ROBOTIC ARM CONTROL USING HAPTIC TECHNOLOGY

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report "**ROBOTIC ARM CONTROL USING HAPTIC TECHNOLOGY**" is the bonafide work of "**RAMKUMAR VENKATASAMY, M.SRIDHAR, S.SRINIVASAN**" who carried out the project work under my supervision.

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ABSTRACT

Robotics is one of the highly developing fields in today's world. The use of robotics is tremendously increasing in the areas which are isolated from the human intervention or hazardous for humans. In this project, the concept of haptic feedback is utilized in order to control a robotic arm. Haptic technology is the sense of touch which makes us feel the touch i.e., if the robotic arm is made to pick up an object, we will feel the vibration or some kind of feedback. The main work in the project is to design a Haptic Glove with sensors integrated in it. The accelerometer sensor and potentiometer will be helpful to replicate our robotic arm movement with respect to the movement of our hand which contains the glove. In order control the arm movement, the accelerometer sensor has to be calibrated and it's readings with response to the glove movement will be noted. Thus the hand movement will be used to control arm movement. This haptic glove will be helpful to control the arm located in remote places. As of now these types of gloves are widely used in the areas such as Medical Surgery, Nuclear research centers, Bomb disposal and more other fields too.

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CHAPTER 1

INTRODUCTION

1.1 HAPTIC TECHNOLOGY

Haptic technology can be described as a technology which is used to interface the user with a virtual environment with the help of the sense of touch by using vibrations, forces and motions. This mechanical stimulation is used to help in the creation of virtual objects and also to improve the remote control of various devices. This is an emerging technology with wide range of applications

The term haptic originated from the Greek word “haptikos” meaning pertaining to the sense of touch and comes from the Greek verb “haptesthai” meaning to contact or touch.

For example the haptic technology has made it possible to investigate the way in which human sense of touch works by allowing the creation of the controlled haptic virtual objects. These objects are used to systemically probe the human haptic capabilities, which would be definitely difficult to achieve without this technology.

This new research tools will contribute to our understanding of human touch and the functions of brain beneath it. These devices are very much capable of measuring the reactive forces that are applied to the user.

1.2 HISTORY OF HAPTICS

In the early 20th century, psychophysicists introduced the word haptic to label the subfield of their studies that addressed human touch-based perception and the manipulation. In the early 1970s and 1980s, important research efforts had been carried out in the totally different field. Robotics also began to focus on the manipulation and perception by touch.

At first they are concerned with the building of autonomous robots; researchers found very soon that the building of the dexterous robotic hand was much more complex and subtle than their hopes suggested them. In time the above mentioned communities, one which tried to understand the human hand and one which is interested to create astonishing devices with dexterity inspired by human abilities found interest in the topics such as design of sensors, processing of signals and the coding of haptic information.

In the early 1990s a new usage of the word haptics began to develop. The combination of several developing technologies made virtual haptics possible. Like computer graphics, virtual haptics introduces the display of simulated objects to humans in a way to interact well. However, this haptics uses a display technology through the objects that can be physically examined by touch.

Future applications of haptic technology cover wide varieties of human interaction with technology. Current research focuses on the complete control of tactile interaction with holograms and distant objects, which if successful may result in applications and advancements in gaming, movies, manufacturing, medical, and other industries. The medical industry stands to gain from virtual and telepresence surgeries, which provide new options for medical care. The clothing retail industry could gain from haptic technology by allowing users to "feel" the texture of clothes for sale on the internet. Future advancements in haptic technology may create new industries that were previously neither feasible nor realistic.

1.3 TYPES OF HAPTIC FEEDBACK

The information provided by the haptic system will be the combination of (i) Tactile information and (ii) Kinesthetic information.

Tactile feedback

Tactile feedback will allow the users to feel things such as the texture of a surface, temperature and vibration. Tactile information refers the information acquired by the sensors which are actually connected to the skin of the human body with a particular reference to the spatial distribution of pressure, or more generally, tractions, across the contact area.

For example when we handle flexible materials like fabric and paper, we sense the pressure variation across the fingertip. This is actually a sort of tactile information.

Tactile sensing is also the basis of complex perceptual tasks like medical palpation, where physicians locate hidden anatomical structures and evaluate tissue properties using their hands.

Force Feedback

Force feedback reproduces directional forces that can result from solid boundaries, the weight of grasped virtual objects, mechanical compliance of an object and inertia.

It is the area that deals with Haptic Devices that interact with the muscles and tendons which produces the sensation of force application on the player. These devices consist mainly of robotic manipulators applying forces pushing against the user corresponding to the environment in which there is the "effector" device used to produce a desired change in an object in response to a given command.

1.4 PROBLEM STATEMENT

In order to operate the robotic arm in a remote place and to have full control over the operation of the arm, haptic technology is needed. This will be helpful so that the arm can be used for handling materials in nuclear research centers, for bomb disposals and surgery operations. This will be used in hazardous environments too. Nowadays this technology is widely used in the minimal invasive surgical operations with the help of advancement in robotic arm and sensors technology. This led to the accuracy of haptic devices.

1.5 OBJECTIVE

- To control the movement of Robotic Arm using haptic technology.
- To get a tactile feedback from the arm and give sense of touch to the user.
- To pick and place an object from one place to another around the robotic arm.

CHAPTER 2

LITERATURE REVIEW

2.1 Robotics arm control using haptic technology[1]

Vipul J. Gohil, Dr. S D. Bhagwat,Amey P. Raut, Prateek R. Nirmal

This paper mainly depends on the movement of robotic arm using haptic technology. Haptic technology is tactile feedback technology and it takes the advantage of sense of touch by applying motions, forces or vibration. The sensor used in the haptic device act as a transducer. It converts hand motion into electric signal. These hand movements are based on the required movement of robotic arm. It also consists of haptic glove and this glove act as a transmitter. This glove can be fit over the entire hand and this glove consists of potentiometer mounted on the fingers, wrists and pickup. This potentiometer can change the resistance with respect to the hand movement. The receiver part consists of robotic arm. This arm can be moved in different directions based on the degree of freedom. Each degree of freedom is a joint in the robotic arm and they are revolute type.

