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A Proficient Technique to Communicate and to Detect Emotions of a Differently - Abled Persons Using Sensor Devices and Electroencephalogram Signals

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Abstract*— This paper presents an effective communication method for differently-Abled persons. Emotion is an important aspect in the interaction between humans. It is fundamental to human experience and rational decision-making. Generally, normal people can easily interact with one another but Sign language is the only means of communication for those who are dumb and deaf. This paper describes the design and working of a system which is used to communicate and to detect emotions of dumb and deaf. Hence by this methodology differently-abled people can able to interact with each other and also with the normal people. The dumb people use their standard sign language which is not recognizable by common people. For This purpose we are converting the sign language into voice which is easily understandable by normal people. Sensors and electrodes are used to detect the sign language and emotions that are processed by microcontroller (ATMEGA) where the in-built ADC converts the given analog signals into digital form. Then this digital signal is transmitted to PC via zig-bee. The PC produces the voice output for sign language (Differently abled to Normal people) and voice is translated into text form(normal people to Differently-Abled) and their corresponding EEG signal determines the state of mind(Happy, Sad, Frustrated, etc.)

Keyword **— ATMEGA (Microcontroller), EEG (Electrodes), Flux Sensor, Speech Synthesis, Zig-bee.**

I. INTRODUCTION

"Speech" and "gestures" are the expressions, which are mostly used in communication between human beings. Learning of their use begins with the first years of life. Research is in progress that aims to integrate gesture as an expression in Human- Computer Interaction (HCI). In human communication, the use of speech and gestures is completely coordinated. Machine gesture and sign language recognition is about recognition of gestures and sign language using computers. A number of hardware techniques are used for gathering information about body positioning; typically either image-based (using cameras, moving lights etc) or device-based (using instrumented gloves, position trackers etc.), although hybrids are beginning to come about [1], [2], [3]. However, getting the data is only the first step. The second step, that of recognizing the sign or gesture once it has been captured is much more challenging, especially in a continuous stream. In fact currently, this is the focus of the research. This research paper analyses the data from an instrumented data glove for use in recognition of some signs and gestures and the third step is to determine the neuronal brain activity by the electrodes. The Electroencephalogram (EEG) is one of the useful bio signals detect the human emotions. This paper also discusses research conducted to determine the changes in the electrical activity of the human brain related to distinct emotions. Thus the statistical learning method that can provide very stable and successful emotional classification performance over six emotional states.The acquired signals are processed by the microcontroller which in-turn transmit these signals through Zig-bee protocol to interface with PC. Hence this system is developed for recognizing emotions, signs and their conversion into speech and text (vice-versa). The results will show that despite the noise and accuracy constraints of the equipment, the reasonable accuracy rates have been achieved.

II. LITERATURE REVIEW

The A wonderful and latest survey of the work done in this field is described in reference [4]. Reference [5] and [6] discuss the gesture recognition for human robot interaction and human robot symbiosis. Reference [7] offers a novel "signal-level" perspective by exploring prosodic phenomena of spontaneous gesture and speech co-production. 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].Continuous hand gesture recognition requires the detection of gestures in a video stream and their classification. Before a system can recognize the face and hand poses, it must possess knowledge of the characteristic feature of these poses. This means that the system designer must either build the necessary discriminating rules into the system or the system must learn them. To adapt to new users and new hand poses the system must be able to perceive and extract relevant properties from the unknown faces and hand poses, find common pattern among them and formulate discrimination criteria consistent with the goal of the recognition process.[10] Many gesture can be described by the motion pattern generated by the upper body. The spatial movement of the hands, in particular, contain meaningful information about a performed gesture. We therefore focused on the time series of the hands' movement as a basis for our gesture recognition system. It is known to be difficult to

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reconstruct the 3D configuration of the human body parts if a 2D image is the only data source. [11]

III. METHODOLOGY

This research paper analyses the data from an instrumented flex and accelerometer sensor for use in recognition of some signs and gestures. A system is developed for recognizing these signs and their conversion into speech. The results will show that despite the noise and accuracy constraints of the equipment, the reasonable accuracy rates have been achieved. The Electroencephalogram (EEG) is one of the useful bio signals detect the human emotions. This paper also discusses research conducted to determine the changes in the electrical activity of the human brain related to distinct emotions. Thus the statistical learning method can provide very stable and successful emotional classification performance over six emotional states. Block Diagram Of The System is Shown Fig.1.

