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Research paper



Sign Language Interpreter

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Abstract

The world's population now stands at 7.6 billion. Out of these, millions of people are not blessed with the ability to hear or/and speak. Although speech becomes a barrier between these people and other abled persons but, there are three types of sign languages which help to decrease this gap. There are about 250 types of sign language interpreters which translate their language for other people. This paper describes a similar type of device aimed to facilitate a bridge between the two groups of population. It develops a wearable device having motion detecting sensors to sense the orientation and direction of fingers in order to recognize the gesture made by the user. Also, it transmits the gesture to a wireless display unit through a Bluetooth module which displays the corresponding word to the gesture made on an LCD. Thus, in this way, sign-to-text conversion is carried out. The heart of the device is Atmega328 with flash memory of 32k bytes enabling us to store a wide range of words. The designed system was capable to recognize the pre-stored gestures according to ASL (American Sign Language). Prototype was designed for one hand and it was tested on a few gestures.

Keywords: *ASL; atmega; Bluetooth; component; deaf; dumb; interpreter; LCD; motion detection; sign; wearable.*

1. Introduction

Communication is of utmost importance whether it is for a task as simple as shopping or as difficult as visiting doctors or government institutions where there is a need for proper and efficient communication. The people with hearing and/or speaking disability face problems due their different way of communication. It is imperative that they be given the same opportunity to express themselves. It is not always possible for them to have an interpreter to remove the confusion of the communication barrier. As explained by Anna et al. much has changed over time and technology has crossed all the barriers to reach to the special population of the world in one way or the other [1]. Anusha L. et al. implemented a system to detect the sign language using MPU6050 sensors and processing was done on raspberry pi to convert the recognized gestures into English alphabets from A-Z. The system generated a voice output using voice RSS and Microsoft translator [2]. Inspired by the choice of motion detection sensor, the proposed device also used five MPUs, one of each finger to detect the change in accelerometer and gyroscope values with respect to the movement of hand. All the information processing is done by Atmega328p and Bluetooth devices HC-05 are used for transmitting the data. Output is in the form of text displayed on an LCD. Atmega328p is the IC used in Arduino Uno board and the prototype device uses this IC and not the full board to reduce size, complexity and cost of the device. However, all the functions of Arduino were still accessible and usable because of connecting the peripheral components such as crystal, reset switch etc. along with IC on a PCB. The code was written in Arduino IDE and it was uploaded on the IC serially using RX, TX and RESET pins of IC and Arduino board [3,4]. MPU-6050, based on MEMS technology, is used for collecting information because of its low cost and high reliability [5]. It is important to first calibrate the MPU before using because of some manufacturing errors. Calibration process is uncomplicated and FreeIMU is the library used for this purpose. This library can be used with Arduino as well. The first step for activating MPU is to power it with (2.3-3.6) V and then defining the SCL and SDA ports. After this, AD0 pin of each MPU attached on each finger is connected to one of the digital pins of Atmega328p and INT0 pin of all the MPUs is connected to digital pin 2 of the IC to generate interrupts [6,7]. For the purpose of transmitting values of gestures, a receiver and transmitter system is required and this is accomplished by Bluetooth module [8]. Operating voltage for hc-05 is up to 5v and TX, RX pins are on 3.3v. The two Bluetooth modules are configured as slave and master using Arduino code and wire library. The master sends the data and slave receives it to display the recognized gesture. The Bluetooth modules are configured in slave and master modes using the respective AT commands [9,10,11]. A 16x2 LCD screen is used to show output in form of text. It is connected with atmega328p using a library call LiquidCrystal. It is one of the most basic forms of display units and connection with atmega is also very simple. It is capable of displaying characters in two different rows with sixteen characters in each row [12,13]. Thus, the prototype device aims to simply the lives of those in need so that this specific population can also connect with other people with normal abilities.

2. Aim

The project is designed to act as a bridge between people with listening and speaking disabilities and the outer world so that the communication is not limited to only group of people who are aware of the sign language. To achieve this aim, following objectives have been laid out:

- To detect motion of hands
- Training Atmega328 about gestures
- To recognize appropriate gesture
- To successfully form and transmit over a Bluetooth connection

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❖ To receive and display the output

In addition to these, the project aims at cost efficiency and simplicity of the circuit.