2.2 "Haptic interfaces and devices" by *Vincent Hayward* et al. Sensor Review Volume[2]

In this project, the basic concept of haptic technology is used in surgical simulation and medical training. PHANTOM is small robot arm with three revolute joints each connected to a computer-controlled electric DC motor. Cyber grasp is also used to measure the position and orientation of the fore arm in three dimensional spaces. Cyber grasp and phantom are haptic devices. Force feedback is the area of haptic that deals with devices that interact with the muscles and Tendons that give the human a sensation of a force being applied with hardware and software that stimulates humans' sense of touch and feel through tactile vibrations or force feedback. This device manly consists of robotic manipulators that push backs against a user with the forces that correspond to the environment that the virtual effector's. This device is normally used to indicate whether or not the user should contact with virtual object.

CHAPTER 3

METHODOLOGY

3.1 WORKING CONCEPT

In this project the methodology is to control the robotic arm with the help of the haptic glove. The haptic glove consists of the following parts namely,

- Accelerometer sensor
- Joystick potentiometer
- Vibrator motor (cellphone)

The haptic glove's movement will be used to pick and place an object in the required place around the robotic arm. The main objective is to control the arm to pick and place the object.

3.1.1 Robotic arm movement with respect to haptic glove

As per the above figure, the movement of the haptic glove will be sensed by the accelerometer sensor. Then based on the movement of the hand in the x, y or z direction, the accelerometer will send the signal to the microcontroller.

The microcontroller based on the conditions given to it via program will give signal to the driver IC board to drive the dc gear motors in the joints of the arm.Thus the arm will be moved in the up, down, left or right direction as per requirement.

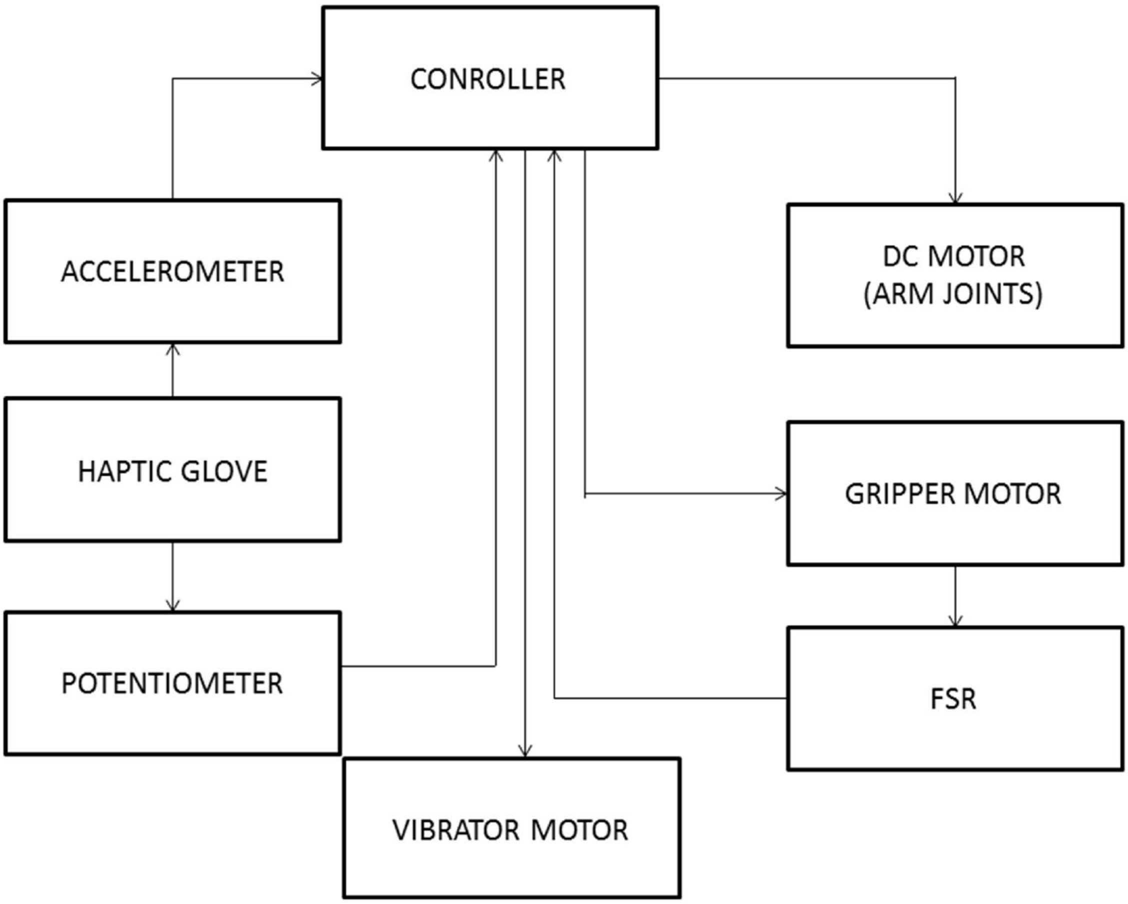

FIGURE 1 BLOCK DIAGRAM

3.1.2 Gripper movement with respect to index finger

After the robotic arm is moved to the required position, the index finger of the glove will be bent. This finger will be attached to the analog stick potentiometer which is used in joystick in order to know the movement of the finger. Thus when the finger is bent the potentiometer will give the corresponding values to the controller. The controller will send the signal to the driver IC, in order to open or close the gripper.

3.1.3 Haptic feedback to the user

After the object is picked the force sensitive resistor will send a feedback signal to the controller. The controller will make the user to realize that the object has been picked by giving a pulse to the vibrator motor at the end of the haptic glove.

