Sign Language Converter Using Electronic Glove

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Abstract : In this paper we present a sensor glove capable of converting hand gestures to audio wirelessly using Indian Sign Language (ISL). The key components of the device are strain sensors made of inexpensive and conductive material sheet, 'Velostat'. Velostat sheet, which is made of a film surfaced with carbon particles used for anti-static package of electronic parts. Resistance in the sensors varies according to the strain of the film. The sheet is a polymeric foil (polyolefins) impregnated with carbon black to make it electrically conductive. These sensors are integrated on the glove along with IR (infrared) sensors mounted on each finger and Gyroscope on each hand to record the hand movements. A wearable electronic module consisting of a STM32 microcontroller and a Bluetooth module is mounted on the glove. In concert with sensors, glove is able to translate all 26 alphabets and general English language sentence gestures of the ISL into English words and corresponding text. Lastly, data received from the glove is converted into an audio. This application suggests new ways in which stretchable and wearable electronics can minimize communication gap between hearing impaired and outer world to ensure effective communication.

IndexTerms – *Social, Communication, Sign Language, ASL, Disabled, Engineering, Signal Processing, Wireless, Humans*.

I. INTRODUCTION

Over 5% of the world's population or 466 million people has disabling hearing loss (432 million adults) and 34 million of these are children. It is estimated that by 2050 over 900 million people i.e. one in every ten people will have hearing disability. 1.1 billion young people are at risk of hearing loss due to exposure to noise in recreational settings [1]. One of the main impacts of hearing loss is on any individual is inability to communicate with outer world. Spoken language development in children is often delayed with unaddressed hearing loss. Exclusion from communication with outer world can have a significant impact on person's everyday life, causing feelings of loneliness, frustration and isolation, particularly among older people with hearing loss. Reducing the communication gap between hearing impaired and normal people becomes a necessity to ensure effective communication among all.

Indian Sign Language (ISL) is a complete language that employs signs made by moving the hands combined with facial expressions. Sign languages are based on the idea that vision is the most useful tool a deaf person has, to communicate with other people [2].A hearing person can communicate directly with the deaf person using sign language gestures. However, if a hearing person does not know sign language, it would be hard for them to communicate with deaf counterpart. Sign language conversion is a technique used for converting the hand gestures into their respective voice or text, so that normal people can communicate with deaf people easily. Different software can be used for this type of conversion like MATLAB, etc. Sign language conversion is one of the efficient way to ensure communication between normal and impaired people.

Related Work- There have been various attempts by companies and research institutes to develop a sign language converter. Engineers at the University of California, San Diego successfully developed a smart glove that wirelessly translates the American Sign Language alphabets into text and controls a virtual hand to mimic sign language gestures [3]. In addition to decoding Sign Language gestures, researchers are developing the glove to be used in a variety of other applications ranging from virtual and augmented reality to telesurgery[4], technical training and defense.

Many software based sign language converters had been developed by engineers which converts sign language into text. Typically two methods used most commonly are: 1) Computer Vision (CV) based method, which enables development of visual based gesture recognition systems [5]. Second method is using motion sensor glove, that enables the measurement of different parameters like hand position and fingertip location. The device which uses motion sensors to detect the gesture converts them into readable text. Currently, the primary methods for tracking the positions of the human body are through optical systems, by using an electromagnetic field, or by employing arrays of wearable sensors. Optical systems comprising infrared emitters and receivers, have been successfully developed into systems for virtual reality. While these systems have low latencies and high spatial resolution, they require expensive and immovable infrastructure [6].

Many wearable strain sensors have been developed and integrated with computation and communication. Stretchable piezo resistive [7] strain sensors made from patterned silicon nano membranes, composite nanomaterials, conjugated polymers, graphene, and many other material systems possess a number of desirable qualities such as ultra-thinness, flexibility or stretchability, or ease of fabrication by printing. Work has begun to develop more complex systems that integrate stretchable circuitry, sensing, computation, and communication, as human-machine interfaces using systems of advanced materials. These systems employ pressure and capacitive transducers made of micro cracked gold to measure the articulation of fingers, composites of gold nanowires and poly-aniline to control a robot arm, patterned grapheme, hetero structures and silver nanowires to control a virtual hand, and carbon nanotubes for tracking human movement. Such materials, can require expensive starting materials and complex processing. An alternative approach using available materials would benefit the field. As a model application, we designed a system to translate the ISL alphabet because it requires a sophisticated integration of at least three types of sensors with electronics and data processing.

