Automated Sign Language Interpreter

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***Abstract*— Taking huge leaps in technologies with each passing year, the humans are making smart inventions every year to help themselves and for the ones who are affected by any disability. We aim to make the communication for dumb people easy and hence proposing a sign interpreter, which automatically converts sign language into audio output. For the dumb people, sign language is the only way of communication. With the help of sign language, physically impaired people express their thoughts to the other people. It is difficult for common people to understand the specific sign language therefore communication becomes difficult. The sign language recognition has become an empirical task, as it consists of various movements and gesture of the hands and therefore getting the right accuracy at a low-cost is a mammoth task. Instrumented gloves with audio out are the solution to this problem. The gloves attached with various sensors are worn for sign interpretation. Hence, the proposed system solves the problem and helps the dumb people in communication with the rest of the world at low cost.**

Keywords—Automated Interpreter; Indian Sign language; Instrumented Gloves; Sensors; Audio output;

I. INTRODUCTION

Sign language is the medium of communication for the people who cannot speak. It uses gestures to convey what they want to say. Sign language is a combination of hand-shapes, hand-orientation and hand, arm or body -movement, facial expressions and lip-patterns for conveying messages. American Sign Language (ASL), British Sign Language (BSL), Indian Sign Language (ISL) etc. are some of the common sign languages in the world [1]. As per the census 2011, there are 19,98,535 people with speech disability in India [2]. Communication is a way of exchanging thoughts and feeling and should not be restricted by usage of words or speech. Sign language interpreters (SLI) are required to translate sign language to spoken language [1]. Sign interpreters have been developed in the recent decade and have gained a lot of significance in the field of research and development. Over the years, several hand-movement trackers have been developed, that are different in their performance parameters like accuracy, jitter, drift, and latency [3].

However, generic automated sign interpreter methodologies include the use of sensors such as optical fibers and flex sensors to detect the movement of the palm and the fingers for mapping various letters. Every country has its specific sign language; however, the sign for the same word varies from country to country [4]. Significant research on the sign language interpreters can be noted in countries like USA, UK, Singapore, Canada etc. However, no significant research has been done in India until now. The products that already exist fail to compete with the international level when it comes to the ease of use.

The major problem faced by Indian SLI until now was the ambiguity in the sign language community. The words that need to be covered in sign language dictionary are business, leisure, emotions, alphabets, numbers, ask-learn, colors, family, food, relations, games, interview, medical, health, place, money months, sentences, travel, animal, basic, days, fruits, government etc. Proposed sign interpretation uses India's first-of-its-kind dictionary [5], which aims to bring uniformity in sign languages across the nation.

Indian Sign Language Research and Training Centre developed "The Indian Sign Language" (ISL) dictionary which consists of 3,000 Hindi and English words with the corresponding representation of their signs [11]. The ISL dictionary was created with a focus on removing the ambiguity and redundancy in the Indian sign language prevailing throughout the nation. The dictionary is updated time to time in order to expand the vocabulary used by SLI [4]. It will also enable government officials, teachers, professionals, community leaders and the public at large to learn, use and implement sign language.

The proposed sign interpreter uses Arduino Uno based microcontroller as a core controlling components. The proposed sign language interpreter is wearable gloves. Interpreter gloves have a microcontroller with various other sensors to capture the hand gesture and hand movements. Sensors connected to the gloves include flex sensors and the accelerometer integrated with a gyroscope sensor, which provides the input to the microcontroller. Both the gloves communicate with each other through Bluetooth module to produce various signs, which are further communicated through the speakers.

The proposed system aims to keep the sign language interpreter as simple, affordable and efficient. Further, presented paper discusses the existing literature of sign language interpreter in section II, in addition to the pros and cons of it. In section III, the architecture of the proposed system is discussed. It briefly discusses the software and hardware components used in the proposed system. In section IV, the implementation of the proposed system is discussed in detail. In section V, the results of the proposed system are discussed along with cost analysis and its limitations. Section VI concludes the work with the future scope.

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II. LITERATURE SURVEY

This section discusses broad issues and background of the SLI and its various existing SLI algorithms.

A. Broad Issues and Background

The basic issue that is being faced by the majority of the existing SLI is that they are only capable of detecting single alphabets from the hand gestures which is commonly known as finger spelling. Finger spelling is not a practical approach as it compromises the efficiency of SLI due to repeated delay [5][1].

The second most concerning issue is the pertaining ambiguity regarding the authenticity of the sign for different words and letters for Indian sign language [6]. Many of the existing systems use signs made by the convenience of the developer of those products. Such ambiguity in the gestures leads to a chaotic atmosphere where the user has to learn product specific signs, which is not prescribed [6][7][8].

B. Sign Language Interpretation Algorithms

- *Hidden Markov Models (HMM)*

A Hidden Markov model [9] consists of finite states and each state consisting of two sets of probabilities: (i) A transition probability, (ii) either a discrete output probability distribution or continuous output probability density function. Each state is characterized by the given state. HMM is a doubly stochastic model and is appropriate for coping with the stochastic properties in gesture recognition. The best gestures are recognized by evaluating the trained HMMs.

- *Artificial Neural Networks(ANN)*

An artificial neural network [10] involves a network of simple processing elements (artificial neurons) which can exhibit complex global behaviour, determined by the connections between the processing elements and element parameters. An interconnected group of artificial neurons using a connectionist approach processes the signs. As ANN is an adaptive system, it changes its structure based on external or internal information that flows through the network. The effectiveness of ANN models lies in the fact that they are used to infer a sign from the observations.

- *Support Vector Machine(SVM)*

The SVM [11] uses supervised learning for sign recognition. SVM can handle unknown signs by dividing the feature space for each glove. The SVM predicts the output on the basis of the input sign.

III. ARCHITECTURE

The proposed system uses architecture as shown in Fig1. The architecture comprises hardware and software components. During experiments, sign language data set has been created according to the sensors value ranges observed because of the hand-movements. Following are the hardware components used in the proposed system.

A. *Arduino uno*

Arduino is an open-source development board that has on-board microcontrollers, which can be interfaced with various analog and digital sensors. Some of the features of Arduino are listed below

- Input Voltage: 3.3V/5V
- Programming through SD card
- Push pop socket Slightly over PCB.
- Serial communication

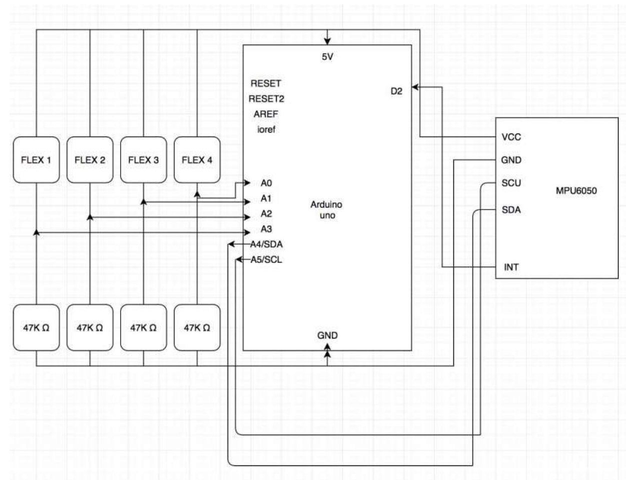

Fig. 1. Proposed Sign Language Interpreter (SLI) architecture

B. Flex Sensors

Flex sensors are nothing but resistive carbon substrates. On bending the substrate, a resistance output correlated to the bend radius is produced [12]. The proposed SLI uses flex sensors to get the inputs from the fingers in the form of resistance, which is further used to calculate the angle. The calculated angle values, are further mapped to the words and words are outputted on speaker.