CHAPTER 4

COMPONENT DESCRIPTION

4.1 ARDUINO BOARD

Arduino is an open source platform which is used widely in the projects by the engineering students because of their user friendly programming environments. It also doesn't require any separate hardware setup called a programmer which is used enter the new code onto the board, a simple USB cable can be used for this purpose from computer to the board directly. But in the previous programming boards a programmer board is must.

It consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer. [6]

The Arduino Integrated Developing Environment (IDE) uses a user friendly version of C++ programming la4.1nguage. Moreover it can easily interact with the cameras, motors, buttons, LEDs and more. The Arduino software is freeware and even the hardware boards are very much cheap. They are easy to learn too. These reasons have now led to the large number of users.

In this project an Arduino Uno board with the ATmega 328 controller is used. This has about 14 digital input or output pins, 6 analog input pins, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. Among those 14 digital pins, six are PWM pins. Thus it has each and everything needed to support a controller. The next thing to be done is to connect it to the pc via usb cable and start programming. [3]

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

TABLE 1 ARDUINO BOARD PROPERTIES[4]

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Advantages

- Inexpensive
- Cross platform
- Simple, clear programming environment
- Open source and extensible software

4.2 MOTOR DRIVER IC

L293D

In order to rotate a wheel or an action even a small robot requires a motor. These motors usually require higher amount of current than the microcontrollers can generate typically. Hence there arises a requirement of some type of switch such as transistors, MOSFET or Relay. These devices can accept a small amount of current, amplify it and then generate a larger current. This current can be used to drive a motor. This process is done by a device or IC called as Motor driver.

In this project a L293D motor driver IC is used. It is standard 16-pin DIP (dual in line package). This driver IC can be used to control two motors at a time in both the directions that is, in forward and reverse direction.

It requires only four microcontroller pins to this operation. It works based on the concept called as H-bridge. This is a circuit which allows the voltage to flow in one of the direction. It usually called as h-bridge IC but it is actually a dual H-bridge driver since it contains two h-bridge to control two motors.

Thus if the direction of the voltage is changed, then the motor can be made to rotate either in clockwise or anticlockwise direction. As a result, at the end the h-bridge IC seems to be ideal to drive the motors.

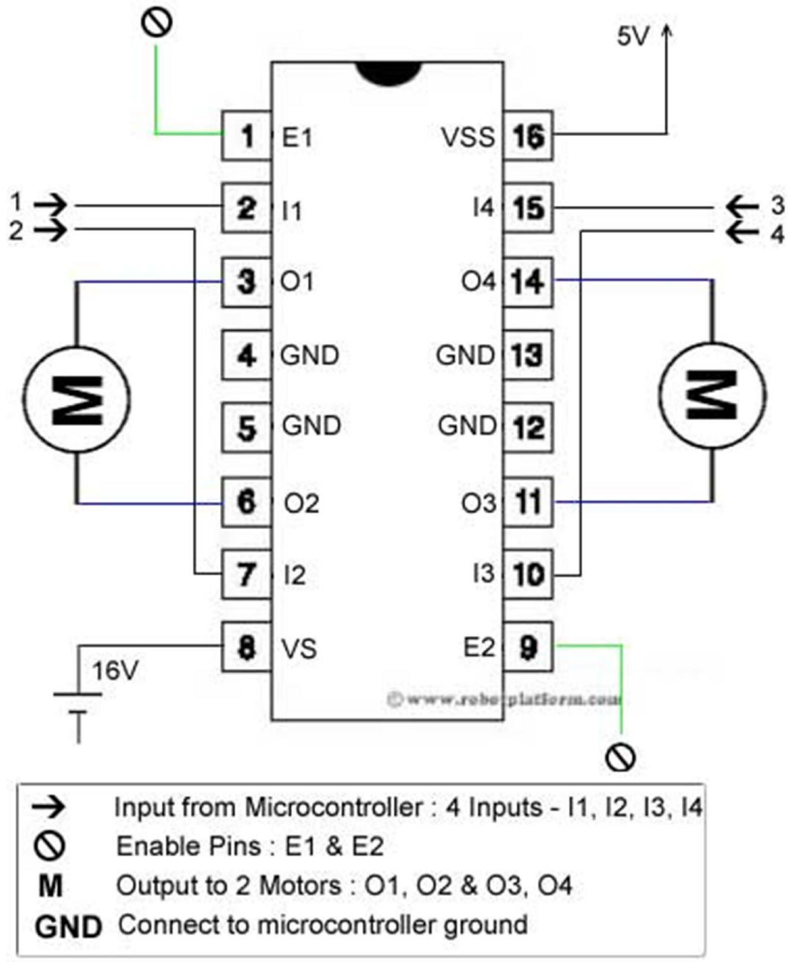

FIGURE 2 L293D PINOUT DIAGRAM[5]

TABLE 2 TRUTH TABLE FOR L293D IC

Pin 1	**Pin 2**	**Pin 7**	**Function**
High	High	Low	Turn Anti-clockwise (Reverse)
High	Low	High	Turn clockwise (Forward)
High	High	High	Stop
High	Low	Low	Stop
Low	X	X	Stop

