# Wireless Assistive Communication System for Speech Impaired Person

**Vaijayanti Gajul, Pranita Sharangdhar, Shanta Shinde and Smita S. Pawar**

**Abstract** Speech is a necessary element for every human being, importance of which is summed up into two: expression and conception. People suffering from speech disability are apprehensive while communicating with normal people and even to involve in community interaction. This paper proposes development of a wearable assistive vocalizer, designed as two distinct modules communicating wirelessly, with Gesture Sensing Module placed on wrist of person and speech synthesizing module provided with portability to either mount around waist or connect to any audio device. Every gesture is assigned one word message that is transmitted employing Amplitude Shift keying modulation at 433.92 MHz radio frequency. The error probability for receiving multiple messages that were transmitted consecutively is plotted to analyze wireless response of system.

**Keywords** MEMS accelerometer • Flex sensor • Manchester encoding

## 1 Introduction

Assistive Technology came into existence with the aspiration of developing devices to compensate for physical disability and improve quality of life [1]. Augmentative and alternative communication (AAC) devices are special assistive devices designed for speech disabled people for generating voice. The major aspect of implementation of idea presented in paper is to enhance the AAC technology by

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extending features like modularity (wireless connectivity between modules), and portability which will raise comfort of use. Data Glove is used which enables us to practice sign language without being connected to a PC [2].

Oral communication is most effective way of communicating one's ideas, emotions and thoughts. Speech disability includes both type of people who are completely and partially aphasiac. A person may or may not be speech impaired by birth. Elderly population can become susceptible to speech disorders by disease of larynx, or as a side effect of stroke or cancer [3].

### 1.1 Speech Disability Statistics

See Table 1.

### 1.2 A Survey for Gesture Recognition Techniques

The goal was to study different technologies involved in recognizing physical human gestures since the method of communication adopted by deaf-dumb people to interact with each other is Sign Language that employs use of gestures made by hands, face and body. Sign Language practiced by speech disabled people varies in different countries. India being culturally diverse country, the gestures vary up to large extent even within a single state. This raised a crucial need for development of a common sign language across the country which led to establishment of Indian Sign Language Dictionary [4]. Technologies that employ recognition of gestures are broadly classified into two types: Vision based and Sensor based [5].

The drawback of vision based solution is the level of complexity of algorithms implemented in capturing a movement. MicroElectroMechanical Sensor is a sensing technology consisting of electronic parts (such as capacitors, diodes etc.) and mechanical parts (such as mass-spring system, strain gauge) of size of order of microns which are capable of movement with or without application of external force [6]. MEMS sensors can be easily placed on gesture formulating human body parts like hand and arm. Bending of fingers possess significant role in performing gestures by hands. Flex sensor is one of the examples of bend sensors structured in thin and elongated design and hence can be attached along the length of fingers to

**Table 1** Disability statistics 2011 Indian Census [15]

| Disability | Total | Male | Female |
|---|---|---|---|
| Total | 26,810,557 | 14,986,202 | 11,824,355 |
| In speech | 1,998,535 | 1,122,896 | 875,639 |

sense bending motion. This project takes into consideration the gestures performed by hands of person, thus a combination of accelerometer and flex sensors is implemented.

## 2 System Model

The system is designed in two communication modules: a transmitter module and a receiver module. Transmitter section is comprised of Data Sensing Module, Data Processing Module and Data transmitting Module, while the Data Processing Module in Receiver section is incorporated with a Data Receiver and Speech Synthesizer. If the two modules would be integrated as one complete device, the interaction of user would be restricted only up to one-to-one communication. The modularity of the system provides the flexibility of community interaction by means of coupling the receiver section to suitable audio amplifier.

### *2.1 Block Diagram*

The system model as shown in Fig. 1 consists a Data Sensing Module that captures the gesture performed by hand movements of the person which is then processed by a microcontroller that allocates a message for corresponding gesture which is then wirelessly communicated to receiver section where the message is given voice. Data sensing module is basically a data glove which is to be worn by the person performing gestures, the transmitter module is placed on the wrist connected to data glove by means of wires, while the receiver module is placed on a belt which can be worn at waist.

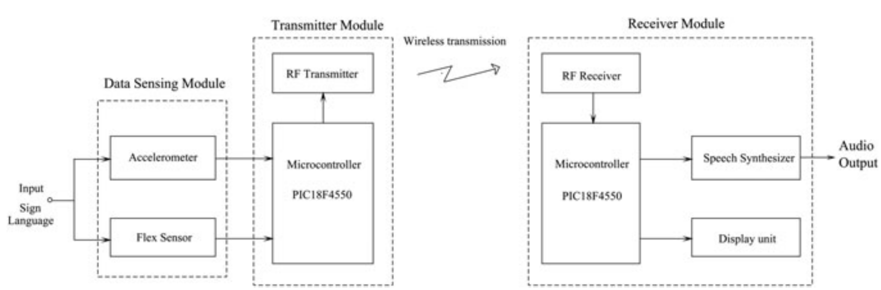


**Fig. 1** Block diagram of system

## 2.2 Data Sensing Module

Data Glove is mounted with accelerometer, at back of hand, and flex sensors along the length of fingers. Analog Devices' IC, ADXL335, is a differential capacitance based model accelerometer measuring the change in acceleration, tilt of object in three axes i.e. *X*, *Y*, *Z*. When even a slight movement is subjected to accelerometer, the floating capacitor plate gets displaced resulting in an electrostatic force proportional to change in capacitance between fixed and moving plate. The total force exerted by single plate is addition of two oppositely directed forces. The analog output for a single axis is proportional to this net force [6]. The position of accelerometer on hand is placed in a manner that *X*-axis should be sensitive to pitch, *Y*-axis to yaw, while *Z*-axis sensitive to direction parallel to g-force exerted by earth. The sensor values are tabulated in Tables 2 and 3.

Bend sensors reconciles with the flexile structure of human body that embellishes wearable technology. Flex sensor used is made up of conductive black plastic ploy bag whose resistance changes proportional to bending of fingers. One finger position can be captured as two states i.e. bent and relaxed [7]. The voltage supplied to one pin of flex is $V_{\text{flex}} = 5$ V, It has an internal resistance of $R_1 = 25$ kΩ—straight position (specified in datasheet), the other pin is connected to analog port of microcontroller as well as grounded via a resistor of $R_2 = 10$ kΩ. The output analog voltage $V_{\text{analog}}$, obtained by voltage divider formula [8], is varied by varying flex resistance, $R_1$, due to bending motion and rest two external parameters, $V_{\text{flex}}$ and $R_2$, being constant.

**Table 2** 1g force: *X*, *Y* and *Z* analog voltage equivalent to electrostatic force

| g-force exerted | Axis | *X*-out (V) | *Y*-out (V) | *Z*-out (V) |
|---|---|---|---|---|
| +1g | *X* | 1.31 | 1.52 | 1.55 |
| +1g | *Y* | 1.53 | 1.32 | 1.53 |
| +1g | *Z* | 1.52 | 1.55 | 1.31 |
| −1g | *X* | 1.72 | 1.53 | 1.54 |
| −1g | *Y* | 1.56 | 1.71 | 1.55 |
| −1g | *Z* | 1.53 | 1.52 | 1.69 |

**Table 3** Voltage values of flex sensor for bending at various angles in both direction

| Angle (°) | Direction | Flex output (V) |
|---|---|---|
| 0 | Straight | 2.6 ± 0.5 |
| 45 | Forward | 2.1 ± 0.2 |
| 90 | Forward | 1.7 ± 0.2 |
| 45 | Backward | 2.72 ± 0.2 |
| 90 | Backward | 2.75 ± 0.2 |

## 2.3 Transmitter Module

The design of transmitter module should be compact for the system to become compatible as a wearable device. The microcontroller used for data processing is PIC18F4550. The major reason behind picking up this particular controller is the 10-bit ADC resolution provided to digitize the sensor data [9]. The process of assigning a message to the captured gesture is programmed on transmitter module processor. Radio Frequency (RF) Transmitter, operating at 433.92 MHz is being employed for transmission of messages. The communication is of simplex type. RF being a low power transmitter, a string transmission results in high Bit Error Rate (BER). Hence, a message is substituted with a short symbol. Manchester encoded form of this symbol is sent to RF transmitter where it is modulated by the technique of Amplitude Shift Keying(ASK) and further transmitter wirelessly. It is represented graphically in Fig. 2. A dedicated short range communication is accomplished via Manchester encoding technique that provides dc balance and enhances signal reliability [10].

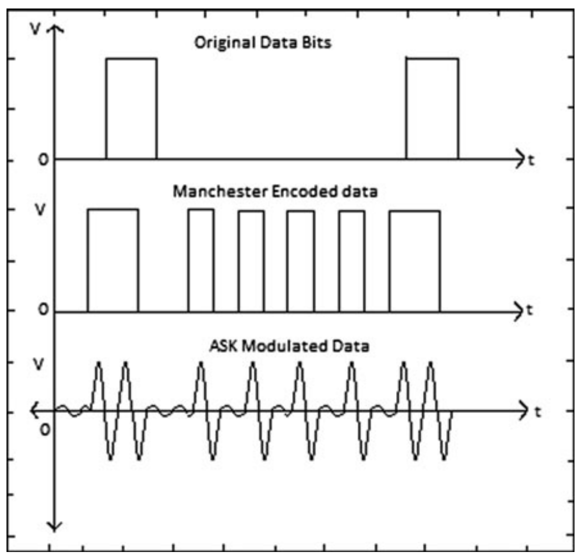


**Fig. 2** Symbol A is transmitted as a substitute for a message. Binary representation is 01000001. The first plot represents the original data bits to be sent, second plot is encoded form of Data bits, the third plot represents ASK modulation carried out by RF Transmitter

### 2.4 Receiver Module

Receiver module consist a RF receiver (433.92 MHz) and PIC18F4550 microcontroller responsible for decoding the message from symbol. Once original message is retrieved, speech is synthesized. The text to speech module is of type The IC used in speech synthesis is PIC24FJ64GB002. The EPROM of IC is programmed with phonemes of English Language [11]. A string is sent to PIC24 IC via UART protocol, phoneme of each letter is accessed from EPROM memory and passed to speaker for being expressed in audio output.

### 2.5 Data Flow of System

The algorithm, as in Fig. 3, starts with receiving the gesture co-ordinates at analog port of controller [12]. There should be an appropriate amount of delay while taking data from sensors to avoid detection of unwanted gesture while transitioning from one desired gesture to other. This reduces the error in gesture recognition. To establish communication between transmitter and receiver it is necessary to send a synchronization wave before transmitting each symbol. This ensures secure communication between transmitter and receiver pair [13].

## 3 Result and Analysis

The values of sensors for assigned message are tabulated in Table 4. The hardware unit is shown in Fig. 5. Basic gestures are captured and audio output is achieved successfully. Each message is transmitted ten times continuously and a graph is plotted representing the effectiveness of system, which is shown in Fig. 4.

Static gestures can be combined to form a meaningful sentence. The Text-to-Speech module is of type Concatenative, since it provides a natural speech compared to other types [14].