Our Contribution- 1) We are using light weight, inexpensive (resistance changing) material 'Velostat' to make flex sensors.2) Resistance range for each alphabet and word is mapped with the gesture. 3) An android app is used to make it easier for user to turn ON/OFF the translation process. 4)A portable android smartphone is used as a speaker and display.

Organization- Section II discusses about the overview of whole system. Section III is about the hardware used in in making of the glove. In section IV information about how sign language is used by people is given. Section V gives details about the making of the glove.

II. SYSTEM OVERVIEW

Electronic Glove we have developed consists of five sensor pairs – one on each finger. A single pair of sensors consists of a velostat strain sensor and a IR sensor. These sensors are integrated with the electronic module which consists of a STM32 Microcontroller board and HC-05 Bluetooth module. Each part of the system is described in detail in section III. Bluetooth module will send the data received from sensors to android smartphone which acts as a speaker. Figure 1 shows the overview of the glove.

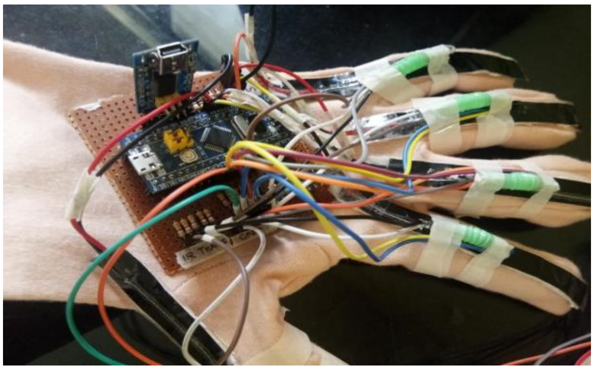

Figure 1: Overview of the device with the main working of modules

III. HARDWARE OVERVIEW

Hardware design approach of the glove consists of two key suspects: 1) capability using recent technology break through for low-cost and targeted feature inclusion and 2) longevity of impact through development of interface standards. This section covers the current state of the glove's design.

A. *Velostat sensors*- Velostat is a packaging material made of a polymeric foil (polyolefins) impregnated with carbon black which makes it electrically conductive. It is used for the protection of devices that are susceptible to damage from electrostatic discharge(charge). We used this resistance changing material to make the sensors. Depending on the strain on the velostat material strip sensors gives different resistance values for different hand gestures [8]. Figure 2 shows the strain sensors we have made using the Velostat material.

Figure 2: Velostat Sensors

Figure 3 shows the change in stress and resistance when strain applied on the sensors.

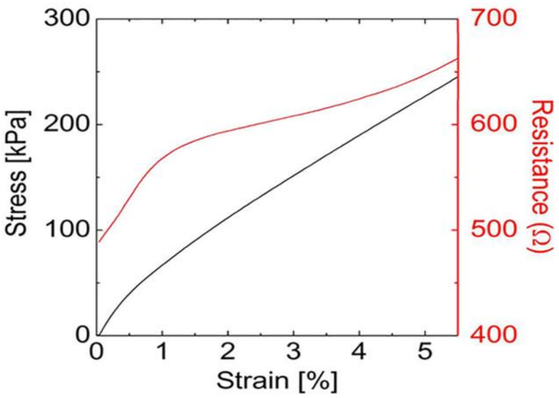

Figure 3: Stress vs Strain vs Resistance

B. *STM32 microcontroller board*- The STM32 family of 32-bit microcontrollers based on the Arm® Cortex®-M processor is designed to offer new degrees of freedom to MCU users. It offers product combining very high performance, real-time capabilities, digital signal processing, and low-power and low-voltage operation, and connectivity, while maintaining full integration and ease of development.Key features of the board-

- Leading edge architecture with the latest Cortex-M3 core from ARM
- Excellent real-time behaviour
- 64 KB/ 128 KB Flash
- 32kHz real time clock crystal
- Jump links on Boot0 and Boot1