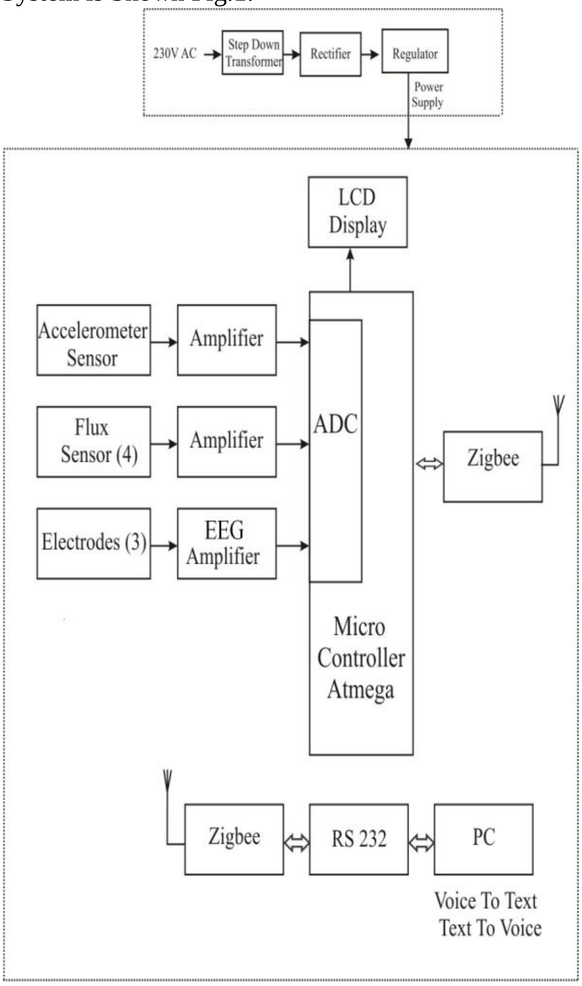

Fig. 1: Overall Block Diagram

The system is consisted of following modules:

- Data Glove
- Tilt detection
- Gesture detection
- Speech Synthesis
- LCD Display

Data glove is consisted of two sensors; bend sensors and tilt sensor. The output of the tilt sensors is detected by the tilt detection module, while the output of the bend sensors, and the overall gesture of the hand are detected by the gesture detection module. The gesture detection module gives an 8-bit address to speech synthesis module; 8-bit address is different for each gesture. Speech Synthesis module speaks the message respective to address received by it.

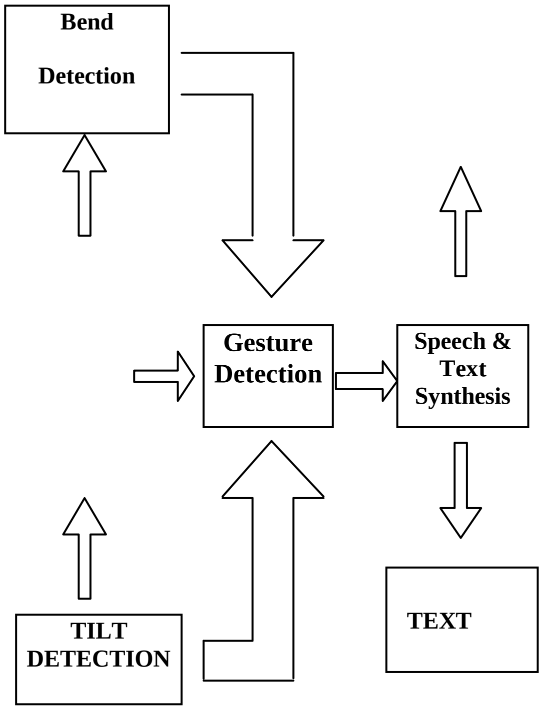

Fig.2 : Block Diagram Of The System

IV. SYSTEM DESCRIPTION

A) Data Glove

Data glove is consisted of two sensors; flux sensors and accelerometer.

1) Flux Sensor

Flexion sensors, (from Latin *flectere*, 'to bend') also called bend sensors, measure the amount of deflection caused by bending the sensor. There are various ways of sensing deflection, from strain-gauges to hall-effect sensors. The three most common types of flexion sensors are:

- Conductive ink-based
- Fibre-optic
- Conductive fabric/thread/polymer-based

Fig.3: Flux sensor

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A property of bend sensors worth noting is that bending the sensor at one point to a prescribed angle is not the most effective use of the sensor. As well, bending the sensor at one point to more than 90˚ may permanently damage the sensor. Instead, bend the sensor around a radius of curvature. The smaller the radius of curvature and the more the whole length of the sensor is involved in the deflection, the greater the resistance will be (which will be much greater than the resistance achieved if the sensor is fixed at one end and bent sharply to a high degree). In fact, Infusion Systems define the sensing parameter as “flex angle multiplied by radius”.