3. Materials Used

1. MPU-6050 Sensor - The MPU6050 consists of a 3-axis MEMS accelerometer and a 3-axis MEMS gyroscope and Digital Motion Processor on the same IC. It has an I²C bus to communicate with the Atmega328 IC. AD0 pin of each MPU is connected to a digital pin of Atmega328. The corresponding digtial pin is put on low logic to activate the MPU connected to it and readings are taken correspondingly from MPU. The range of values given by these MPUs is used to decide the gesture made by the user.
2. ATMEGA328P-PU - It is an 8-bit AVR RISC-based microcontroller operates between 1.8-5.5V. It consists of 32 general purpose registers, 23 general purpose I/O lines, 2KB SRAM, I²C capability among many other features.
3. BLUETOOTH MODULE – HC-05 - The Bluetooth module HC-05 is a master/slave module. AT commands are used for setting properties like password, being open to all/specific connections, viewing address of the module, viewing and setting baud rate, setting it to master/slave etc. The HC-05 has 6 pins as follows:

❖ **ENABLE:** Voltage level on this pin determines whether module is functioning or not. +5V/Open on this pin is required for module to get into operation. If enable is pulled low, no communication will take place since the module will not be turned on.

❖ **Vcc:** Range – 3.3v – 5v

❖ **GND:**

Ground provided to module by this pin

❖ **TXD & RXD:** These Tx and Rx pins act as a UART interface for communication. The Rx pin should not have a voltage level exceeding 3.3V.

❖ **STATE:** This gives indication on the status of module. The led connected to this pin is continuously flashing and this shows the user that BT module is not connected to other BT module.

Whenever BT module gets connected, a high signal is passed on this state and the blinking rate of led is changed to notify the user about the connection. There is a delay of 2000ms in led blinking which is unlike to the state when module is not connected.

4. LIQUID CRYSTAL DISPLAY (LCD) SCREEN - LCD module consists of two rows which can print 16 characters each. Consists of a backlight, without which the current consumption is 1mA. Operating voltage is 4.7-5.3V. These prove to be a good option for projects due to its low price and ease of interfacing. All standard LCD's have eight (8) data pins D0-D7, Vcc, Ground, Rc, Rw, En and might/might not have a back light.

4. Methodology

1. Connecting MPU-6050 - First of all, the sensors are connected in order to be able to take readings from different fingers and hence sense motion. In Fig 1, as depicted, the pins of MPU6050 are connected with the IC as follows:

❖ VCC- To 5V of the board

❖ GND- To ground of board

❖ SCL- To analog pin A5 of the board (which is the SCL pin)

❖ SDA- To analog pin A4 of the board (which is the SDA pin)

❖ INT- To the digital pin 2 of the board (which is the interrupt pin)

After successful connection of the MPU6050 with the board, we take readings from the sensors using I²C. The default address of the MPU6050 is 0x68. 0x68 is observed when the AD0 pin of the MPU6050 module is LOW. Therefore, to enable an MPU, the corresponding AD0 pin was set to LOW and readings from that observed. The AD0 pins of MPUs were connected to digital pins 3-7 of the board.

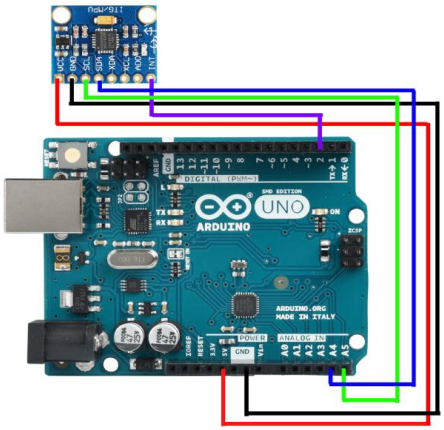

Fig. 1: Connecting MPU-6050 and Arduino

Algorithm for Selecting MPU (Figure 2):

STEP 1 – Declare five digital pins as OUTPUT (D9, D10, D11, D12, and D13) in this case.
STEP 2 – Begin wire transmission at address of MPU and declare register for storing MPU values.
STEP 3 – Put first digital pin at logic low and other at logic high and call function for getting MPU data.
STEP 4 – Repeat step 3 until each digital pin is consequently put at logic low while others were kept at logic high.
STEP 5 – The values from five MPUs is collected and it can be either printer or stored in an array/string.