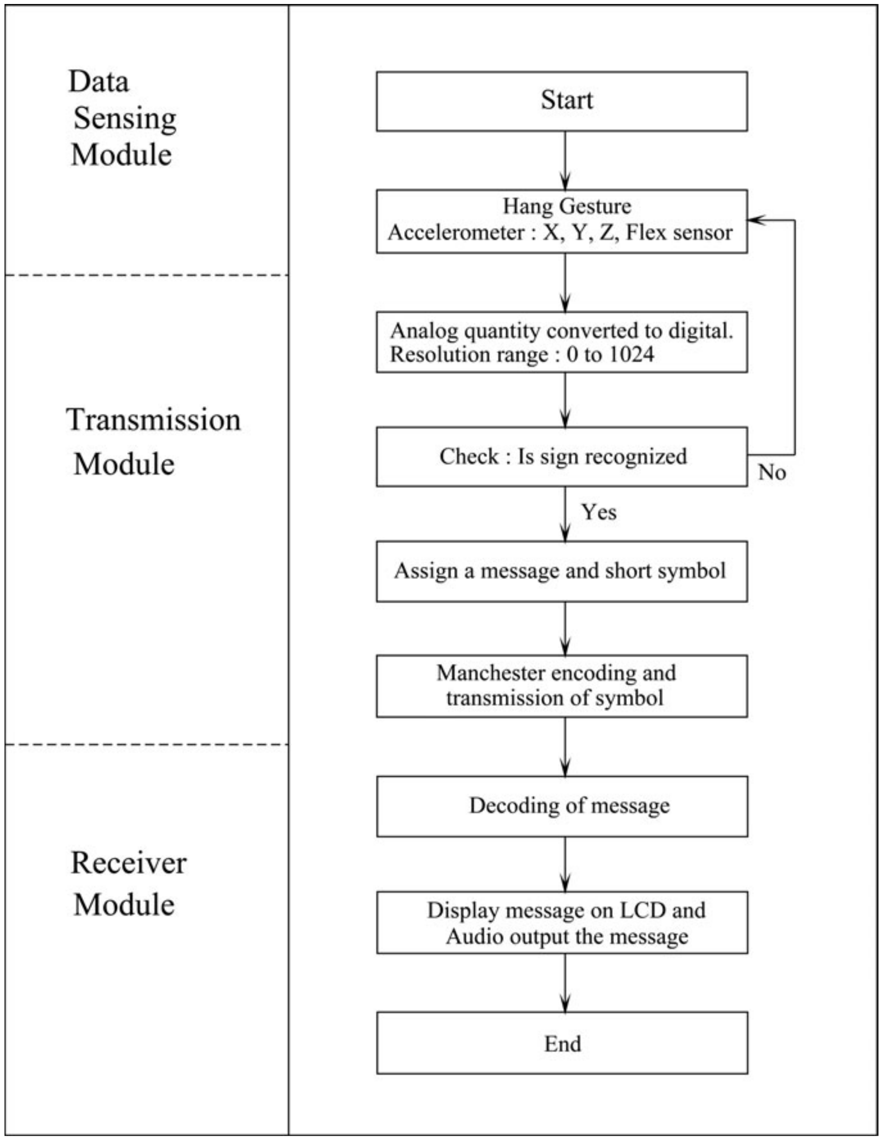


**Fig. 3** Data flow of system from gesture sensing to its voice conversion

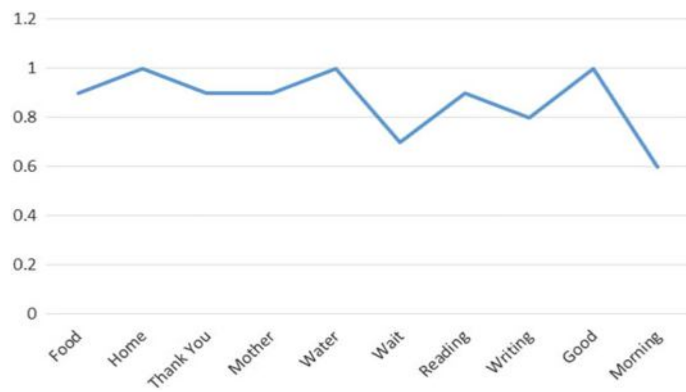


**Fig. 4** *X*-axis represents different messages transmitted where each message is transmitted ten times. *Y*-axis represents probability of each message received

**Table 4** Values of accelerometer sensor: *X*, *Y*, *Z* and two flex sensors for corresponding gesture

| Message Conveyed | *e* | *X*-axis (V) | *Y*-axis (V) | *Z*-axis (V) | Flex 1 (V) (Index finger) | Flex 2 (V) (Middle finger) |
|---|---|---|---|---|---|---|
| Food | | 1.427 | 1.501 | 1.352 | 2.197 | 2.250 |
| Home | | 1.354 | 1.432 | 1.698 | 2.548 | 2.549 |
| Thank you | | 1.335 | 1.473 | 1.468 | 2.548 | 2.540 |
| Mother | | 1.393 | 1.578 | 1.357 | 1.598 | 1.893 |
| Water | | 1.400 | 1.378 | 1.513 | 1.598 | 1.893 |
| Wait | | 1.294 | 1.520 | 1.597 | 2.548 | 2.549 |
| Reading | | 1.489 | 1.473 | 1.326 | 2.558 | 2.550 |
| Writing | | 1.486 | 1.367 | 1.775 | 1.910 | 1.893 |
| Good | | 1.626 | 1.572 | 1.279 | 1.598 | 2.540 |
| Morning | | 1.626 | 1.572 | 1.279 | 2.500 | 2.544 |

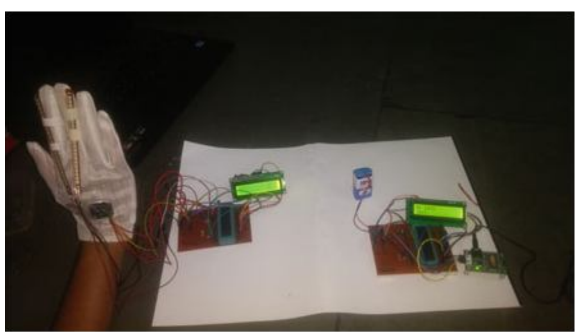

**Fig. 5** Data Glove gesture co-ordinates for message ‘wait’ which is displayed on LCD at transmitter. The message is received at receiver module that is displayed on LCD

## 4 Conclusion and Future Scope

This paper has described the development of a portable and modular wireless communication system for speech disabled to enable them not only for one-to-one talk with normal people but also in a community talk. Basis words used by speech impaired are studied and voice generation is tested successfully. Practically for 30 m, messages are received without errors by receiver module. The system can become better user customizable by interfacing a memory chip port in which user can insert SD card programmed with various messages in a language compatible for them.

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