- Easy development, fast time to market

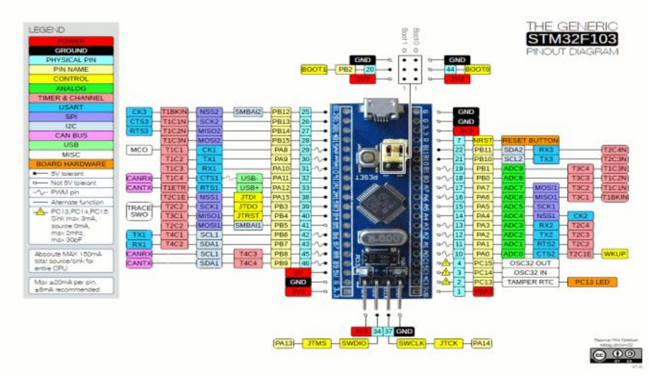

Figure 4: Pinout of STM32 Board

C. HC-05 Bluetooth module- The HC-05 is a bluetooth module which can add two-way (full-duplex) wireless communication to your projects. Module can be used to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like an android smartphone or Laptop. Many android applications that are already available makes this process a lot easier. This module communicates with the help of USART at 9600 baud rate hence it is easy to interface with any microcontroller deivce that supports USART. It is also possible to configure the default values of the module by using the command mode. Figure 5 gives the details about the this Bluetooth module [10].

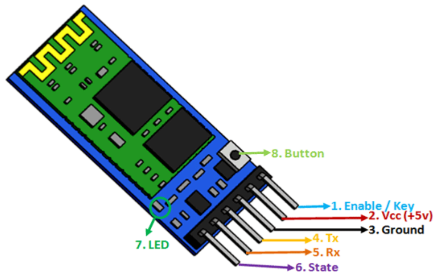

Figure 5: HC-05 Bluetooth Module

D. MPU 6050 module- The MPU-6050™ parts are the world's first Motion Tracking devices designed for the low power, low cost, and high-performance requirements of smartphones, tablets and wearable sensors. The MPU-6050 devices combine a 3-axis gyroscope and a 3-axis accelerometer on the same silicon die, together with an onboard Digital Motion Processor™ (DMP™), which processes complex 6-axis Motion Fusion algorithms. The device can access external magnetometers or other sensors through an auxiliary master I²C bus, allowing the devices to gather a full set of sensor data without intervention from the system processor.

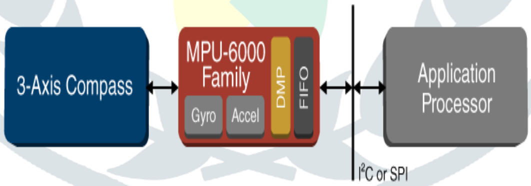

Figure 6: MPU-6000 Family Block Diagram

Key features of MPU sensor-

- I2C interface
- Supply voltage :3 to 5V
- I/O voltage: 2.3 to 3.4 V
    - Triple axis gyro (angular rate sensor) with selectable scale (from ±250 to ±2000 dps)
- Triple axis accelerometer with selectable scale (from ±2g to ±16g)
- Temperature sensor with digital output
- Digital Motion Procesing

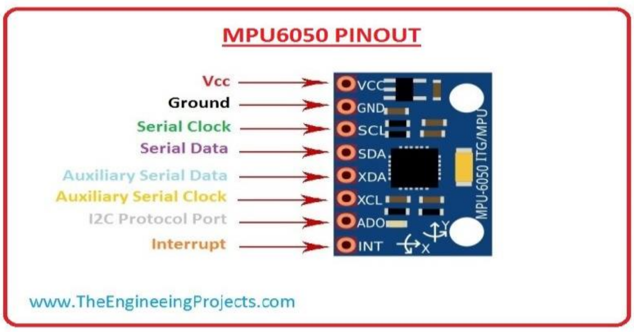

Figure 7: MPU 6050 Pinout

E. *IR sensors*- An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiations.

IV. Sign Language

Sign languages (or signed languages) are languages that use the visual-manual modality to convey meaning. Sign language is expressed via the manual sign stream in combination with non-manual elements like head or facial movements. Sign languages are full-fledged natural languages with their own grammar and lexicon [11]. Gestures used to express English language alphabets using sign language are given in Figure 8 below.