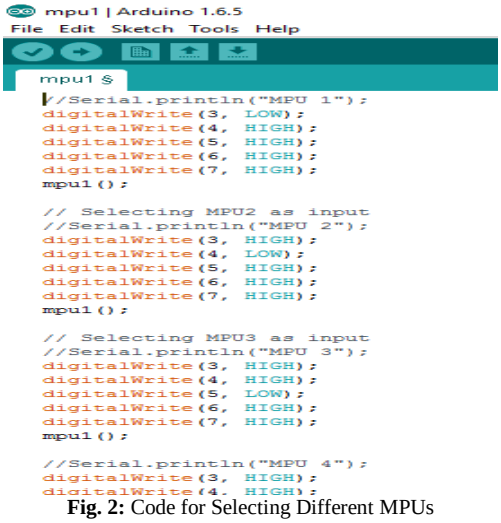

Fig. 2: Code for Selecting Different MPUs

Algorithm for Getting MPU Data (Fig 3):

STEP 1 – As each MPU is put at logic low, this function is called.
STEP 2 – Begin wire transmission for I2C Communication.
STEP 3 – Declare MPU power register for activating MPU.
STEP 4 – Write 0 to MPU power register for activating the selected MPU.
STEP 5 – Again begin wire transmission and declare register for storing MPU data.
STEP 6 – Request a total of 14 registers to store all the data available from MPU
STEP 7 – The accelerometer value from x-axis is shifted and stored in registers 0x3B and 0x3C
STEP 8 – Step 7 is repeated to stored accelerometer values from y and z axis respectively.
STEP 9 – The three values are divided by a constant to change them into dmp mode values.
STEP 10 – Values stored in variables acx, acy and acz can be used for deciding hand position

```
mpu1 | Arduino 1.6.5
File Edit Sketch Tools Help
mpu1 §
}

void mpu1()
{
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x6B);  // PWR_MGMT_1 register
  Wire.write(0);     // set to zero (wakes up the MPU-6050)
  Wire.endTransmission(true);

  Wire.beginTransmission(MPU_addr);
  Wire.write(0x3B);  // starting with register 0x3B (ACCEL_XOUT_H)
  Wire.endTransmission(false);
  Wire.requestFrom(MPU_addr, 14, true); // request a total of 14 registers

  AcX = (Wire.read() << 8 | Wire.read()); // 0x3B (ACCEL_XOUT_H) & 0x3C (ACCEL_XOUT_L)
  AcY = (Wire.read() << 8 | Wire.read()); // 0x3D (ACCEL_YOUT_H) & 0x3E (ACCEL_YOUT_L)
  AcZ = (Wire.read() << 8 | Wire.read()); // 0x3F (ACCEL_ZOUT_H) & 0x40 (ACCEL_ZOUT_L)
  GyX = (Wire.read() << 8 | Wire.read()); // 0x43 (GYRO_XOUT_H) & 0x44 (GYRO_XOUT_L)
  GyY = (Wire.read() << 8 | Wire.read()); // 0x45 (GYRO_YOUT_H) & 0x46 (GYRO_YOUT_L)
  GyZ = (Wire.read() << 8 | Wire.read()); // 0x47 (GYRO_ZOUT_H) & 0x48 (GYRO_ZOUT_L)

  // Changing to dmp mode
  acx = AcX / 16384;
  acy = AcY / 16384;
  acz = AcZ / 16384;
  gyx = GyX / 131;
  gyy = GyY / 131;
  gyz = GyZ / 131;
```

Fig. 3: Code for Getting MPU Data

The range of values of the sensor observed in a particular gesture are unique in terms that only a certain gesture would result in those values. Thus, it is possible to identify the gesture by noticing the values when it is initially made. Several gestures are made during training and multiple values for each gesture observed and recorded.

When the user makes a gesture, a change in the values obtained from the sensor occurs. This change is one from the pool of gestures previously recorded. The output corresponding to that gesture is generated which is the meaning of the gesture in simple English.

2. CONNECTING HC-05 - HC-05 Bluetooth module is quite an easy and inexpensive module to use. It can be used in Master or Slave configuration. It has programmable baud rate whose default value is 9600. It also has the capability to auto-connect to the last connected device and also to forget all previous connections. All these, and several other properties can be viewed and changed by the AT commands. The command AT+ROLE=0 sets the module in slave mode and command AT+ROLE=1 sets the module in master mode. The response of AT+ADDR? Must be noted because this address will be used to connect the master to his slave. The password is also displayed which is 1234 by default. The command used is AT+PSWD?

