Glove based Sign Language Translator

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Abstract

Sign language is used by individuals with hearing difficulties to communicate with outside world. This language is made up of expressions, emotions and hand gestures made up of different type of signals. Hand movement along with the emotion together makeup the message to be communicated. Though this works perfectly, it takes time to learn this language. Even after learning this person with hearing and speaking difficulties cannot communicate with a larger audience as the other party might not understand this language. There are multiple varieties of sign language available as per the local region like ASL – American Sign Language, ISL – Indian Sign Language, GSL denoting German sign language. All these languages are specifically customised to the local geography to improve the effectiveness of communication. However the key focus is to make speech impaired individuals to communicate with common man. Our solution is to create a middleware that can detect and convert sign language to a audio output heard through a android hand held. This can also be useful to monitor the health of the individuals in a centralised environment.

Keywords: Sign Language, Smart Glove, ADXL-335, Arduino, Raspberry Pi

1. Introduction

Across the globe there are few million individuals who are not able to communicate proper due to unforeseen disabilities in speaking or hearing. Due to these they struggle to complete any basic activities or even to express sentiments. Sign language is a common form of communication within individuals with hearing or speaking disabilities. Sign language uses gestures and expressions as a way of communication hence normal individuals would find it difficult to understand sign language. Learning curve of sign language is also steep. Smart gloves help to overcome these issues by without any assistance from anyone. Smart glove has sensors triggers by output of Arduino middleware which can read the sensor data and convert it into a form that is recognised but common man (mostly an audio output). Vision based is an alternative to glove based but later solution is more effective and accurate. Pre-processing step is complex in vision based solution and impacts accuracy.

1.1 Sign-Language

It is a methodology of communication based on position of fingers, expression, hand gestures and movements. There are 5 key elements that form the building blocks of sign language. A) Point of Articulation is the geometrical data related to fingers and wrist joint, B) Posture of Hands similar to articulation point data related to bends in fingers and palm is used for communication as well, C) Type of movements like front, Back, Right and Left and associated signals, D) Orientation of Palm (Up or Down along with the direction) and E) Facial expressions like anger, depressing, joyful, surprised , geometric location of lips and orientation of head combined together gives a meaning and used as a tool for communication.

1.2 ADXL-335 sensor

ADXL-335 is an accelerometer which uses very less energy and supports 3-axis supporting range of -3g to +3g. This is mainly used for sensing accelerations created due to static or dynamic activity. Sample circuit of ADXL-335 is shown in Fig 1.

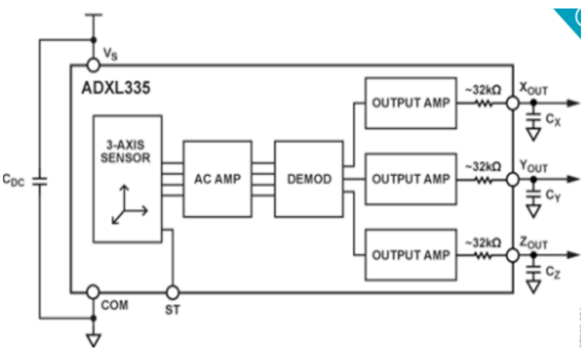


Figure 1: Sample ADXL-335

Real time Usability:

- Motion and Gesture recognition

- Geo satellite navigation
- Games related to Virtual reality
- Detecting free fall
- Devices to consume Power based on motion
- Robotics

Features:

- Sensors for 3-Axis
- Minimal size
- Energy Consumed - 350 µ
- Single Supply – 1.6 volts to 3.5 volts
- 10500 g shock endurance
- Automatically adjusts to fluctuation in temperatures

1.3 Raspberry Pi

It's a small sized and low cost electronic boards used in programming to easily integrate with hardware components like sensors and smart devices. This can function as single board PC. Latest version of Raspberry pi is Model B. When compared to the previous version the processing speed is more with this model and 10 times quicker that 1st gen version. This model has seamless connectivity to Bluetooth and wireless LAN.

Figure 2: Raspberry Pi

Sample specification of Raspberry Pi:

Attribute	Value
Processor	8-12 V
RAM	25 V
HDMI	6
Voltage	6
GPIO	16 mhz
Weight	25 g
Memory (Flash)	32 KB

1.4 Arduino Board

This is more or less similar to Raspberry pi but the major difference is Arduino board is not a single board but a micro controller. This doesn't have an inbuilt operating system and can work well with electrical signals.