4.3 ACCELEROMETER SENSOR

ADXL335

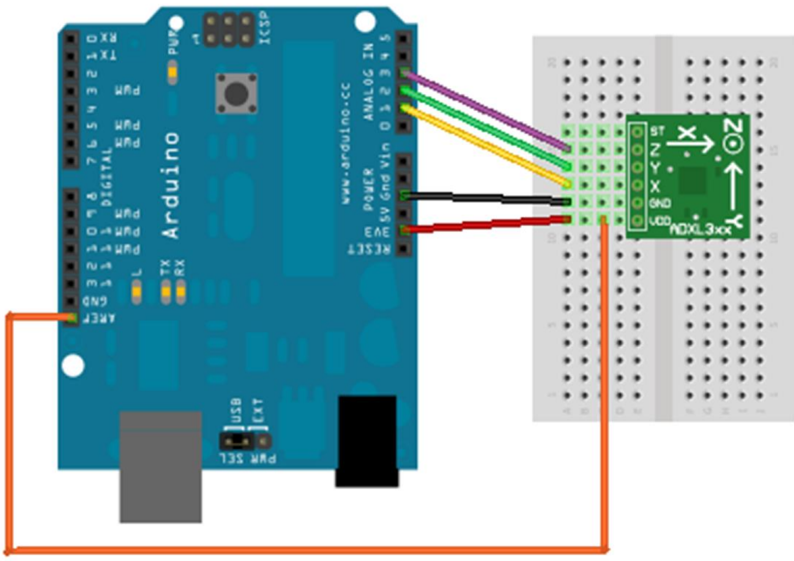

FIGURE 3 ADXL335+ARDUINO

The accelerometer consists of mechanical sensing elements and it converts the mechanical signal into electrical domain.ADXL335 is a small, thin, low power and completed 3-axial accelerometer with signal conditioning voltage output. This ADXL335 measures the acceleration with minimum full scale range of +3g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The programmers select the bandwidth of the accelerometer using cx, cy and cz capacitors at the xout, yout and z out pins.[6]

Accelerometer

Accelerometer is used to measure proper acceleration. Accelerometer is defined as the rate of change of velocity. The gravity is a unit of acceleration and it is equal to earth gravity at sea level.32.2f/s2or9.81 m/s2.

Features

- 3-axis sensing
- Small
- Low profile package
- 4 mm × 4 mm × 1.45 mm LFCSP
- Low power -350 µA
- Single-supply operation-1.8 V to 3.6 V
- 10,000 g shock survival
- Good temperature stability
- Bandwidth adjustment with a single capacitor per axis.

Types of accelerometers

- Capacitive
- Piezoelectric
- Piezo resistive
- Hall effect
- Magneto resistive
- Heat transfer

Sensor terminology

Three types of sensor terminology are used in accelerometer. They are +1g, +0g and -1g.

- +1g-the sensor output with the base connector pointed up.
- +0g-the sensor output with the base connector horizontal.
- +1g-the sensor output with the base connector vertical.

ADXL335

ADXL335 is a complete three axis accelerometer. It can measure acceleration with minimum full scale range of +/-3g.they also measures static acceleration such as tilt sensing application and dynamic acceleration such as resulting from motions, shock or vibrations.[7]

The accelerometer module has 5 pins

GND, VCC, X, Y and Z

Operation

ADXL335 contains polysilicon surface micro machined sensor and signal condition circuit. Both of them are used to implement open loop acceleration measurement architecture. The output signals are basically analog voltage and it is directly proportional to acceleration. The sensor is mounted on the top of a silicon wafer.

The polysilicon springs are suspended over the surface of the wafer and it provides resistance against acceleration forces. Then the differential capacitor consists of independent fixed plates and plates attached to the moving mass. This capacitor can be used to measure deflection of the structure.so that acceleration deflects the moving mass and unbalances the differential capacitor. The output of the sensor i.e., amplitude is proportional to acceleration. Then phase-sensitive demodulation are used to determine the magnitude and direction of the acceleration .the demodulator output is amplified through 32k resistor using off chip. Then the user sets the signal bandwidth of the device by adding a capacitor. This filtering method improves the measurement resolution.

Applications

- Motion
- Tilt sensing
- Mobile devices
- Gaming systems
- Disk drive protection
- Image stabilization
- Sports and health devices

4.4 POTENTIOMETER

It is a device used to measure potential difference by balancing with it a known potential difference. Potentiometer is an electrical device and a potential is applied across a resistance wire of uniform cross sectional area and length of about 4 to 10m. They are used to measure the emf of a cell and compare the EMF of a cell. There are two methods to determine the internal resistance of a cell.[8]

They are

1. Individual method.

2. Sum and difference method.

Construction and working

Potentiometer consists of a uniform cross sectional area of resistance wire and length of about 4m to 6m. The potentiometer is fixed on a rectangular wooden board between point A and point C in zigzag way. Then the meter scale is used to measure the length of the null point so as to fix the meter scale below the first wire. The EMF of a cell is connected between point A and point C. This cell is also called as lead cell or auxiliary cell .It consists of two terminals. The positive terminal is connected to point A through plug key K and the negative terminal is connected to point C through rheostat R. As a result, there will be a gradual fall of potential along the potentiometer wire.

4.4.1 JOYSTICK POTENTIOMETER

It consists of two independent potentiometers and it can be used as a dual adjustable voltage dividers. It also provides 2 axis analog inputs in a control stick form. One potentiometer is used for one axis and another potentiometer for second axis. It includes spring auto return to center and a cup type knob. The cup type knob gives the feel of a thumb stick. [9]

Features

- Connection of bread board is easy
- Common ground with two independent potentiometers
- Center position using spring auto return
- Existing with most micro controllers
- Cup type knob is preferable

Applications

- Camera pan tilt control
- Game input control
- Robot control
- Analog input of parameters

4.5 FSR

FSR sensors are used to detect physical pressure, squeezing and weight. The below diagram of the FSR sensor is specially the inter link of 402 model. The sensitive bit of the FSR sensor is the half diameter round part of the FSR sensor .FSR sensors are fairly low cost ,connection of breadboard is easy and comfortable to use.

FIGURE 4 FSR SENSOR[10]

Types of FSR sensors

Two types of FSR sensors are normally used. They are large and square sensors and small round sensors. The smaller sensors are used in hands, shoulders and head. The most of the sensors are normally larger ones. They are used to detect if there was contact or not with particular parts of the body. There are many types of FSR sensor are available wherever necessary it should be manufactured.