Figure 8: Gestures in ISL

V. Materials And Methods-

1) *Fabrication of glove*- Five velostat sensors (mentioned in section III) were fabricated and placed on the back of a glove in locations, in such a way that they covered the each finger from tip to knuckle. Proper adhesives were used to bond the sensors to the glove. The custom designed module which included STM32 microconntroller board, Bluetooth module and MPU 6050 sensor was adhered at the back of the glove on Velcro strap to allow the wearer to easily put on and take off the glove.

2) *Mapping of words*- Letters were selected by monitoring the state of each sensor for different hand gestures. A specific resistance range is mapped to each letter. Each gesture is assigned with a particular resistance range, IR combination and Gyroscope values. In completely relaxed mode sensor gives the minimum resistance value, 0 output value of IR sensor and gyroscope is calibrated 0 each time we press the button before starting the action.

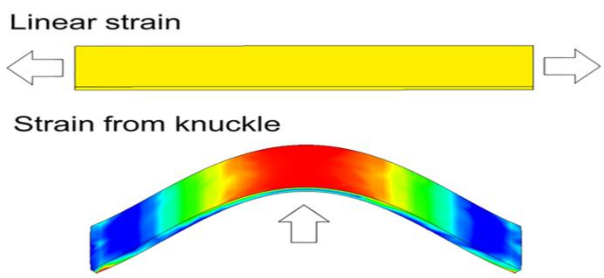

Figure 9: Strain on the Velostat sensor

3) *Android application*- We are using an android application in which all the data related to the resistance range of alphabets is stored. The user can switch ON/OFF the translation process with the help of the Bluetooth button. Figure below shows the home page of the android application.

Figure 10: Android application GUI

4) *Working of code*- As the specific resistance range, ir values and MPU 6050 values are mapped to each and every alphabet and English sentences, the values received are checked and matched to the database created. IR vales are read as digital values for each finger, Flex sensor values are analog values. For MPU 6050, a special code is written to implement a filter which gives steady gyroscope values and minimizes errors by taking average of the values, the values of MPU 6050 are calibrated to 0 for all axis and treadted that point as origin whenever the button is pressed before making the sign language. Theses values are then mapped to positive and negative X-axis, Y-axis, and Z-axis, ouput is given accordingly. Values from 1st glove is transferred to 2nd glove using Bluetooth Module. The values received from 1st glove and the values generated from 2nd glove are then compared with the database created for specific alphabets, words and sentences. A specific number is assigned to every word and database is created. Whenever the range for a word is matched with both IR sensor, Gyroscope values and strain sensor range the number is given as output to the android app and based on that number, the word is pronounced.

As every letter has different hand gesture, the set combination of data values of all five fingers cannot be repeated for two letters. Every letter has unique set of data values of five fingers. Some and gestures are shown in Figure 11, with data (alphabets decoded) which will be transmitted wirelessly through Bluetooth the application.

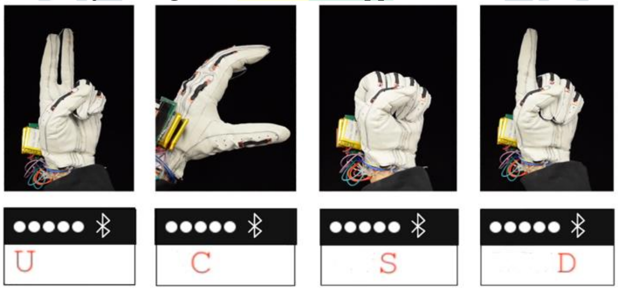

Figure 11: Data received through Bluetooth

V. RESULTS

Through the integration of Velostat sensors, open-source computation, and low-energy Bluetooth, we developed a low-cost system for decoding and transmitting human hand gestures. This system can serve as a testing platform for new materials, flexible hybrid electronics, and low-power circuits in human-machine interfaces. Attractive features of the system are low-cost, modularity (exchangeable material and components), and a complete description, which will allow other researchers to use the device. In particular, the stretchable conductive sensor is commercially available and thus may play a similar role in stretchable electronics for human-machine interfaces as PDMS now plays in micro patterning and soft robotics. While the electronic components used to decode and transmit the data are modified from rigid, there is an opportunity to make purpose-designed components in flexible, hybrid form factors. The methods and material mentioned here for the recognition of human gestures can also be applied to gather biometric data. The availability of open-sourced, test-bed systems can accelerate the development of materials and integration strategies for low-cost human-machine interfaces. Finally, we have discussed about all the important points related to the our device which will help understand the working of the sign language converter.

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