1.5 Smart Glove

Figure 3: Sample Smart glove

Smart gloves are sensory devices that can simulate human hand gestures. This can enable sensitive signals that can be felt by humans. These are used in multiple applications and integrate with Raspberry pi or Arudino.

1.6 Project objective and contributions

Our study aims at creating a framework that can covert sign language into voice output. Accelerometer data is used for interpreting sign language. There are few working prototypes available for a similar work but most of them use Flex sensors. Main downside of flex sensors is accuracy of sensor output is little less when compared accelerometer data. Our study uses ADXL335 accelerometer to recognise 16 vital signs with less training. Signs detected are then processed and converted as voice data. Application is capable of adjusting automatically to the speed of gestures as accelerometer is used. Rest of the sections covers the existing literatures available in dealing sign languages, our proposed work and future enhancements that can be taken

2. Literature Survey

Gesture recognition is one of the evolving fields, and it's used in many IoT based smart platforms and in hand held applications. Health care, unmanned surveillance systems, Rocket science are few of the key areas where gesture recognition systems are used in anger. Our study has referred to multiple surveys in this area to implement our prototype and few are discussed in this section.

Flex Sensors:

Bhaskaran et al (2016) created a working sample of smart glove which can convert hand gestures to an audio and text output. This was done using flex sensors. LCD panels and speakers were used to show the output

Lakshmi et al (2020) shaped a Platform to assist physically disabled individuals. Using this prototype, electrical and electronic devices can be controlled without the need to move around.

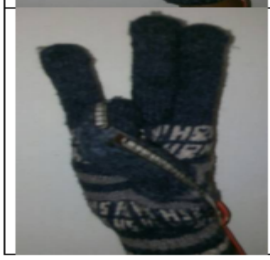
Finger Movement	Message
	Switch off light
	Switch on light

Figure 4: Voice enabled Smart glove Source: Kasar et al (2016)

Kasar et al (2016) created voice enabled smart glove using Flex Sensors and ATmega328. This recognises the hand movements in sign language and transmits the output to LCD display and also a speaker.

Syed et al (2002) investigated the prospective of using gloves based on flex sensor to understand the gestures. Output of the model was approximately 88%. Accuracy was little less due to the orientation of flex sensor and specimens used for training wasn't fully aware of sign language. There were few challenges faced while using this model. Smart gloves were not able to recognize alphabets precisely so those were scoped out of the project to improve the accuracy of remaining gestures.

Shrote et al (2014) created a glove using flex sensors. Initial prototype was to identify few alphabets and covert that into a text output in LCD screen. Slowly this was modified to supper few basic sentences. This set up was using flex sensors and accelerometer voltages. Variation in resistances combined with the gestures will be able to identify the alphabets and sentences. Lokhande et al (2015) constructed more or less similar setup with increase in efficiency.

Other Sensors used in Smart gloves:

Kumudha et al, (2020) detected Gestures using signal processing kit in LabVIEW software and relay back the output in web UI and also audio signals.

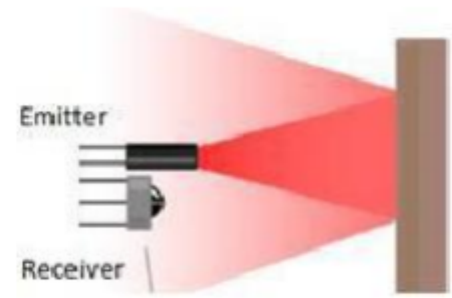


Figure 5: IR sensor with obstacle Source: Rohit et al (2017)

Rohit et al (2017) created a sign language detecting system by making use of IR sensor in smart glove. This is one of the few prototypes available to convert these gestures into real time messages. Gloves identify the bend in fingers by tracing obstacles.

Rajamohan et al (2013) performed a study based on deaf-mute communication interpreter. This study used flexible resistive sensors.

IoT:

Stefanov et al, (2004) study was focusing on on building smart homes using IoT devices, additional care has be taken to monitor health based on gestures and raise alarms if needed.

Khan et al (2019) created a smart electric Vehicle. This concept is based on IoT integration to remotely control the vehicle based on movements.

IoT is used more in surveillance systems and to identify thefts or damages to surrounding environment. Leninpugalhanthi et al (2021) created power theft identification system using Arduino and smart IoT sensors. This was mainly used to detect illegal consumption of power from distribution lines.

Human Activity Recognition:

Detecting actions based on Wi-Fi data was studied by Ma et al. who, in a literary point of view, showed the predominant techniques involved in designing a model for activities identification using Wi-Fi from the results of a small survey. The processes include selecting the base station signal, preliminary processing, tapping of properties and categorization.

Mobile Phones were considered as HAR devices since they have inherent sensors. Guiding the action identification processes in a smart phone can be made in geometric patterns along with categorization using SVM (Support Vector Machine). Machine learning tools can be utilized for reading the information gathered from the sensors without internet. Modern smart phones have now enabled online reading and identification of actions and provide required data for HAR application with their natural and inbuilt processing capabilities.

3. Proposed System Architecture

3.1 Accelerometer set up:

Basic ADXL-335 circuit is shown in Fig 1. In our proposed set up four accelerometer sensors are connect to micro-controller. Analog to digital convertor (ADC) is used along with this setup to convert all analog signals to digital format.

3.2 Arduino Uno:

We have used single board micro-controller that uses ATmega-328p specification. Board used in proposed set up has 14 input / output ports. Selected hardware is an open source and available in both 8 bit and 32 bit variants.

Additional Specification:

Attribute	Value
Input voltage	8-12 V
Max Voltage	25 V
Digital Input Ports	6
Analog Input Ports	6
Speed	16 mhz
Weight	25 g
Memory (Flash)	32 KB

Figure 6: Arduino Microcontroller

3.3 Block Diagram:

Proposed setup has three layers 1) Input layer, 2) Core processing middleware made up of Arduino and 3) Output layer. Accelerometer output of 4 fingers excluding the thumb is captured in layer1.

Four sensors were used in our set up. These sensors are attached to the smart gloves. Four sensors correspond to index, middle, ring and little finger. This output from each sensor is made up of 3 axes. Proposed architecture uses ADX335 to capture finger coordinates. Accuracy of this approach is better than using flex sensor. ADX335 employs same-structure to sense all axes (x, y and z). Due to this the output of all axes are extremely orthogonal and chances of mechanical issues are also very less. Controller is made up of poly-silicon exteriors and the sensors are deployed on this poly-silicon base. Circuit is an open loop system to measure input accelerations. Output of sensors used in the circuit is a signal which is relative to input acceleration. This circuit supports the following types of accelerations as mentioned below.

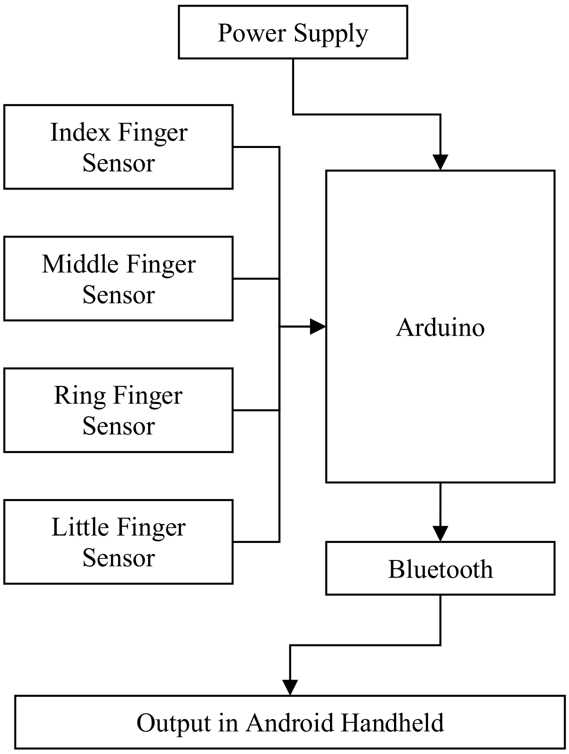


Figure 7: Proposed System Architecture

Types of accelerations supported:

Static: This is used in sensing gestures that are related to tilt or gravity sensing.