Construction and working

FSR is made of two layers .This two layers are separated by a spacer. The more number of active element dots touch the semiconductor and it makes the resistance go down. FSR consists of a resistor and this resistor value changes depending on how much it is pressed. FSR resistor changes when more pressure is applied .If there is no pressure FSR sensor will act as an infinite sensor, when the pressure increases the resistance will go down.[11]

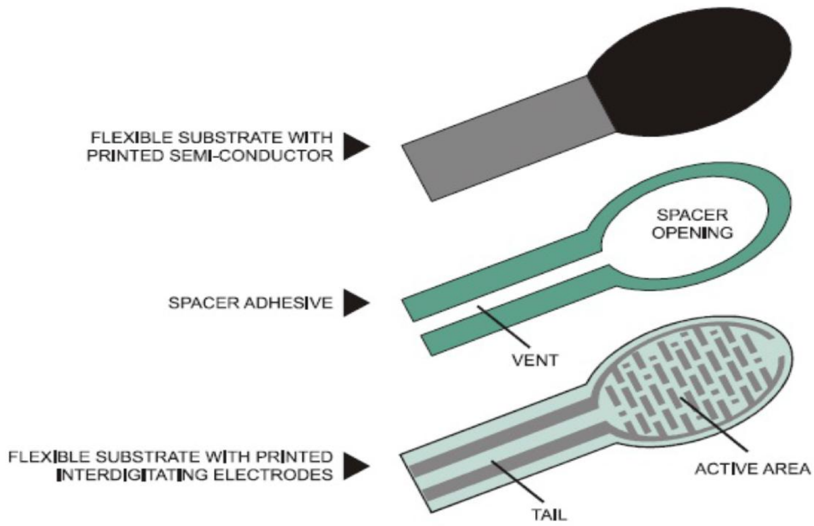

FIGURE 5 CONSTRUCTION OF FSR[10]

Advantages

- It is very cheap
- It is used as self-adhesive.
- FSR sensors are simple variable resistors.
- FSR sensor circuit used for reading the resistor value is very simple.

4.6 ROBOTIC ARM

- A robotic manipulator is a device capable of moving in different directions (base, shoulders, elbow, yaw, pitch, roll directions) relative to base and controlled by Haptic Technology.

- Its base, shoulder, elbows and gripper were actuated by a D.C motor.

- It has three degrees of freedom.

- Two motor driver IC's are connected in order to control four DC motors (base, shoulder, elbow and gripper motors).

- It is made up of acrylic polymer sheet.

- Its payload capacity is 500g.

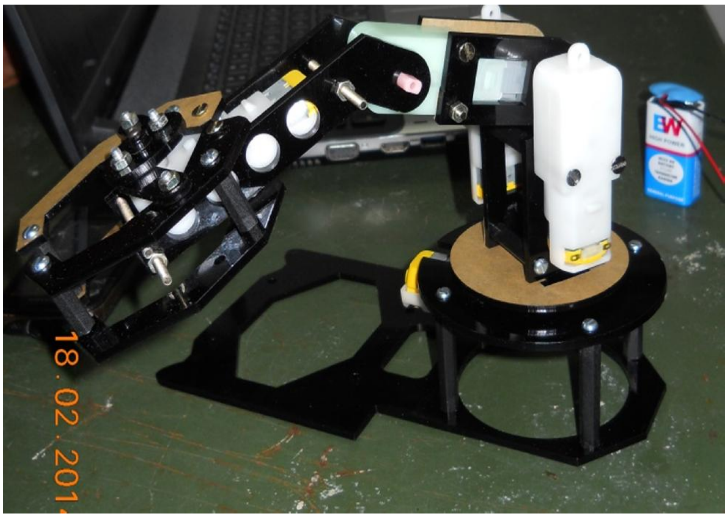

FIGURE 6 ROBOTIC ARM

4.7 BATTERY

Battery is a primary source of electric energy. It is used to store chemicals not electricity. This electrochemical reaction changes chemical energy to electric energy.

Functions of battery

Battery energy is utilized in many ways such as engine off, engine starting and engine running. In engine off battery energy is used to operate the lightning and accessories system. Then the engine starting battery energy is used to operate the starter motor and to provide a current for the ignition system during cranking. Finally the Engine running, battery energy is used to operate the vehicle electric load requirements, when the vehicle electrical load requirements exceed the supply from the charging system. In addition to this battery energy acts as a voltage stabilizer or large filter. It is used to absorbing abnormal transient voltage in the vehicle‘s electrical system. Without this protection electrical and electronic components are damaged by this high voltage.[12]

Types of battery

1. primary cell
2. Secondary cells
3. Wet charged
4. Dry charged
5. Low maintenance

Primary cell

After a period of time, the chemical reaction totally destroys any one of the metals. It can be used small batteries for flashlight and radios for primary cell. Primary cells are chargeable.

Secondary cells

Lead acid batteries are known as secondary cells. The metals and acid mixture changes the battery supplies voltage. The metal becomes similar the acid strength weakness. This is called discharging. When the current supply given to the battery in opposite direction. The battery materials can be restored. This type of process is known as charging process.

Wet charged

The lead acid batteries is filled with electrolyte and charged when it is built. During storage process, a slow chemical reaction will occur. It will cause self-discharge. Periodic changes are required for this type of batteries.

Dry charged

This type of batteries is constructed by charged, washed and dried. It can be sealed and shipped without electrolytes. While in use it requires electrolyte and charging. This type of batteries is stored for 12 to 18 months.

Low maintenance

This battery is used to reduce internal heat and water loss. Most type of batteries used in toyota vehicles are low maintenance battery.

FIGURE 7 BATTERY

The specifications of this battery are:

- Voltage – 12V
- Capacity – 1.3Ah
- Constant voltage charge

CHAPTER 5

EXPERIMENT AND RESULTS

5.1 ACCELEROMETER ADXL335

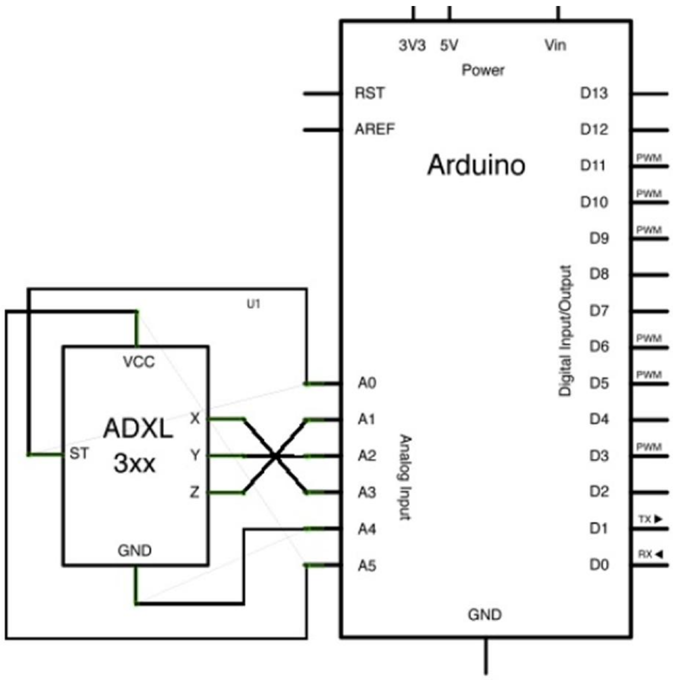

FIGURE 8 ADXL335+ARDUINO

In this project, the accelerometer plays a vital role as far as the haptic glove is concerned. This is the main component for the shadowing movement of robotic arm along with the glove movement.

The Accelerometer module has 5 pins for operation, namely

1. GND-To be connected to Arduino board's GND
2. VCC-To be connected to Arduino's 5V
3. X-To be connected to Analog Pin A5
4. Y-To be connected to Analog Pin A4
5. Z-To be connected to Analog Pin A3

ALGORITHM

1. As first step, required variables and pins are defined for the corresponding accelerometer pins.

2. Then the serial communication has been initialized with the Arduino and to that of the computer.

3. This is done in order to monitor the result of the sensor variations in the computer.

4. The pin mode is defined whether it is to be used as input or output.

5. The corresponding values from analog input pins will be read as they are the one which give us the acceleration values in the range of 0 to 1023.

6. This process to read the accelerometer values will be included in the loop with certain delay in order to monitor the change continuously.

PROGRAM

```
const int groundpin = 18;
const int powerpin = 19;
const int xpin = A3;
const int ypin = A2;
const int zpin = A1;
void setup()
{
   Serial.begin(9600);
  pinMode(groundpin, OUTPUT);
  pinMode(powerpin, OUTPUT);
  digitalWrite(groundpin, LOW);
  digitalWrite(powerpin, HIGH);
}
void loop()
{
  Serial.print(analogRead(xpin));
   Serial.print("\t");
  Serial.print(analogRead(ypin));
 Serial.print("\t");
  Serial.print(analogRead(zpin));
```

```
Serial.println();
delay(100);}
```

RESULT

- X=516; y=512; z=594 when it was flat.
- And these three values vary between 0 and 1023 for variation of tilt angle from -90 to +90.

5.2 JOYSTICK POTENTIOMETER

The joystick in the picture is nothing but two potentiometers that allow us to measure the movement of the stick in 2-D. Potentiometers are variable resistors and, in a way, they act as sensors providing us with a variable voltage depending on the rotation of the device around its shaft.

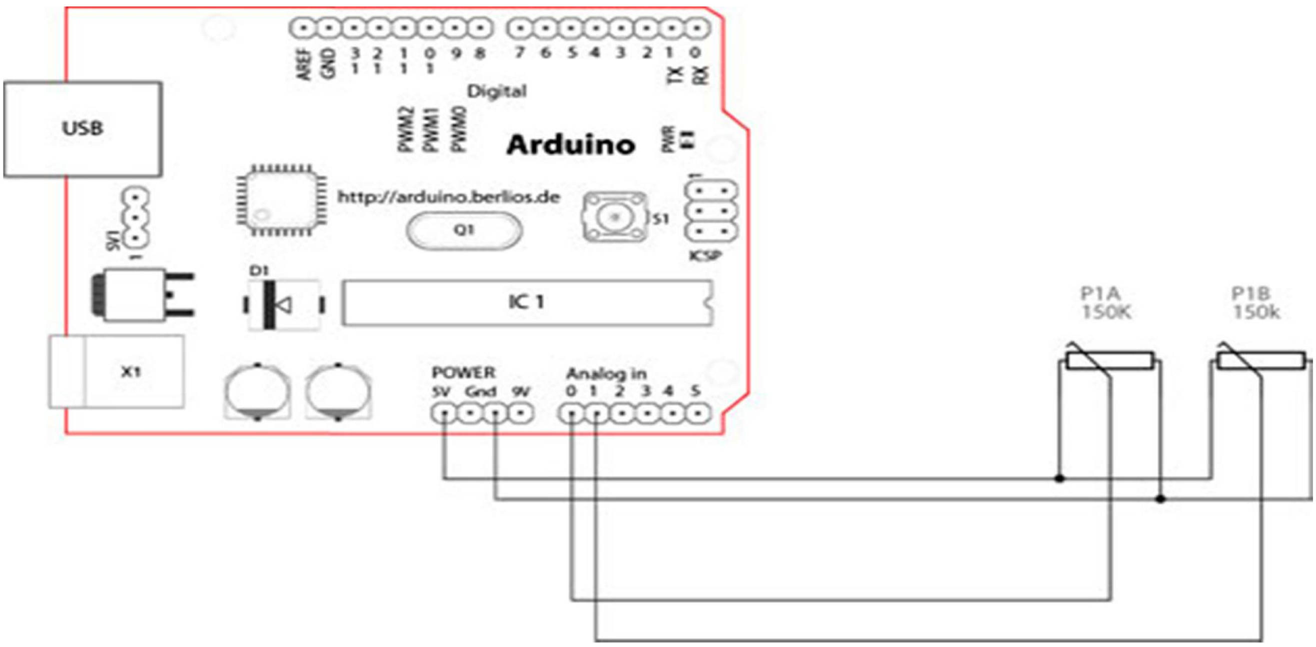

FIGURE 9 POTENTIOMETER + ARDUINO[9]

ALGORITHM

1. The potentiometer pins which are connected to the Arduino board analog input will be declared in the start of the program.

2. After that, the serial communication has been initialized with the Arduino and to that of the computer.

3. Then the corresponding pin modes will be mentioned as output or input.

4. The potentiometer pin's value which gives us the change in analog stick movement will be read continuously in the loop.

5. The corresponding movement and resulting values will be noted for further improvement.

PROGRAM

```
#define X_AXIS    A0

#define Y_AXIS    A1

#define Z_SWITCH  3

int  Xvalue;

int  Yvalue;

int  Zvalue;

void setup()   {

Serial.begin(9600);

}
```

```
void loop()   {
Xvalue = analogRead (X_AXIS);
Serial.print ( "X:" );
Serial.print (Xvalue, DEC );
Yvalue = analogRead (Y_AXIS);
 Serial.print ( " | Y:" );
Serial.print (Yvalue, DEC );
Zvalue = digitalRead (Z_SWITCH);
 Serial.print ( " | Z: " );
Serial.print (Zvalue, DEC );
Serial.println ();
delay(250);
}
```

RESULT

- The resulting analog values range from 0 to 1023 (i.e., 1024 values. 1024 is "2 to the power of 10" and Arduino has a "10 bit Analog-to-Digital Converter").
- When the joystick is in the centered 'hands off' position, the values will be somewhere near 512 (Half of 1024).
- And it will vary, when moved to forward or backward position

5.3 FORCE SENSITIVE RESISTOR (FSR)

Force sensitive resistor as the name suggests is a resistor which changes its resistance when it is made to undergo a force or pressure on its surface

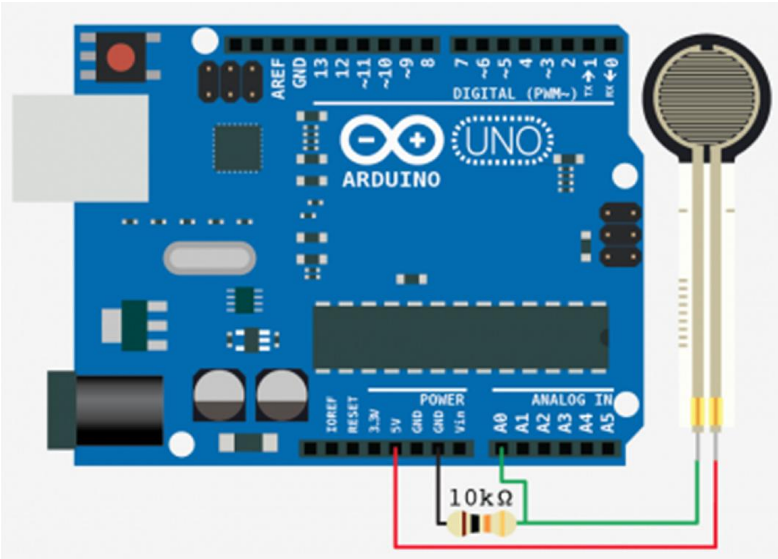

FIGURE 10 ARDUINO AND FSR CONNECTION

PROGRAM

```
int FSR_Pin = A0; //analog pin 0

void setup(){

  Serial.begin(9600);

}

void loop(){

  int FSRReading = analogRead(FSR_Pin);

  Serial.println(FSRReading);

  delay(250); }
```

RESULT

- The analog reading on the Arduino is actually a voltage meter. At 5V (it's 34max) it will read 1023, and at 0v it will read 0. So that we can measure how much voltage is on the FSR using the analogRead option and we will have force reading that we give.
- The amount of that 5V that each part of the voltage divider gets is proportional to its resistance. So if the FSR and the 10k resistor have the same resistance, the 5V is split evenly (2.5V) to each part. (i.e., analog reading of 512)
- But if the FSR is being pressed on pretty much hard, reading only 1K of resistance, then the 10K resistor is going to soak up 10 times as much of that 5V. As a result, the FSR would only get .45V. (i.e., the analog reading of 92)
- And if there is something pressing on it very lightly, then the FSR may be 40K of resistance, and so the FSR will soak up 4 times as much of that 5V as the 10K resistor. Thus the FSR would get about 4V. (i.e., the analog reading of 819)

5.4 ROBOTIC ARM MOTOR CONTROL

Another important programming part in this project is to control the direction and speed of the dc motor as per the need i.e., the current position of the haptic glove. The driver IC L293D is the tool for this purpose as described in the components section.

There are five dc motors in the robotic arm of which two of them need to be actuated together due to the arrangement. So the need is to control four DC motors, for which two driver ICs are required.

The first step is to connect the enable and input pins to the digital I/O ports of the Arduino. Especially the enable pins need to be connected to the pwm ports for speed control of motors.

PROGRAM

```
//VARIABLE DECLARATION
const int xpin = A3;
const int ypin = A2;
const int zpin = A1;
int FSR_Pin = A4;
int grip1 = 2;
int grip2 = 4;
int enablePin = 3;
int elbow1 = 7;
int elbow2 = 6;
int enablePin1 = 5;
int base1 = 8;
int base2 = 10;
int enablePin2 = 9;
int shoulder1 = 12;
int shoulder2 = 11;
int  x1;
int  VIB = 13;
int  x_val;
int  y_val;
```

```
int  z_val;
# define speed 64
#define X_AXIS A0

void setup()
{
   // DECLARE PINS AS OUTPUTS
   pinMode(grip1, OUTPUT);
   pinMode(grip2, OUTPUT);
   pinMode(enablePin, OUTPUT);
   pinMode(elbow1, OUTPUT);
   pinMode(elbow2, OUTPUT);
   pinMode(enablePin1, OUTPUT);
   pinMode(base1, OUTPUT);
   pinMode(base2, OUTPUT);
   pinMode(enablePin2, OUTPUT);
   pinMode(shoulder1, OUTPUT);
   pinMode(shoulder2, OUTPUT);
   Serial.begin(9600);
}
```

```
void loop()
{
  // ACCELEROMETER AND POTENTIOMETERS READING THE PIN
  x_val=analogRead(xpin);
  delay(100);
  y_val=analogRead(ypin);
  delay(100);
  z_val=analogRead(zpin);
  delay(100);
  x1 = analogRead (X_AXIS);
  delay(100);
  int FSR = analogRead(FSR_Pin);
  //THE IF CONDITIONS FOR ARM MOVEMENT
if(FSR<222)
{
digitalWrite(VIB, HIGH);
}
if (x1 < 444)
        {
          drive_gripcw();
          delay(1000);
```

```
        grip_stop();
        }
      else if(x1>512)
         {
         drive_gripacw();
         delay(1000);
         grip_stop();
         }
           else{
           grip_stop();
           delay(1000);
           }
if (x_val>650)
        {
        drive_basecw();
        delay(1000);
        base_stop();
        }
         else if(x_val<350)
         {
         drive_baseacw();
```

```
        delay(1000);
        base_stop();
        }
          else{
          base_stop();
          delay(1000);
          }
if (y_val>650)
       {
       drive_elbowcw();
       delay(1000);
       elbow_stop();
       }
        else if(y_val<350)
        {
        drive_elbowacw();
        delay(1000);
        elbow_stop();
        }
          else{
          elbow_stop();
```

```
            delay(1000);
            }

if (z_val>650)
        {
        drive_shouldercw();
        delay(1000);
        shoulder_stop();
        }
          else if(y_val<350)
          {
          drive_shoulderacw();
          delay(1000);
          shoulder_stop();
          }
            else{
            shoulder_stop();
            delay(1000);
            }
}
```

```
// FUNCTIONS TO DRIVE MOTORS
void drive_gripcw()
{
	analogWrite(enablePin, speed);
	digitalWrite(grip1, HIGH);
	digitalWrite(grip2, LOW);
	delay(1000);
}
void drive_gripacw()
{
	analogWrite(enablePin, speed);
	digitalWrite(grip2, HIGH);
	digitalWrite(grip1, LOW);
	delay(1000);
}
void grip_stop(){
	analogWrite(enablePin, speed);
	digitalWrite(grip2, LOW);
	digitalWrite(grip1, LOW);
	delay(1000);
}
```

```
void drive_basecw()
{
        analogWrite(enablePin1, speed);
        digitalWrite(base1, HIGH);
        digitalWrite(base2, LOW);
        delay(1000);
}
void drive_baseacw()
{
        analogWrite(enablePin1, speed);
        digitalWrite(base2, HIGH);
        digitalWrite(base1, LOW);
        delay(1000);
}
void base_stop(){
  analogWrite(enablePin1, speed);
        digitalWrite(base2, LOW);
        digitalWrite(base1, LOW);
        delay(1000);
}
```

```
void drive_shouldercw()
{
        analogWrite(enablePin2, speed);
        digitalWrite(shoulder1, HIGH);
        digitalWrite(shoulder2, LOW);
        delay(1000);
}
void drive_shoulderacw()
{
        analogWrite(enablePin2, speed);
        digitalWrite(shoulder2, HIGH);
        digitalWrite(shoulder1, LOW);
        delay(1000);}
void shoulder_stop(){
   analogWrite(enablePin2, speed);
        digitalWrite(shoulder2, LOW);
        digitalWrite(shoulder1, LOW);
        delay(1000);
}
void drive_elbowcw()
```

```
{
        analogWrite(enablePin2, speed);
        d
igitalWrite(elbow1, HIGH);
        digitalWrite(elbow2, LOW);
        delay(1000);
}
void drive_elbowacw()
{
        analogWrite(enablePin2, speed);
        digitalWrite(elbow2, HIGH);
        digitalWrite(elbow1, LOW);
        delay(1000);
}
void elbow_stop(){
  analogWrite(enablePin2, speed);
        digitalWrite(elbow2, LOW);
        digitalWrite(elbow1, LOW);
        delay(1000);  }
```

CHAPTER 6

COST ESTIMATION

TABLE 3 COST ESTIMATION

S.NO	COMPONENTS	RANGE	QUANTITY	COST (Rupees)
1.	Arduino board	---	1	1750
2.	Robotic arm	---	1	2400
3.	Accelerometer sensor	---	1	700
4.	Joystick potentiometer	---	1	250
5.	Battery	12 V/1.2A	1	500
6.	Driver IC	---	2	280
7.	FSR sensor	---	1	800
8.	Miscellaneous cost(wiring, tapes, gloves, etc.,)	---	few	500
TOTAL				7180

CHAPTER 7

RESULT

Thus the robotic arm is made to move along with the movement of the haptic glove. And the arm is made to pick an object and send the feedback to the user in the form of vibration, with the help of a mini vibrator motor. The various movement of arm with respect to that of the glove is given in the following table.

TABLE 4 MOVEMENT OF ROBOTIC ARM

Haptic glove movement	Robotic arm motor movement
Tilt the glove towards right	Base motor rotates to move arm right
Tilt the glove towards left	Base motor rotates in opposite direction to move arm left
Tilt the glove up	Shoulder motor rotates to move arm up
Tilt the glove down	Shoulder motor rotates in opposite direction to move arm down
Tilt the glove forward	Elbow motor will rotate to move arm forward
Tilt the glove backward	Elbow motor will rotate in opposite direction to move arm backward
Move the index finger forward	Gripper motor rotates to close the gripper
Move the index finger backward	Gripper motor rotates in opposite direction to open the gripper

CHAPTER 8

CONCLUSION

Thus the robotic arm is controlled using haptic technology and proper feedback for the haptic part is done. We have used potentiometers and accelerometers for the sensors part. Even highly sensitive and costlier accelerometer sensors alone can be used for this purpose. This will definitely improve the performance and accuracy. If high performance controllers are used, it will improve the speed of operation with much finer movement.

CHAPTER 9

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