METHODOLOGY

The ergonomic design of JediGlove is constructed with the help of four major components. These are namely HC-SR04 Ultrasonic Sensor, Grove- Vibration motor, Arduino UNO and GY291 ADXL345 3-Axis Digital Acceleration. Apart from the stated elements, a glove, 9V battery, battery snap connector, breadboard, jump wires and a box for protecting the circuitry from the surrounding.

3.1ELECTRONIC COMPONENTS OF JEDIGLOVE

1. Ultrasonic sensor is an electronic device which measures the distance of the obstacle within its range. It consists of four pins that are for power supply, trigger, echo and ground respectively. The trigger pin emits ultrasonic sounds waves which on reflection from the object are converted into an electrical signal. The trigger pin or the transmitter uses piezoelectric crystal for emitting the waves.

Figure 3: Ultrasonic sensor with its four pins.

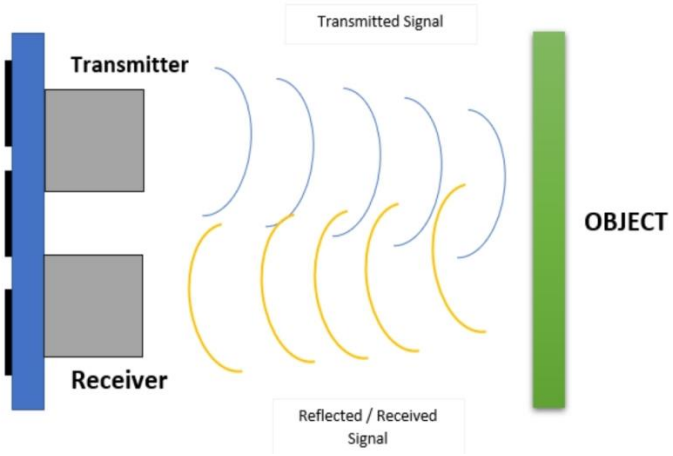

Figure 4: Schematic of principle of ultrasonic sensor.

(A) General Specifications of the Ultrasonic sensor:

- Working Voltage: 5V.
- Working Static current: Less than 2mA.
- Sensor angle: Not greater than 15 degrees.
- Precision: Up to 3mm.
- Detection Range: 2cm to 450cm (approx.).
- Input trigger signal: 10μs impulse TTL

(B) Output Signals:

- Electric Frequency signal: HIGH=5V, LOW=0V.
- Echo signal: PWM signal with proportional to measured distance.
- Transmitter output: Eight 40KHz pulses.

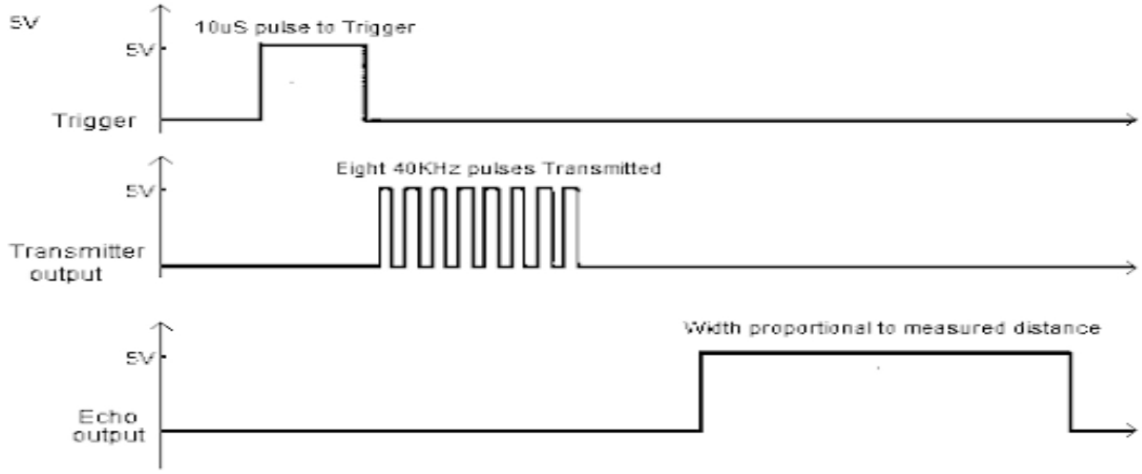

Figure 5: Ultrasonic sensor Timing diagram.