Dynamic: This is used for sensing vibrations or movement in hands or expression in face. Gestures related to sign language are mostly captured using this type of acceleration.

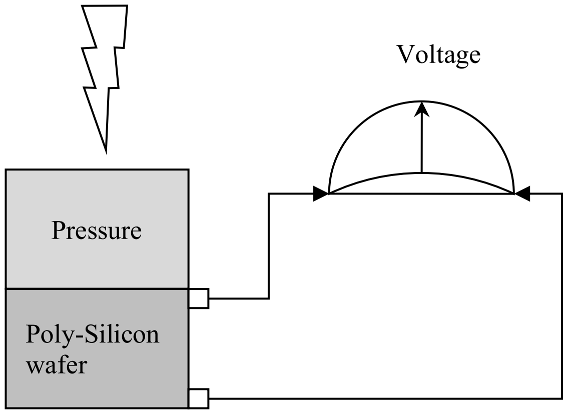


Figure 8: ADX335 Voltage signal

Sample output at position 1:

X,Y,Z :: 410,514,509 ::-1G,-0G,-0G

X,Y,Z :: 410,515,509 ::-1G,-0G,-0G

X,Y,Z :: 410,514,509 ::-1G,-0G,-0G

Output of ADX335 (x-axis, Y-axis and z-axis) are connected to arduino's input pins. Subsequently determine the min and max output value in Arduino. Which will be a voltage ranging from 0 to 3.4 volts. Also define to total iterations so that the output is sine tuned and more accurate. Since the input voltage varies analog-Ref is set to appropriate value depending on the controller ('EXTERNAL' for this use-case). This step is done to make sure aurdino board is safe and doesn't get spoilt. Finally the output needs to be transformed as acceleration (g) value, in-order to detect gestures. Depending on output signal the gestures are identified and mapped to a corresponding value and transmitted to Bluetooth module. Android devices like tablets, mobile or any hand held are connected to the blue tooth device and converted as voice output.

Algorithm:

1. Initialize 4 sensors used in smart glove with appropriate energy levels

2. Connect ADX335 output ports from step 1 to arduino's input

3. Define range for X,Y,Z axis

4. Define to total samples need to be processed

5. Set analogue ref to appropriate safe value. Board specification need to be carefully checked before setting up this value else this will damage the board.

6. Process the input data and convert to acceleration (milliG)

7. Test the set up with multiple gestures from sign language.

8. Repeat this testing until the model is trained with sufficient samples and until the accuracy of system adhers to appropriate value.

3.4 System Requirement:

Hardware:

Hardware used in our prototype is discussed in the previous section which includes Arduino, ADXL335, and Bluetooth board with connectivity to Andriod handheld.

Software Requirement:

Arduino IDE Version 1 was used for this project on Windows 10 machine. Sketches with extension .ino were saved in a local repository. CPU and baud rate configuration in the IDE was varied as per the input data and it was used appropriately in boot-load instructions. Core program was developed in 'C' and embedded in this prototype.

4. Results and Discussion

Proposed set up was integrated to Android Mobile Version 10 and different gestures were simulated. Result analysis was done in two phases. In Phase 1, 50 plus experiments were conducted to recognize sign language using gestures. First step in this phase is to convert the accelerometer output to wave forms. Output of three axes were analysed and compared with the actual gesture, accuracy of the experimental set up was in the range between 92 to 99%. Phase2 testing was focused more on Bluetooth to android connectivity. Recognised sign language was converted successfully to voice message and sent to android device.

5. Future enhancements

Using this prototype we have demonstrated how sign language can be converted to voice output with higher accuracy. This prototype is well balanced to be deployed in large scale due to less complexity of setup involved along with low cost, effective and affordable solution. Though there are fewer products available in the market this can be a potential replacement for those products as the accuracy is more and it is less costly. Main advantage of this product is, it is backward compatible to older version of micro controller board and can work in any android versions. Smart hand gloves have the capability to integrate with other IoT devices and it's a light weight setup when compared to existing kits available in market.

This setup was tested only with 16 different gestures, in-order to improve the effectiveness of the product additional gestures can be identified with the data collected from all the sensors. Model is very sensitive to the life style of the person from whom the input data was collected. Testing can be extended across different ethnicity, age and gender and the output can be fine tuned to perfection.

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