The Glove

Design Review

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ECE445
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1. Introduction

1.1 Statement of Purpose

Motion tracking technology has been largely used in Virtual Reality Game to offer more engaging gaming experience. Most motion tracking devices enable people to observe the movement of their hands and interact with virtual objects. Based on this, our team think that providing haptic feedback to the contacts with virtual objects makes the experience even better.

We plan to mount the servo motors on the glove to control the movement of the fingers/palm. We will incorporate Leap Motion with our glove wirelessly to simulate the signal. Conditions like touching or grabbing the virtual object will output a signal sending to a controller to activate the servo motors and give a haptic feedback to the hand.

1.2 Objectives

- Provide force feedback that is similar to real life experience.
- Skeleton will stop fingers from moving into the virtual object.
- Wireless glove with high portability.
- Low power consumption.
- Well incorporated with Leap Motion.
2. Design

2.1 Block Diagram

![Block Diagram](image)

Figure 2.1

2.2 Block Description & Schematics

2.2.1 Power Supply

![Power Supply Schematic](image)

Figure 2.2.1
We are considering two 9v batteries to serve as basic power supply for the device circuits. Arduino UNO microcontroller needs 9v power supply whereas each of five servos needs 6v power supplies. The Bluetooth receiver needs 3.3 volts power supplies which will come from the Arduino outputs. The voltage of our battery is 9 volts and we use a 9v to 5v voltage regulator to supply servos.

2.2.2 Arduino Uno Microcontroller

Arduino Uno with ATmega328P is the heart of the design which is wired to HC-05 (through RX/TX) and servo motors (through PWM pins). It reads the serial data received from HC-05 and uses it as the control signal to program servo motors. It is powered by external lithium battery at 9V. It will also supply power for HC-05 at 3.3V.
2.2.3 Bluetooth Module HC-05

HC-05 is a simple and small Bluetooth module device connecting to Arduino (Details in 2.2.3) which send signal to servo motors. The HC-05 has a breakout board with several pins on it. These pins are able to connect to Arduino.

Bringing KEY to high level before the power on (AT Command). The STATE tells if they are connects or not. Others are shown below.

Connection:

![Connection Diagram](image)

Figure 2.2.2.1

Also, since this Bluetooth module only works in the voltage 3.3V, and the power supply is 5V from the Arduino, we need a voltage divider to shift down the voltage of Arduino signal line from 5V to 3.3V. Seeing the incomplete circuit below. The left side incomplete circuit connects to Arduino RX line and right side (Vin) of the circuit connects to HC-05 RX line (Vout).

Calculation:

\[ 5V \times \left( \frac{R2}{R1+R2} \right) = 3.3V \]
2.2.4 Servo Motor

In our project we decide to use SG90 micro servo motor. The reason we use this type of motor is because it’s cheap and small enough to put on the glove.

Connection:

1. Connect the black wire from the servo to the GND pin on the Arduino
2. Connect the red wire from the servo to the output of Voltage regulator
3. Connect the third wire (usually orange or yellow) from the servo to a digital pin on the Arduino
Figure 2.2.4.1

The signal pin accepts the control signal which is a Pulse Width Modulation (PWM) signal. It can be easily produced by all microcontrollers and Arduino board. This accepts signals from the controllers that tell what angle to turn to. The length of the pulse corresponds to the angle the motor turns to.

The pulse width sent to servo ranges as follows: Minimum: 1 millisecond ---\(\rightarrow\) Corresponds to 0 rotation angle. Maximum: 2 millisecond ---\(\rightarrow\) Corresponds to 180 rotation angle. Any length of pulse in between will rotate the servo shaft to its corresponding angle. For example, 1.5ms pulse corresponds to rotation angle of 90 degree. This is will explained in figure below.
2.2.5 Bluetooth Transmitter in computer

Using computer’s Bluetooth or Bluetooth dongle (no built-in Bluetooth computer) to send data back and forth between PC and Arduino via Bluetooth module HC-05 transceiver (with the breakout board). The PC to Arduino serial connections then will be used to control the servo motors.

As long as we implement the Bluetooth to Arduino, then we don’t need anything more except one 9V battery to transmit data between PC and Arduino.

2.2.6 Leap Motion Hardware and Interface

Computer will supply 5v to the leap motion controller via USB2.0 cable. On the computer, we will build a virtual environment using C# in the leap motion SDK in which we can read and store
the position data of hands into computer. And we will write a C# program to communicate with the Arduino microcontroller and deal with the data from the leap motion.

