall this has taught us to always begin on the hardware side of the project and get accurate and consistent readings from the hardware before we developing the software. Despite the difficulties with the hardware we were able to demo our project and have a proof of concept.