C. Gyroscope with accelerometer

The MPU6050 has an embedded 3-axis MEMS gyroscope, a 3-axis MEMS accelerometer. MPU6050 has been used to calculate the acceleration and rotation angle to distinguish between various levels at which the glove has been rotated.

D. Bluetooth

For wireless communication between the gloves, Bluetooth module called the HC-05 is used [13]. HC-05 uses Serial Port Protocol for transparent wireless serial connection setup [13]. Bluetooth module helps in the communication between the two gloves in turn giving a fixed output by evaluating the combination of the two inputs provided by the output.

E. SD-Card Module

This Micro SD Card is used for transferring data to and from a standard SD Card. The pinout is directly compatible with Arduino and also can be used with other micro-controllers. It allows us to add mass storage and data logging to the system [11].

IV. METHODOLOGY

The implementation design and block diagram of the proposed system is as shown in Fig 2. Each glove has sensors and is activated by powering the microcontroller.

At a first step, the flex sensors acquire the various resistances generated by the movement of the fingers. In the second step, analog input of flex sensors is provided to the microcontroller. As the third step, the gyro angle and the accelerometer angle recorded by MPU6050 (calibration takes around 10 seconds) are input to the microcontroller. In the fourth step, microcontroller makes a decision based on the angles and resistance obtained by sensors of both the gloves. The decision would be a corresponding sign from the stored data set. In the fifth step, microcontroller maps appropriate audio file from SD card. A detailed description of system working has been discussed in section A to section E.

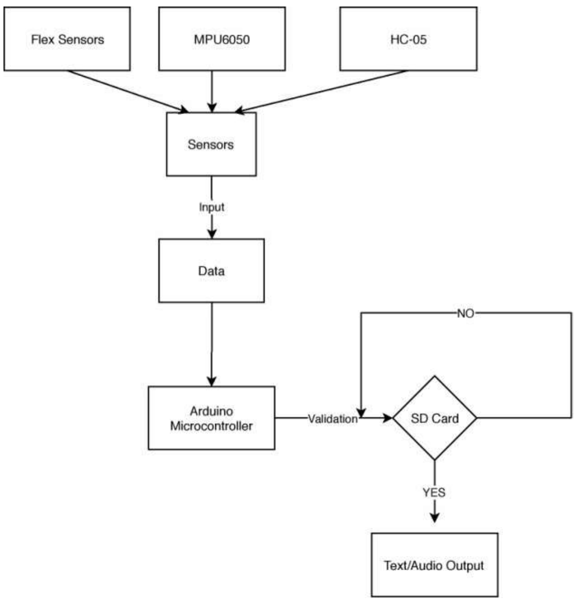

Fig. 2. Block diagram of proposed SLI

A. *Capturing the finger movement*

Flex sensors tap the input from the varying resistance ($flexR$) and voltage ($flexV$) produced by the movement of the fingers and calculates the angle. This data is fed to the microcontroller as an analog input. The flow chart of flex sensors is shown in Fig 3. *Algorithm-1* used to calculate the angle based on the resistance and voltage provided by the flex sensors.

Algorithm-1

Intialization: VCC = 4.98v,
R_DIV = 47500.0,
STRAIGHT_RESISTANCE = 37300.0
BEND_RESISTANCE = 90000.0,
Flex ADC as analog input.

Step1: Calculation of the flex voltage($flexV$) is given by (1)

$$flexV = \frac{\text{flexADC} * \text{VCC}}{1023.0} \tag{1}$$

Step2: Calculation of the flex resistrance($flexR$) is given by (2)

$$flexR = \text{R\_DIV} * \frac{\text{VCC}}{\text{flexV}-1} \tag{2}$$

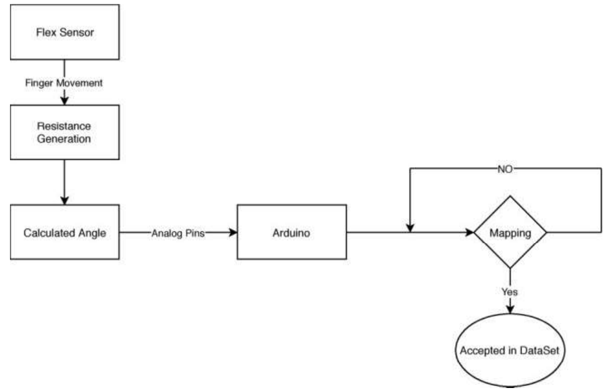

Fig. 3. Capturing variable finger angle using resistance

After the calculation of the final resistance for that particular finger the angle is calculated by an inbuilt function "MAP" of arduino. The dataset entries for a few sample words have been shown in Table I.

TABLE I. FLEX SENSOR DATASET FOR A FEW SAMPLE WORDS

Word	Angle(in degrees)							
	Flex-1		*Flex-2*		*Flex-3*		*Flex-4*	
	Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
YOUR	600	800	950	1150	1500	1800	900	1200
NAME	600	800	900	1100	900	1200	1000	1300
LITTLE	550	750	800	1100	1100	1300	1200	1500

B. *Mapping the orientation of hand using MPU6050*

MPU6050 consists of gyroscope and accelerometer and provides us with the acceleration produced in the x, y, and z-direction (*acc _x, acc _y, acc _z)* by the hand glove and the inbuilt gyroscope helps in the x, y, and z-axis calculation (*gyro_x, gyro_y, gyro_z)*. The MPU6050 gives analog input to the microcontroller. The block biagram of MPU6050 is shown in Fig 4. *Algorithm-2* is to convert the sensor value to angle and Table II gives mapping range of sample words for MPU6050.

Algorithm-2

- **Step1:** calculation of the angle pitch for x, y, z axis, is given by (3)

$$angle\_pitch \mathrel{+}= gyro\_x * 0.0000611 \tag{3}$$

- **Step2:** calculation of the total accelerometer vector is given by (4)

$$acc\_total\_vector = sqrt((acc\_x * acc\_x) + (acc\_y * acc\_y) + (acc\_z * acc\_z)) \tag{4}$$

- **Step3:** calculation of the angle roll output by the formula*:*

$$angle\_roll\_output = angle\_roll\_output * 0.9 + angle\_roll * 0.1 \tag{5}$$

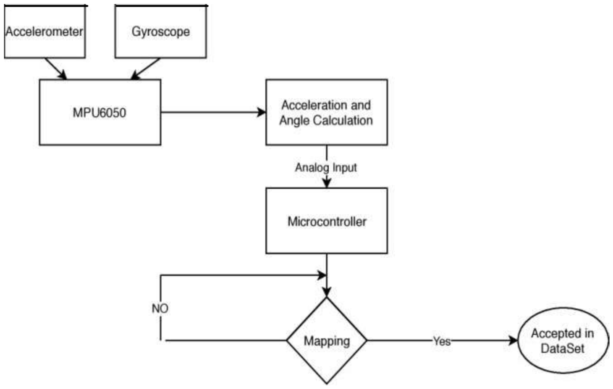

Fig. 4. Mapping the orientation of MPU6050

C. *Recording audio files*

After validating the values from sensors, the microcontroller maps the appropriate audio file on the SD card and further outputs the audio file from the speaker.

TABLE II. MPU6050 DATASET MAPPING

Word	**Orientation(axis angle)**	
	Min value	***Max value***
YOUR	*7.8*	*13.91*
NAME	*4.56*	*9.99*
LITTLE	*5.71*	*10.38*

D. *Bluetooth Connectivity*

HC 05 handles the input of the two gloves by sending the input of one glove to the other using the pins RX and TX,and then, checking for a combination value from dataset that has been produced. The working details of Bluetooth is as shown in Fig. 5.