2.3 Flow Chart
### 3. Requirement and Verification

#### 3.1 Table of Requirement and Verification

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Power Supply</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Both Lithium battery should provide 9V +/- 0.25V output voltage for Arduino Uno and Voltage regulator.</td>
<td>1. Power Supply</td>
<td>25</td>
</tr>
<tr>
<td>b. Voltage regulator should be able to provide 5V +/- 0.25V output voltage for servo motors.</td>
<td>a. Use digital multimeter to measure the output voltage, and it should read 9V +/- 0.25V.</td>
<td></td>
</tr>
<tr>
<td>c. Voltage regulator should be able to provide 220 ±50mA for output current.</td>
<td>b. Use digital multimeter to measure the output voltage after conversion, and it should read 5V +/- 0.25V.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Use digital multi-meter to measure the output current of the Voltage regulator, and it should read 220 ±50mA.</td>
<td></td>
</tr>
<tr>
<td><strong>4. Bluetooth Transmission</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. The Bluetooth in Laptop should catch the signal from computer program and transmit it to HC-05.</td>
<td>4. Bluetooth Transmission</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>a. Transmit 1 and 0 alternatively and program Arduino to activate LED when receives 1 and see if the LED is blinking continuously.</td>
<td></td>
</tr>
</tbody>
</table>
b. The Bluetooth transmitter should be able to transmit data within 10 meters.
c. The Bluetooth should be able to communicate in baud rate 38400 (bps).

b. Take the transmitter 9.9 meters away and check whether the system is still working.
c. Transmit the date to HC-05 and transmit back to laptop. It should transmit and receive data in 38400 bps.

3. Arduino Uno
a. Arduino Uno should be able to output 3.3V +/- 0.25V to HC05.
b. Microcontroller must output the correct PWM signals to servo motors.

3. Arduino Uno
a. Use digital multimeter to measure the output voltage, and it should read 3.3V +/- 0.25V.
b. Use an oscilloscope to check the output of the digital pins to see if it is the corresponding signal.

4. Servo Motor
a. Each motors must draw 4.8V +/- 0.25V from the power supply.
b. Actual rotation angle should be within +/- 2 degrees of desired angle.

4. Servo Motor
a. Use digital multimeter to measure the output voltage after conversion, and it should read 4.8V +/- 0.25V.
b. Record the initial position and final position on the paper and measure the actual rotation angle. It should be within +/- 2
degrees with the desired angle that is been programmed on the Arduino.

**5. Leap motion:**

a. The leap motion hardware is compatible with the computer.

**5. Leap motion:**

a. Set up the leap motion software on the computer and connect the leap motion controller with computer. Test using the motion visualizer within leap motion SDK (and pre-loaded demos).

<table>
<thead>
<tr>
<th>5. Leap motion:</th>
<th>5. Leap motion:</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The leap motion hardware is compatible with the computer.</td>
<td>a. Set up the leap motion software on the computer and connect the leap motion controller with computer. Test using the motion visualizer within leap motion SDK (and pre-loaded demos).</td>
<td></td>
</tr>
</tbody>
</table>

### 3.2 Tolerance Analysis

#### 3.2.1 Power Analysis

The capacity of our battery is 750mAh. To operate all the servos it needs 1100 mA and to operate Arduino microcontroller, it needs about 20mA. We can use a battery for worst case (5 servos running together and non-stop) about 0.7 hours. It is a slightly small value but we could increase the battery live by using one more battery. In the ideal condition (only one servo running at a time), we could use our device for about at least 3.4 hours. If the current goes 30% higher than we expect, we can still use the device for 2.6 hours.

#### 3.2.2 Bluetooth Transmission Distance

According to the datasheet, the Bluetooth receiver has typically -80dBm sensitivity and up to +0dBm RF transmit power. And as we know that Free-space path loss formula is FSPL (dB) = 20 log10 (d) + 20 log10 (f) − 27.55 where d is our distance between the transmitter and
receiver in meter, and f is the signal’s frequency in MHz which is 2400MHz thus 

\[80 = 20 \log_{10}(d) + 20 \log_{10}(2400) - 27.55 \approx 100(m)\]

That means we can use this mouse in 100 meters.