(C) Distance Calculation: The distance is calculated by using the formula mentioned below.

$$Distance = \left(\frac{traveltime}{2}\right) * speedofsound$$

Where speed of sound ≈340m/s

2. The Grove Vibration motor consists of a one coin type motor which is a Permanent Magnet coreless DC motor. Vibrations are observed when the input is logic HIGH. This vibration motor is non-audible and consumes very low power. It has four coloured wires attached directly to the pins. The red wire is for the power supply whereas the black is

designated for the ground. The pin with yellow wire acts as a connecting interface. However, the fourth white wired pin is not connected in the circuit.

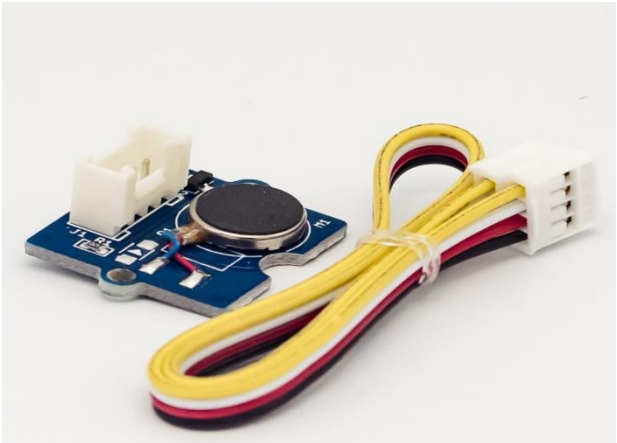

Figure 6: Grove Vibration Motor.

(A) Specifications of Grove Vibration motor:

- Supply Voltage: 3.3/5V.
- Rated speed: 9000rpm.
- Interface: Digit port.

3. The ADXL345 3-axis Digital Acceleration is a type of accelerometer sensor that can sense 3-axis acceleration. It detects static acceleration of gravity in tilt-sensing. In addition, the dynamic acceleration can be also be sensed resulting from shock or motion. The ADXL345 consists of 8 pins in which two are power supply (VCC) and ground (GND). CS pin stand for Chip select while INT1 and INT2 are the interrupts output. SDO pin is serial data output. SDA and SCL are Serial Data and Serial communication clock respectively. SDA and SCL are mainly used for the programming of JediGlove.

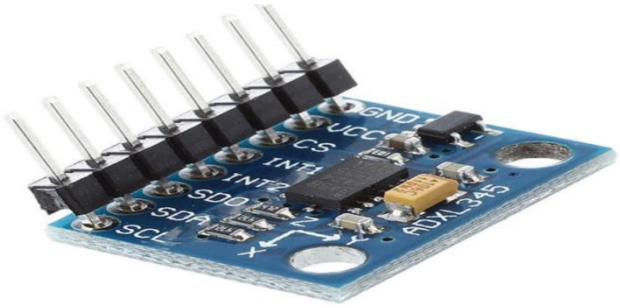

Figure 7: ADXL345 3-axis Digital Acceleration Sensor.

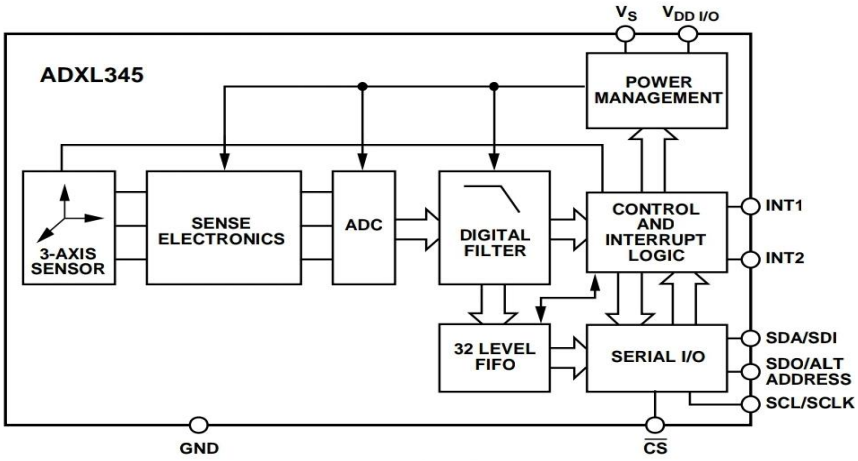

Figure 8: Functional Block diagram of ADXL345

(A) Specifications of ADXL345 3- axis Digital Acceleration sensor:

- Power Supply: 3-5V.
- Means of Communication: IIC/SPI communication protocol.
- Measuring Range: ±2g, ±16g (where 'g' is in terms of acceleration due to gravity).
- High Resolution: 3.9mg/LSB.
- Measures inclination changes of less than 1.0 degrees.

4. Arduino UNO is the heart of JediGlove. It is a microcontroller board based on ATmega328P. It contains 14 digital input/output pins among which 6 can be used as PWM outputs. In addition, Arduino UNO supports 6 analog inputs. Also, a 16MHz ceramic resonator is attached to the board and is supported by a USB connection. USB connection can be used for powering up the board as well as for programming it.

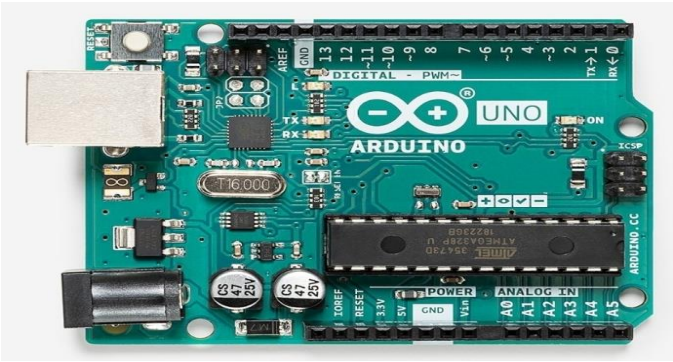

Figure 9: Arduino UNO

(A)Specifications of ATmega328P microcontroller based Arduino UNO:

- Operating Voltage: 5V.
- Input Voltage: 6-20V (limit).
- Flash Memory: 32KB (ATmega328P) of which 0.5KB used by bootloader.
- SRAM: 2KB (ATmega328P).
- EEPROM: 1KB (ATmega328P).
- Clock Speed: 16MHz.

5. Battery used in Jediglove is a PP3 9V Zinc Chloride. This is suitable for heavier duty high-drain applications.

3.2 BLOCK DIAGRAM OF THE PROTOTYPE

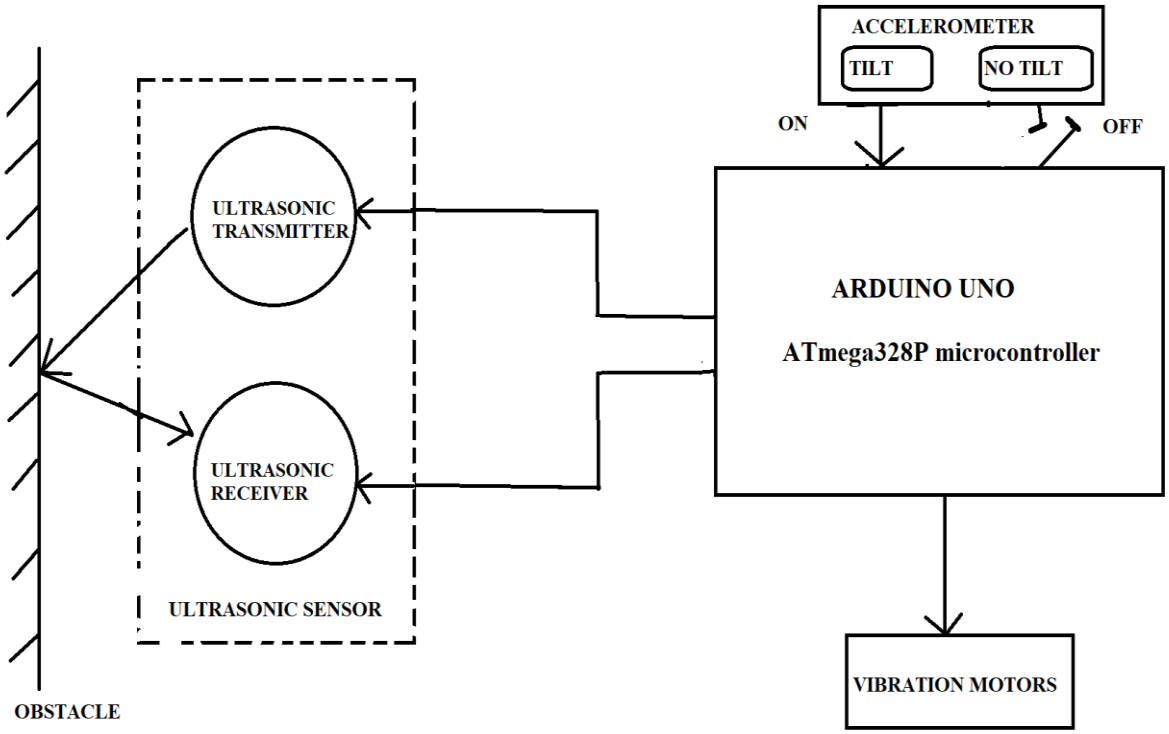

Figure 10: Working of JediGlove in Block Diagram

The block diagram in Figure 10 depicts the simple functioning of the JediGlove. The accelerometer depending on the position of hand will connect the power supplied to the arduino UNO. The microcontroller follows commands for ultrasonic sensor which transmits the wave towards the object and is received at the echo pin of the sensor. The distance is then

computed by microcontroller. Consequently, the distance will decide for which vibration motor (among five motors attached near the tips of hand) to switch on.

3.3 RESEARCH METHODOLOGY

The initial approach for the designing of glove prototype or the JEDIGLOVE was by using one Ultrasonic sensor, two Vibration motors and ATmega328P microcontroller. The bread board implementation was carried out. The idea was to detect objects via ultrasonic module and with the aid of programming in microcontroller controlling the vibration motor. The first design can be seen in Figure 11.

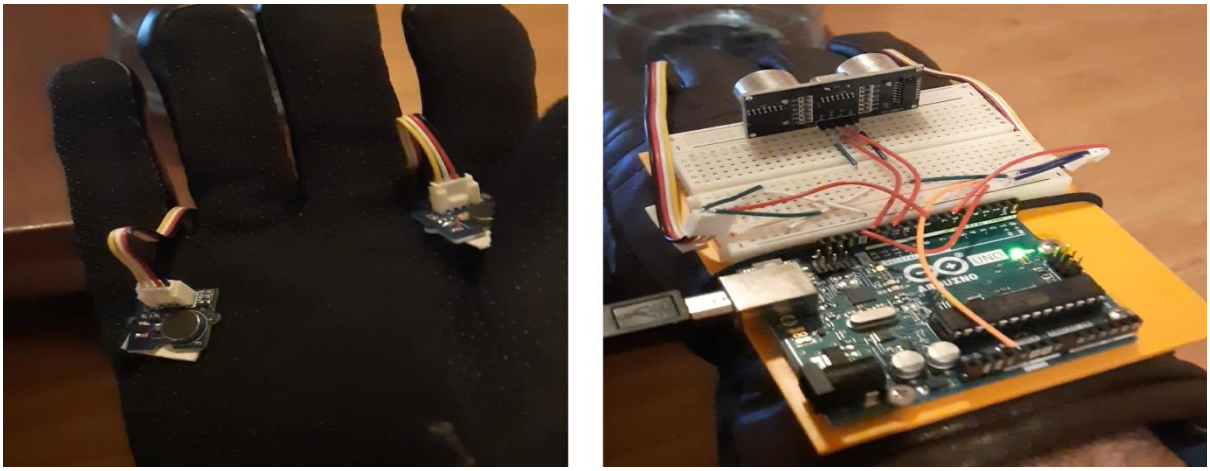

Figure 11: Initial design approach of JediGlove

The programming was executed in such a manner that the vibrations from the motors totally depended on the distance between the obstacle and JediGlove. The idea was to alert the blind by increasing the frequency of vibrations if they get really close to the object. The role of ultrasonic sensor was just to calculate the distance. The distance was the interpreted by the ATmega328P microcontroller. The microcontroller then gave command to either one of the vibration motor or both of the motors according to the value of distance. If the distance was less than 150cm only one vibration motor switches ON to vibrate. However, if the distance between the target and the glove becomes less than 50cm; both the motors start to vibrate. Thus, alerting the blind person that the object is too close with high intensity of vibrations that could be felt in the hand. The prototype was working well. Nevertheless, after discussing the initial design with the supervisor, two main limitations were observed. Firstly, the range was too less. Secondly, the circuitry became slightly big in size. So, to fit it in a box for protection purpose was an issue.

The changes were implemented in the JediGlove after considering with supervisor. The new modelling was done. In this new approach, one ultrasonic sensor and five vibration motors were integrated along with the microcontroller. The changes in programming were completed. The new programming commands worked on the same principle of vibration in accordance with distance. However, this time each vibration motor corresponded to a particular distance range. These vibration motors were placed in such a manner that all the fingers and a thumb were designated one vibration motor each. Figure 12 depicts the second prototype of JediGlove.