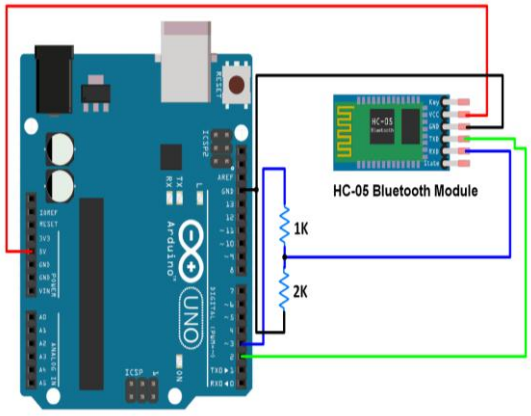

Fig. 4: Connection Between HC-05 and ARDUINO

When all the AT commands have been loaded successfully in both modules, the modules will connect automatically when powered up.

5. Hardware Development

Eagle software was used to create schematic and board layouts. Two PCBs were made. One was having MPUs, Bluetooth module configured as master and an Atmega IC. The other PCB had Bluetooth module configured as slave and an LCD display to print the output. Final PCBs are shown in Fig 5 and Fig 6.

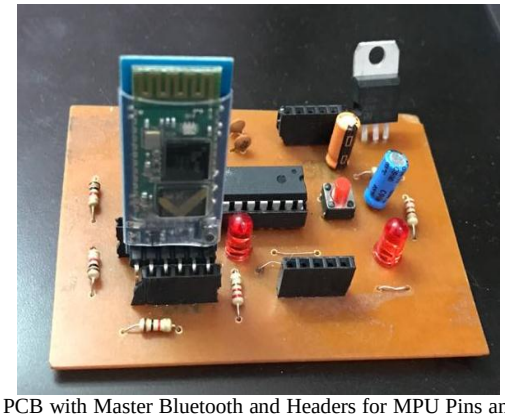

Fig. 5: PCB with Master Bluetooth and Headers for MPU Pins and Power Supply

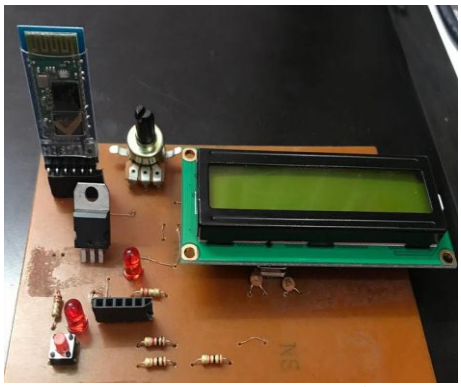

Fig. 6: PCB with Slave Bluetooth and Headers for Power Supply

Five MPUs were sewed on the glove and the PCB with master Bluetooth was pasted on the same glove.

6. Results

The gestures were made according to American Sign Language (ASL) and the prototype was capable to differentiate between the gestures and display them wirelessly on LCD screen. Figure 7 shows a gesture and its corresponding output.

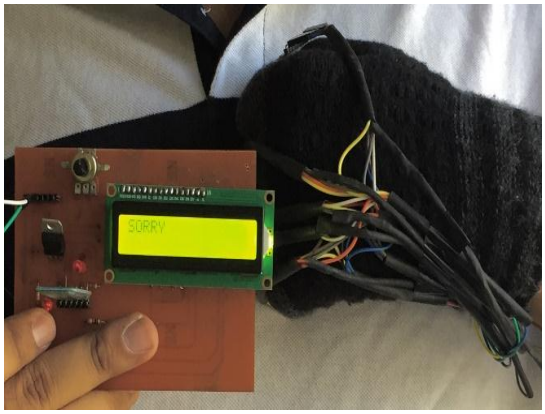

Fig. 7: 'Sorry' Gesture in ASL and Output on LCD Screen

Similarly, other gestures were made and its corresponding output is shown in fig 8-fig 12.