4. Cost and Schedule

4.1 Cost Analysis

4.1.1 Labor:

<table>
<thead>
<tr>
<th>Name</th>
<th>Hourly Rate($)</th>
<th>Total Hour Invested(hrs)</th>
<th>Total($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lei Wang</td>
<td>25.00</td>
<td>225</td>
<td>5625.00</td>
</tr>
<tr>
<td>Jiayi Wang</td>
<td>25.00</td>
<td>225</td>
<td>5625.00</td>
</tr>
<tr>
<td>Chenhao Wu</td>
<td>25.00</td>
<td>225</td>
<td>5625.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>675</td>
<td>16875</td>
</tr>
</tbody>
</table>

4.1.2 Parts & Total

<table>
<thead>
<tr>
<th>Items</th>
<th>Quantity</th>
<th>Cost($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Battery</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>DC/DC converter</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Leap motion</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>-----------------</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Bluetooth Module</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>servo motor</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Skeleton Component</td>
<td>unmeasurable</td>
<td>30</td>
</tr>
<tr>
<td>PCB</td>
<td>/</td>
<td>free</td>
</tr>
<tr>
<td>Others</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>167</td>
</tr>
<tr>
<td><strong>Total with labor</strong></td>
<td></td>
<td>17,042</td>
</tr>
</tbody>
</table>

### 4.2 Schedule

<table>
<thead>
<tr>
<th>WEEK</th>
<th>TASK</th>
<th>DUTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 10th</td>
<td>Finalize Proposal</td>
<td>All</td>
</tr>
<tr>
<td>February 18th</td>
<td>Prepare Mock Design Review</td>
<td>Lei Wang</td>
</tr>
<tr>
<td>February 25th</td>
<td>Research about Leap Motion interface</td>
<td>Chenhao Wu</td>
</tr>
<tr>
<td>Date</td>
<td>Task Description</td>
<td>Person</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>February 25&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Research about Bluetooth transmission and servo motor</td>
<td>Lei Wang</td>
</tr>
<tr>
<td>February 25&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Research about microcontroller and skeleton control</td>
<td>Jiayi Wang</td>
</tr>
<tr>
<td>March 3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>Finalize Leap Motion Implementation; order parts</td>
<td>Chenhao Wu</td>
</tr>
<tr>
<td>March 3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>Finalize Bluetooth transmission and servo motor Implementation; order parts</td>
<td>Lei Wang</td>
</tr>
<tr>
<td>March 3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>Finalize the connection of the microcontroller and write skeleton code for Arduino; order parts</td>
<td>Jiayi Wang</td>
</tr>
<tr>
<td>March 19&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Program interface of leap motion and drag out the signal from Leap Motion environment</td>
<td>Chenhao Wu</td>
</tr>
<tr>
<td>March 19&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Program Bluetooth with microcontroller</td>
<td>Lei Wang</td>
</tr>
<tr>
<td>March 19&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Program Microcontroller with the servo motor, design skeleton mechanism</td>
<td>Jiayi Wang</td>
</tr>
<tr>
<td>March 31&lt;sup&gt;st&lt;/sup&gt;</td>
<td>Make everything together</td>
<td>All</td>
</tr>
<tr>
<td>April 7&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Finalize and debug</td>
<td>All</td>
</tr>
</tbody>
</table>
5. Ethics & Safety Analysis

5.1. Safety Analysis

Lab safety is the biggest concern of our project. We must take extra care to ensure that all lab policies are followed. When we build our project, we will take care to prevent any possible injuries.

We will use servo to implement the skeleton. Because servo motors allow precise angular positioning of their output shaft, it is possible that the servo motors position our fingers to the places that might hurt ourselves. We will be very careful when using these devices by testing the precise positions, at which we want the servo motors, before wearing it personally.

To prevent damages to the circuits, we will check all wirings to ensure there is nothing has been grounded/shorted.

Finally, we will follow the standard procedures and requirements that are listed on the lab manual as well as the device manuals in order to working with devices, equipment and tools safely in the lab.
5.2 Ethics Analysis

We commit ourselves to the highest ethical and professional conduct and agree the following:

1. To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

2. To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;

3. To be honest and realistic in stating claims or estimates based on available data;

4. To reject bribery in all its forms;

5. To improve the understanding of technology; its appropriate application, and potential consequences;

6. To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;

7. To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

8. To treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;

9. To avoid injuring others, their property, reputation, or employment by false or malicious action;
6. Reference

1) YouTube channel: [https://www.youtube.com/watch?v=XICTT-mTtco](https://www.youtube.com/watch?v=XICTT-mTtco)”


3) Arduino UNO data: [https://www.arduino.cc/en/Main/ArduinoBoardUno](https://www.arduino.cc/en/Main/ArduinoBoardUno)


5) Leap Motion:

   [Leap Motion | Mac & PC Motion Controller for Games …](https://www.leapmotion.com)


7) Servo motor:
