

## THE AMAZING DIGITAL GLOVES THAT GIVE VOICE TO THE VOICELESS

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### ABSTRACT

*Glove-based systems represent one of the most important efforts aimed at acquiring hand movement data. Generally dumb people use sign language for communication but they find difficulty in communicating with others who do not understand sign language. It is based on the need of developing an electronic device that can translate sign language into speech in order to make the communication take place between the mute communities with the general public possible, a Wireless data gloves is used which is normal cloth driving gloves fitted with flex sensors along the length of each finger and the thumb. Mute people can use the gloves to perform hand gesture and it will be converted into speech so that normal people can understand their expression. This paper provides the map for developing such a digital glove. It also analyzes the characteristics of the device and discusses future work. A foremost goal of this paper is to provide readers with a basis for understanding glove system technology used in biomedical science.*

**INDEX TERMS:** *Gesture recognition, Sign language, wearable sensors.*

### I. INTRODUCTION

The development of the most popular devices for hand movement acquisition, glove-based systems, started about 30 years ago and continues to engage a growing number of researchers.

Communication involves the exchange of information, and this can only occur effectively if all participants use a common language. Sign language is the language used by deaf and mute people and It is a communication skill that uses gestures instead of sound to convey meaning simultaneously combining hand shapes, orientations and movement of the hands, arms or body and facial expressions to express fluidly a speaker's thoughts. Signs are used to communicate words and sentences to audience. A gesture in a sign language is a particular movement of the hands with a specific shape made out of them. A sign language usually provides sign for whole words. It can also provide sign for letters to perform words that don't have corresponding sign in that sign language. In this device Flex Sensor plays the major role, Flex sensors are sensors that change in resistance depending on the amount of bend on the sensor. This digital glove aims to lower this barrier in communication. It is electronic device that can translate Sign language into speech in order to make the communication take place between the mute communities with the general public possible. It can also provide sign for letters to perform words that don't have corresponding Sign in that sign language. Sensor gloves technology has been used in a variety of application areas, which demands accurate tracking and interpretation of sign language. The paper explains the designing requirements, factors of digital gloves.

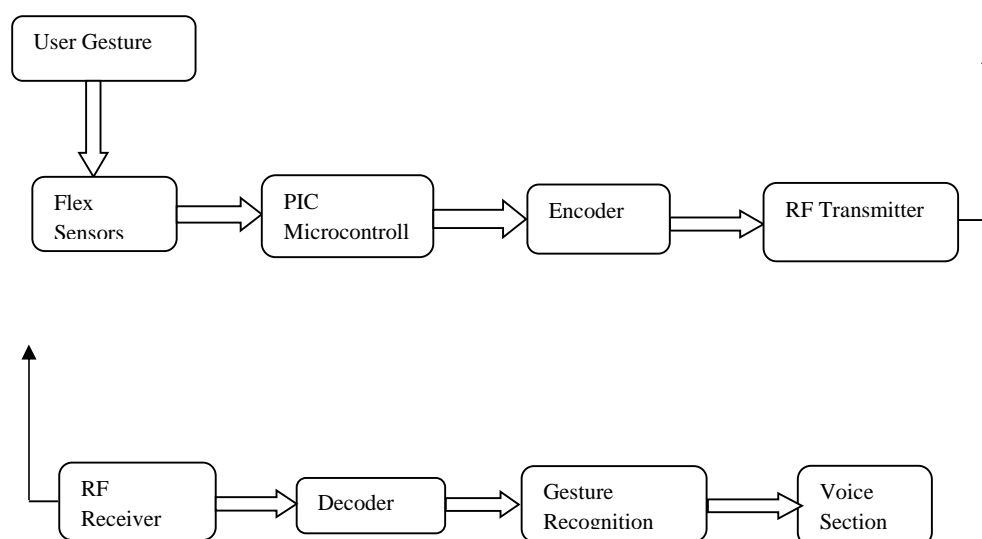
This paper contains the map to develop a pair of gesture vocalize gloves. It gives the related works, explains the system architecture, characteristics and operation of each component in the system architecture. Provides the future works, advantages and disadvantages of this device.

## II. RELATED WORK

Many scientists are working in the field of gesture recognition. A wonderful and latest survey of the work done in this field is described in reference [1]. Reference [2] and [3] discuss the gesture recognition for human robot interaction and human robot symbiosis. Reference [4] offers a novel “signal-level” perspective by exploring prosodic phenomena of spontaneous gesture and speech co-production. It also presents a computational framework for improving continuous gesture recognition based on two phenomena that capture voluntary (co-articulation) and involuntary (physiological) contributions of prosodic synchronization. Reference [5] discusses different categories for gesture recognition. Markov models are used for gesture recognition in reference [6] and [7]. A comprehensive framework is presented that addresses two important problems in gesture recognition systems in [8]. An augmented reality tool for vision based hand gesture recognition in a camera-projector system is described in reference [9]. A methodology using a neighborhood-search algorithm for tuning system parameters for gesture recognition is addressed in [10]. A novel method is introduced to recognize and estimate the scale of time-varying human gestures in [11].

## III. SYSTEM ARCHITECTURE AND IMPLEMENTATION

In this project data glove is implemented to capture the hand gestures of a user. The data glove is fitted with flex sensors along the length of each finger and the thumb. The flex sensors output a stream of data that varies with degree of bend. The analog outputs from the sensors are then fed to the PIC (Peripheral Interface Controller) microcontroller. It processes the signals and perform analog to digital signal conversion. The resulting digital signal is encoded and transmitted through RF system. RF receivers receive the signal and fed to the gesture recognition section through the decoder. In this section the gesture is recognized and the corresponding text information is identified. Text to speech conversion takes place in the voice section and plays out through the speaker. The user need to know the signs of particular alphabets and he need to stay with the sign for two seconds. There are no limitations for signs it is hard to build a standard library of signs. The new sign introduced should be supported by the software used in the system. The system can also be designed such that it can translate words from one language to another. A pair of gloves along with sensors enables mute people to interact with the public in the required language. The performance accuracy of this device can be improved by increasing the number of sensors in the series. These sensors are attached along the fingers and thumb. The degree of bending of fingers and thumb produces the output voltage variation which in turn on converting to analog form produces required voice.



**Fig 1:** Block Diagram Gesture Vocalizer System

Figure 1 illustrates the proposed system architecture; it manifests the system constituting components and the way they are connected to each other. The system is mainly composed of several modules including the input, preprocessing, feature extraction, and recognition modules.

The first module (input) acquires signs performed by a dumb person communicating with the system using sign language; Flex sensors outputs data stream depending on the degree and amount of bend produced by the sign. A group of signs that represent words are collected as the data set for this system.

The output data stream from the flex sensor is fed to PIC Microcontroller where it is processed and converted into digital form. The digital data is then encoded using suitable encoding method. The data is then transmitted using RF transmitter. The RF receiver receives the encoded data and it is decoded by decoder and fed to gesture recognition section. The sign is recognized and in the voice section the required speech output for the sign is produced.

## IV. GESTURE RECOGNITION SECTION

### 4.1. Sign Language Understanding

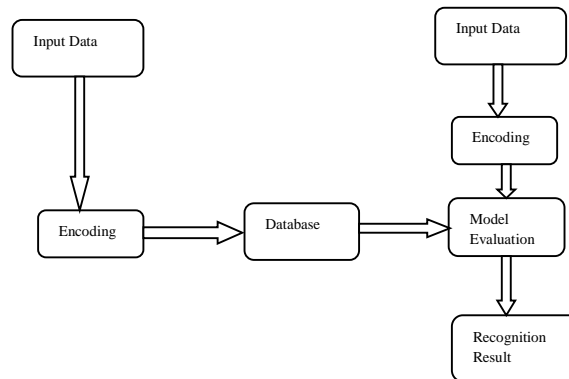
After the pioneering project of Grimes with the Digital Entry Data Glove many projects used glove based systems for automatic understanding of gestural languages used by the deaf community. The systems developed in these projects differed in characteristics such as number of classifiable signs, which could range from a few dozen to several thousand, types of signs, which could be either static or dynamic, and percentage of signs correctly classified. The simplest systems were limited to understanding of finger spelling or manual alphabets (a series of hand and finger *static* configurations that indicate letters). Takashi and Kishino and Murakami and Taguchi used a Data Glove for recognition of the Japanese alphabets. For recognition of the American alphabet, Medhui and Kahn used a Data Glove whereas Hernandez-Herbollar used an AcceleGlove. The more complex systems aimed at understanding sign languages, a series of *dynamic* hand and finger configurations that indicate words and grammatical structures. For instance, Kim and colleagues used a Data Glove for recognition of the Korean language Kadous a Power Glove.



Fig 2. American Sign Language

Here, we develop a real-time hand tracking method which is robust and reliable in complex background. To track the moving hand and then extract the hand shape fast and accurately, we need to consider the trade-off between the computation complexity and robustness. Sensor data are recognized and then recorded while a user performs various sign, correlating these with specific signs and mapping them to a database. The system stores sensor data in an array for recognition. When the

sensor data matches the set of values associated with a sign system recognizes that sign and output it as text. Here the Microcontroller used is AT89S51.



**Fig3:** Model of Gesture Recognition

An important aspect is that a gesture is seen as a sequence of successive postures. Postures in the recognition engine are composed of the flexion values of the finger the orientation data of the hand and an additional value to indicate the relevance of the orientation for the posture. These postures are taught to the system by simply performing them, then associating an identifier with the posture. The recognition engine is divided into two components: the Data acquisition and the gesture manager.

#### 4.2.Data acquisition

The data acquisition component is responsible for processing the received data and then transmits them to the gesture manager. First, a set of filters are used to optimize the data. For example, the position/orientation information is very noisy due to dependence of lighting conditions. Thus, orientation data that exceed a given limit are discarded as improbable and replaced with their previous values. These types of filters are applied: dead band filter, dynamically adjusting average filter. Note that to be recognizing as a posture, the user has to hold a position between 300 and 600 milliseconds in order to allow the system to detect a posture.

#### 4.3.Gesture manager

The gesture manager is the principal part of the recognition system. This library maintains a list of known postures. The system tries to match incoming data with existing posture. This is done by first looking for the best matching finger constellation. Five dimensional vectors represent the bend values of the fingers and for each posture definition the distance to the current data is calculated. Then, the position/orientation data is compared in a likewise manner. Finally, in this gesture recognition system, a gesture is just a sequence of successive postures. For example, let's consider the detection of a "click" gesture. This gesture is defined as a pointing posture with outstretched index finger and thumb and the other fingers flexed, then a tapping posture with half-bent index finger.

In the process for gesture recognition is different and more complex because the recognition concerns the whole upper-limbs including the head. A multi-level process that leads from the recognition of upper-limbs signals to symbols is described. The first level symbols describe types of gestures/postures such as hand-shape or hand-orientation. An abstract body model is used for the derivation of signals to first level symbols. This model can describe the complete posture/gesture of the upper-body. As for others systems, data received from sensors are loaded with noise. Different types of filters must be applied to remove noise and to optimize the signals. Then, a second-level symbols are derived from the first level symbols. This second level symbols constitute the application specific semantic units. The goal of this approach is the possibility and the only necessity to adapt the second-level symbols according to the required interpretation of symbols by an application.

#### 4.4.AT89S51

The AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of In System Programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a

conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with In-System Programmable Flash on a monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, two 16-bit timer/counters, a five-vector two level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next external interrupt or hardware reset

## V. FLEX SENSORS

The Flex Sensor patented technology is based on resistive carbon thick elements. As a variable printed resistor, the Flex Sensor achieves great form-factor on a thin flexible substrate. When the substrate is bent, the sensor produces a resistance output correlated to the bend radius—the smaller the radius, the higher the resistance value. Flex sensors are normally attached to the glove using needle and thread. They require a 5-volt input and output between 0 and 5 V, the resistivity varying with the sensor's degree of bend and the voltage output changing accordingly. The sensors connect to the device via three pin connectors (ground, live, and output). The device can activate the sensors from sleep mode, enabling them to power down when not in use and greatly decreasing power consumption. The flex sensor pictured below changes resistance when bent. It will only change, the resistance increases to 30- 40 kilo ohms at 90 degrees. The sensor measures ¼ inch wide, 4-1/2 inches long and 0.19 inches