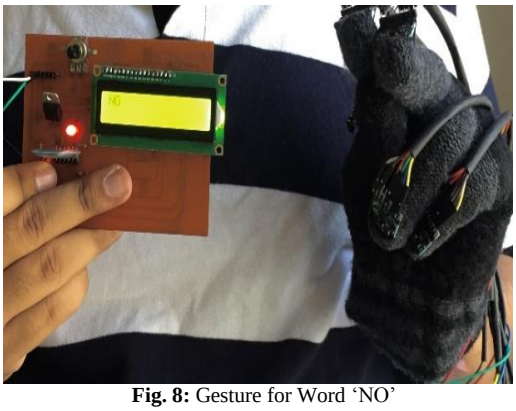

Fig. 8: Gesture for Word 'NO'

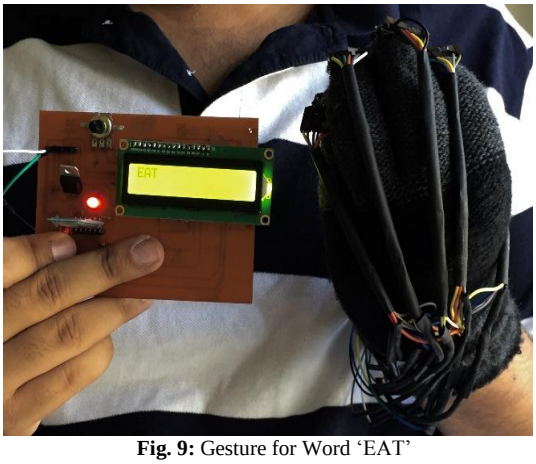

Fig. 9: Gesture for Word 'EAT'

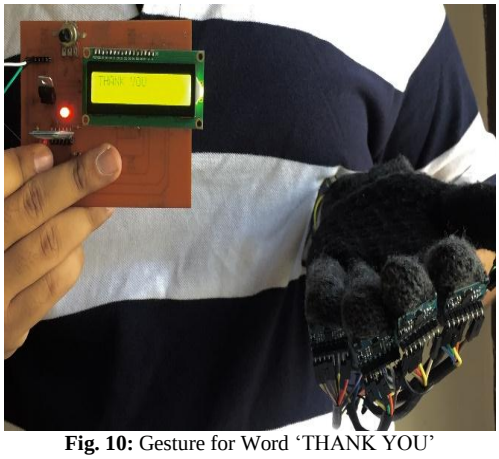

Fig. 10: Gesture for Word 'THANK YOU'

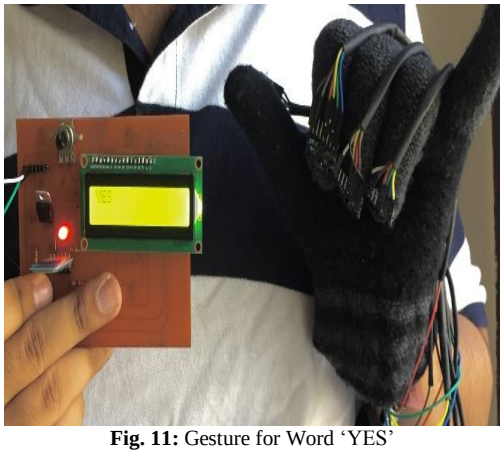

Fig. 11: Gesture for Word 'YES'

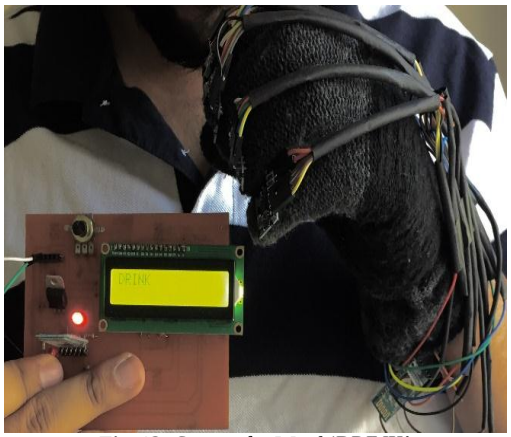

Fig. 12: Gesture for Word 'DRINK'

7. Conclusion

In this prototype, we successfully converted a few gestures of the sign language into text form by detecting the motion of hand while the gesture was made. This device is cost-efficient due to the use of appropriate sensors. Also, the display unit has been made portable and sans wires to avoid hassle. It meets the objectives laid out and provides an efficient means for converting sign language to text for people with hearing and/or speaking disabilities.

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