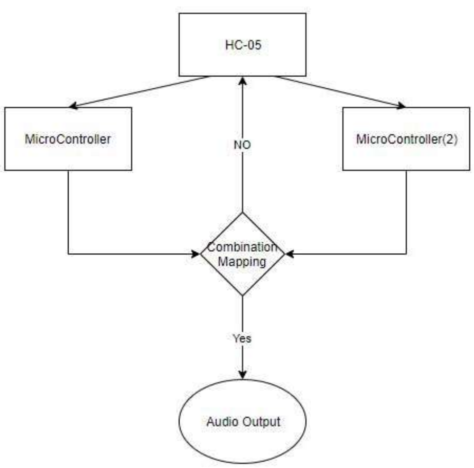

Fig. 5. Bluetooth module workflow

V. RESULTS

The proposed system, interprets the Indian Sign Language and is represented as an application for dumb people especially for Indians.

Few samples were tested around 90 words during the experimentation out of the 3000 words in the Indian Sign Language. Further, remaining words can be interpreted using same algorithmic techniques. Initial development of the proposed system is as shown in Fig.6 and the final development of the system is as shown in Fig. 7.

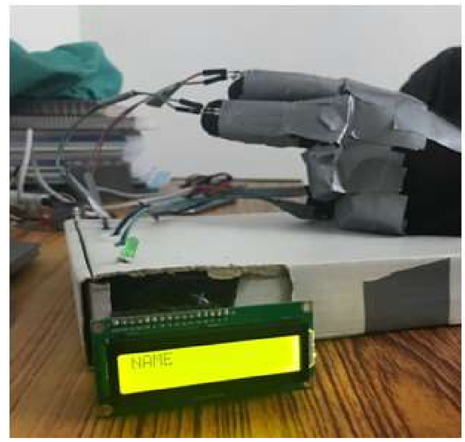

Fig. 6. Initial development of the proposed SLI

Cost Analysis

A detailed description of the cost and quantity of the components used in the proposed SLI is shown in Table III. The estimated cost is much lower than the existing cost of SLIs.

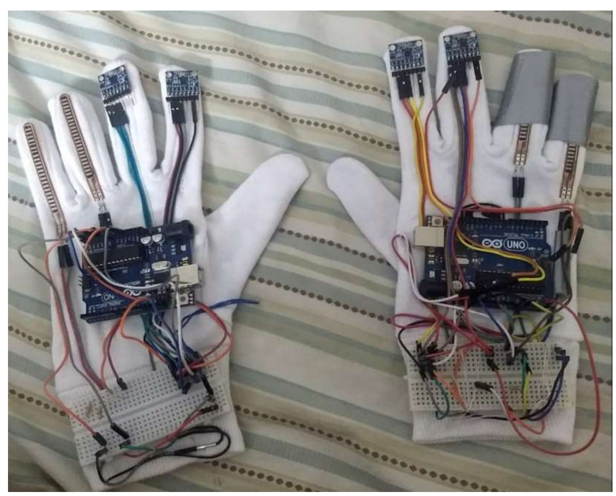

Fig. 7. Final Development of the proposed SLI

VI. CONCLUSION AND FUTURE WORK

Our proposed project, which is the sign interpreter, is a useful tool for the people who cannot speak as this gives them a medium to communicate with the rest of the world without any hesitation or any inconvenience. With the help of various components like flex sensors, MPU6050, HC-05, SD-Card module etc., we have tried to replicate a few signs from the Indian Sign Language. As our project is in developing stage right now we will try to minimize the errors as the flex sensors may change values when used for a long time. The Indian Sign Language also has some words which detect wrist movement and we would work on it so that those signs can be expressed using our glove. Similarly, elbow movement and facial recognition would be the two areas where we would work in the future so that all 3000 words can be expressed easily using our gloves.

TABLE III. COST ANALYSIS

Component	**Quantity**	**Price**
Flex Sensor	8	Rs.4360
MPU6050	5	Rs.1400
HC-05	2	Rs. 600
Arduino Uno	2	Rs.1000
Speaker	2	Rs.400
SD Card Module	2	Rs.200
Miscellaneous	-	Rs.500
Total	**21**	**Rs.8460**

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