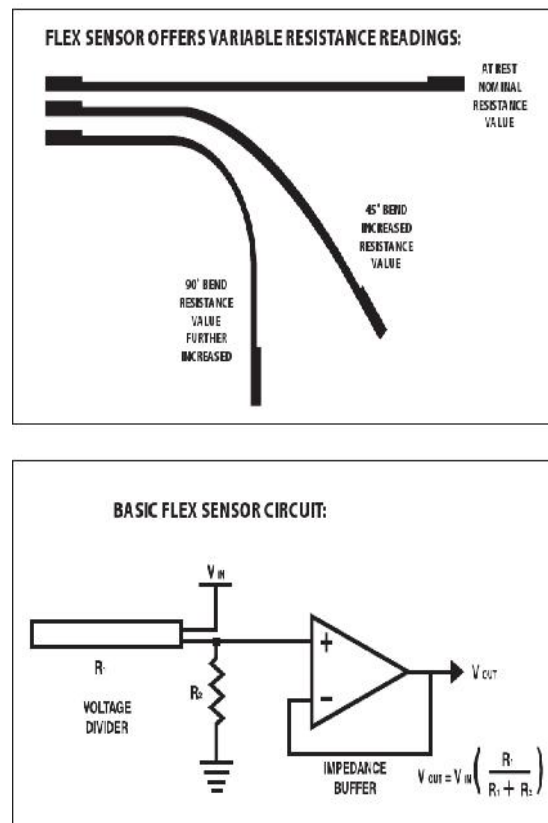


Fig 4: Basic Flex sensor Circuit

In this two or three sensors are connected serially and the output from the sensors is inputted to the analog to digital converter in the controller. The outputs from the flex sensors are inputted into LM258/LM358 op-amps and used a non-inverted style setup to amplify their voltage. The greater the degree of bending the lower the output voltage. The output voltage is determined based on the equation  $V_{in} * R1 / (R1 + R2)$ , where  $R1$  is the other input resistor to the non-inverting terminal. Using the voltage divider concept the output voltage is determined and it ranges from 1.35v to 2.5v.

Adjustable Buffer - a potentiometer can be added to the Circuit to adjust the sensitivity range.

Variable Deflection Threshold Switch – an op amp is used and outputs either high or low depending on the voltage of the inverting input. In this way you can use the flex sensor as a switch without going through a microcontroller. Resistance to Voltage Converter - use the sensor as the input of a resistance to voltage converter using a dual sided supply op-amp. A negative reference voltage will give a positive output. Should be used in situations when you want output at allow degree of bending.

### 5.1.Characteristics of flex sensors

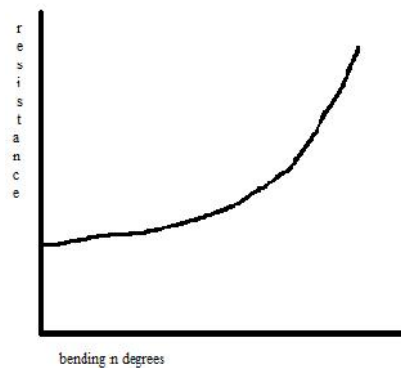


Fig5: Bending VS Resistance

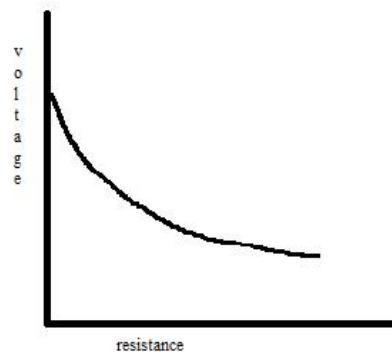


Fig6: Resistance VS Voltage

## VI. PIC MICROCONTROLLER

PIC microcontrollers are popular processors developed by Microchip Technology with built-in RAM, memory, internal bus, and peripherals that can be used for many applications. PIC originally stood for “Programmable Intelligent Computer” but is now generally regarded as a “Peripheral Interface Controller”.

PIC microcontrollers can be programmed in Assembly, C or a combination of the two. Other high-level programming languages can be used but embedded systems software is primarily written in C. PIC microcontrollers are broken up into two major categories: 8-bit microcontrollers and 16-bit Microcontrollers.

Each PIC has unique features and subtle differences. The correct choice for your project depends on many factors:

- 1) Does the project require analog input or output?
- 2) Does the project require digital input or output?
- 3) How many I/O pins are required?
- 4) Does the project require precise timing?
- 5) How much memory does the project require?
- 6) Is serial I/O required?