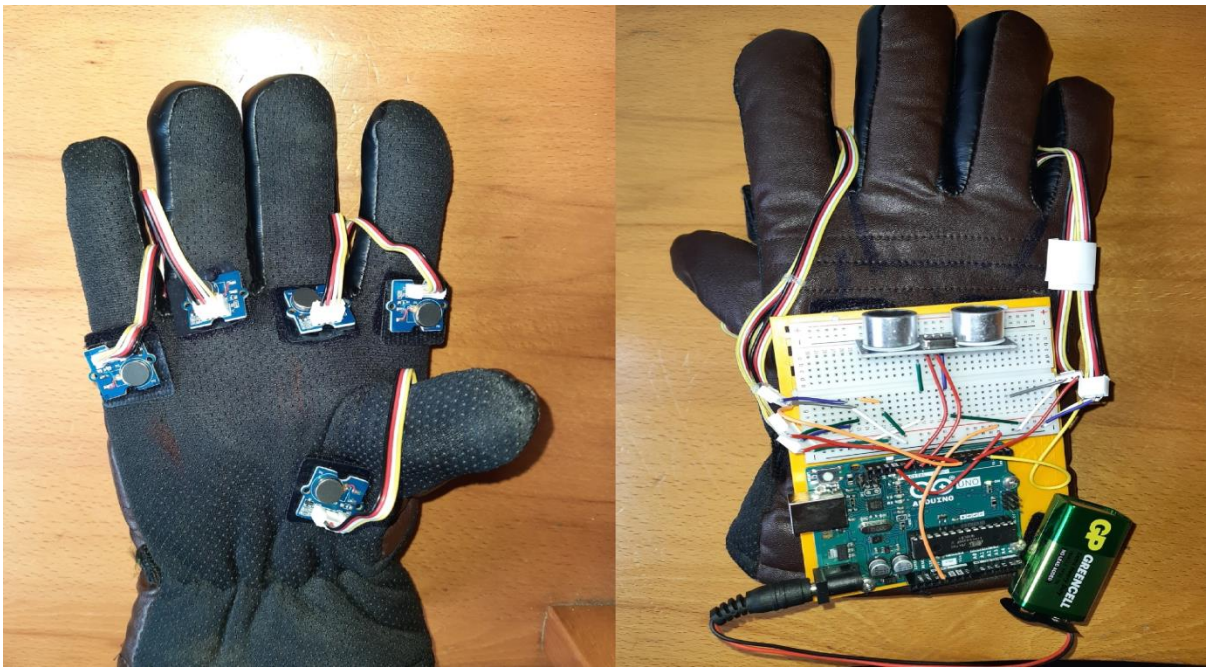

Figure 12: Images after alteration in Design

Consequently, the vibration motors became distinctive. The command was executed by microcontroller again depending on the distance. The coding was done in such a manner that the 1st vibration motor glued at the thumb vibrated when the distance is less than 70cm. Similarly, the 2nd vibration motor at the index finger switches on when the range of distance becomes 71-150cm and so on. Table 1 reveals the designated vibration motor fingers and the distance. Consequently, every finger will now be representing a distance. So for instance, if the blind is 100cm far from an object only 2nd motor vibrates. As soon as the person gets closer to it and the distance becomes less than 70cm, the 1st motor starts to vibrate. Subsequently, vibrations can be felt around the thumb alerting person that the distance is too close.

Designated Positions	Vibration motor number	Distance Range(cm)
Thumb	1	Less than 70cm
Index Finger	2	71 - 150
Middle Finger	3	151 - 250
Ring Finger	4	251 - 350
Little Finger	5	351 - 400

Table 1: Range of Distance with respect to haptic feedback from motors in different fingers

The implementation was successfully completed. The limitations of the previous design were overcome. The range was increased to 400cm from 150cm giving a more knowledge of surrounding. Placing the whole circuitry in junction boxes were quite a challenge as the ultrasonic module needs no hindrance ahead of it or else it kept on vibrating. For this problem, a box with high insulation and temperature resistant characteristic was chosen. Subsequently, certain modifications on the box were made to make it more easy to use. In addition, the ultrasonic sensor was placed carefully so that it performs its role accurately.

Although, the JediGlove was working effectively, there were still two major issues with the prototype. The first was with the intensity of vibrations around the distinctive fingers as it may confuse the person. Furthermore, the vibrations should stop when the hand is in resting phase near the leg. Vibrations are unwanted at the time. Therefore, the whole system must work only if the blind uses his hand for navigation purpose.

The discussions on the standing limitations were made with the supervisor and changes were executed. The positioning of the vibration motor was changed and repositioned near the tips of each fingers and a thumb. Therefore, the intensity of vibrations increased significantly. The other potential challenge was overcome by using the ADXL345 3-axis Digital acceleration. The coding was altered according to the requirement of accelerometer. The ADXL345 works with respect to the acceleration due to the gravity (g=9.8m/s^2). Subsequently, the two gravitational values in two positions for the entire three axes were checked and then coded accordingly. The range of the acceleration of any axis ranges from +2g to -2g (where g= acceleration due to gravity). Figure 13 shows the two different

positions of hands. In (a) the Jediglove is in working state along with values of acceleration of the 3-axis while in (b) the glove is in OFF state.

(a) (b)

Figure 13: (a) ON state of glove ; (b) OFF state of glove

3.4 PROGRAMMING -ATmega328P MICROCONTROLLER

The ATmega328P microcontroller integrated on Arduino Uno is coded using C++ language. However, the environment is limited so not all C/C++ features are used. The Arduino language can be divided into three main parts: function, values (variables and constants) and structure. The high-level programming language used in programming was complied via Arduino complier for any debug.

The coding of JediGlove has basically three essential points. First is the programming the ultrasonic sensor for calculation of distance shown below.

Code:

```
digitalWrite(trigPin, LOW);
```

```
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = duration*0.034/2; // distance calculation
```

Secondly, the coding related ADXL345 3-Axis Digital Acceleration for the purpose of controlling the vibrations from the motors with respect the positioning of the arm. Lastly, operating range with various vibration motors.

For instance, If the distance detected by the ultrasonic sensor is 125cm. After executing of the main part of the coding once, the loop portion initiates. According to the value of distance and acceleration due to gravity in Z-axis, the conditional statement in the coding is executed. Therefore, for the distance 125cm and acceleration in Z-axis in range, the following code will be implemented.

Code:

```
if(Z_g > 0.40 && Z_g <= 0.94) // conditional statement for positioning of hand in working
  {                                  // state
if(distance >=71&& distance <=150){
  digitalWrite(motor2, HIGH); // Index finger motor will vibrate
 }
      else{
       digitalWrite(motor2, LOW);
 }
```