PICs also come in several types of packages:

- 1) Plastic Dual Inline Package (PDIP)
- 2) Small-Outline Transistor (SOT)
- 3) Dual Flat No-lead (DFN)
- 4) Mini Small Outline Package (MSOP)
- 5) Thin Quad Flat Pack (TQFP)
- 6) Plastic Leaded Chip Carrier (PLCC)
- 7) Ceramic QUAD pack (CERQUAD)

The PIC used in this system architecture is PIC16F877A. The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features 200 ns instruction execution, 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART, and a Parallel Slave Port.

### **6.1. Microchip PIC16F877A Microcontroller Features**

#### **A. High-Performance RISC CPU**

- Lead-free; RoHS-compliant
- Operating speed: 20 MHz, 200 ns instruction cycle
- Operating voltage: 4.0-5.5V
- Industrial temperature range (-40° to +85°C)
- 15 Interrupt Sources
- 35 single-word instructions
- All single-cycle instructions except for program branches (two-cycle)

#### **B. Special Microcontroller Features**

- Flash Memory: 14.3 Kbytes (8192 words)
- Data SRAM: 368 bytes
- Data EEPROM: 256 bytes
- Self-reprogrammable under software control
- In-Circuit Serial Programming via two pins (5V)
- Watchdog Timer with on-chip RC oscillator
- Programmable code protection
- Power-saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug via two pins

#### **C. Peripheral Features**

- 33 I/O pins; 5 I/O ports
- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler
  - Can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules

- 16-bit Capture input; max resolution 12.5 ns
    - 16-bit Compare; max resolution 200 ns
    - 10-bit PWM
  - Synchronous Serial Port with two modes:
    - SPI Master
    - I2C Master and Slave
  - USART/SCI with 9-bit address detection
  - Parallel Slave Port (PSP)
    - 8 bits wide with external RD, WR and CS controls
  - Brown-out detection circuitry for Brown-Out Reset
- D. Analog Features
- 10-bit, 8-channel A/D Converter
  - Brown-Out Reset
  - Analog Comparator module
    - 2 analog comparators
    - Programmable on-chip voltage reference module
    - Programmable input multiplexing from device inputs and internal VREF
    - Comparator outputs are externally accessible

## VII. VOICE SECTION

Once the sensor data is matched with the database then the result of that particular sign will appear as output in the text form. This text output is given to the voice section. The speech of each text is pre-recorded and will only play out through speaker if the sign is matched. In this project AM4EC series is used and it is a very low cost voice and melody synthesizer. The audio synthesizer contains one voice channel and two melody channels.

## VIII. RESULT AND DISCUSSION

In this Prototype version, the user forms a sign and holds it for two seconds to ensure recognition. The system is capable of recognizing signs more quickly than this arbitrary two seconds limit. Hence it is a low time consuming approach Furthermore real time recognition ratio of nearly 99% can be easily achieved

### 1. Advantages

- Low cost
- Compact systems
- Flexible to users
- It takes less power to operate system

### 2. Applications

- Physically challenged persons
- Conveying information related Operations

## IX. FUTURE WORK

The completion of this prototype suggests that sensor gloves can be used for partial sign language recognition. More sensors can be employed to recognize full sign language. A handy and portable hardware device with built-in translating system, speakers and group of body sensors along with the pair of data gloves can be manufactured so that a deaf and dumb person can communicate to any normal person anywhere.

- Perfection in monitoring and sensing of the dynamic movements involved in “Microcontroller and Sensors Based Gesture Vocalizer”.



- Designing of a whole jacket, which would be capable of vocalizing the gestures and movements of animals.
- Virtual reality application e.g., replacing the conventional input devices like joy sticks in videogames with the data glove.
- The Robot control system to regulate machine activity at remote sensitive sites.
- Designing of wireless transceiver system for “Microcontroller and Sensors Based Gesture Vocalizer”.
- Perfection in monitoring and sensing of the dynamic movements involved in “Microcontroller and Sensors Based Gesture Vocalizer”.
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- The Robot control system to regulate machine activity at remote sensitive sites.
- Designing of wireless transceiver system for “Microcontroller and Sensors Based Gesture Vocalizer”.

## X. CONCLUSION

Sign language is a useful tool to ease the communication between the deaf or mute community and the normal people. Yet there is a communication barrier between these communities with normal people. This project aims to lower the communication gap between the deaf or mute community and the normal world. This project was meant to be a prototype to check the feasibility of recognizing sign language using sensor gloves. With this project the deaf or mute people can use the gloves to perform sign language and it will be converted in to speech so that normal people can easily understand.

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