2) Accelerometer

One of the most common inertial sensors is the accelerometer, a dynamic sensor capable of a vast range of sensing. An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer. An accelerometer is a device that measures the vibration or acceleration of motion of structure. The force caused by vibration or a change in motion (acceleration) causes the mass to squeeze the piezoelectric material which produces an electrical charge that is proportional to the force exerted upon it. Since the charge is proportional to the force and the mass is a constant, then the charge is also proportional to the acceleration. Accelerometers are available that can measure acceleration in one, two, or three orthogonal axes. They are typically used in one of three modes:

- As an intertial measurement of velocity and position;
- As a sensor of inclination, tilt, or orientation in 2 or 3 dimensions, as referenced from the acceleration of gravity ($1\ g = 9.8 m/s^2$);
- As a vibration or impact (shock) sensor.

There are considerable advantages to using an analog accelerometer as opposed to an inclinometer such as a liquid tilt sensor – inclinometers tend to output binary information (indicating a state of on or off), thus it is only possible to detect when the tilt has exceeded some thresholding angle. Most accelerometers are Micro-Electro-Mechanical Sensors (MEMS). The basic principle of operation behind the MEMS accelerometer is the displacement of a small proof mass etched into the silicon surface of the integrated circuit and suspended by small beams. Consistent with Newton's second law of motion (**F = ma**), as an acceleration is applied to the device, a force develops which displaces the mass. The support beams act as a spring, and the fluid (usually air) trapped inside the IC acts as a damper, resulting in a second order lumped physical system. This is the source of the limited operational bandwidth and non-uniform frequency response of accelerometers.

B) Tilt Detection

The output, which is obtained from the accelerometers after amplification, is an analog output. To deal with this analog output, and to make it useful for the further use, it is required to change it into some form, which is detectable for the microcontroller. The analog output of the accelerometer is converted into digital form. This Gesture Vocalizer system is a dual axis system, which can detect the tilt of the hand in two axes. A dual channel ADC can be used to convert the outputs of the accelerometers in to digital form. The basic function of this module is to detect the tilting of the hand and sending some binary data against meaningful gestures, to the bend detection module. Now the output of the accelerometers is converted into the digital form this output is useful, in a sense that it is detectable by the microcontroller, and useful for the further use. Next step for the microcontroller is to check the data from the ADC’s. The microcontroller checks whether the data received from the ADC’s is some meaningful data, or useless one. Meaningful means that the tilt of the hand is some meaningful tilt and is signaling some defined gesture, or a part of the gesture, because gesture means a complete motion of the hand in which the bending of the finger is also involved. The microcontroller compares the values received from the ADC’s with the predefined values, which are present in the memory of the microcontroller and on the basis of this comparison the microcontroller decides that, is the gesture a meaningful gesture. If the hand is signaling a meaningful gesture then the microcontroller moves toward the next step. The next step of the microcontroller is to send eight bit binary data to the main “bend detection” module. The eight-bit code is different for every valid gesture. On the basis of this code, which is, sent by the tilt detection module, the “bend detection” module checks the gestures as a whole, and takes some decisions. The “bend detection module” sends eight bit data to the speech syntheses module that knows the meaning of each data.

C) Bend Detection

The bend detection module is the most important and the core part of the paper. This module is based on a microcontroller-controlled circuitry. Flexion sensors typically consist of two layers of conductive material with a layer of resistive material in between. It is mostly sandwiched in between layers of more rugged material, e.g. Neoprene. As pressure is applied (directly or by bending) the two layers of conductive material get pushed closer together and the resistance of the sensor decreases. This sensing mechanism is similar to force-sensitive resistors. These types of sensors are pressure sensors which also sense deflection (pressure as a function of deflection): bending the sensor across an angle of a rigid structure results in stretch of the sensor material which exerts pressure onto the sensor. It is this pressure that is measured. In this module one microcontroller is used and three ports of this microcontroller are in use. Port zero takes the input from the five bend sensors, which is to be processed. The port one takes data from the tilt detection module and the port three gives final data, which represents some meaningful gesture to the speech synthesis module. At first the microcontroller takes input of the five-bend sensor at its port zero. Output of the five bend sensors is given at the separate pin. Microcontroller deals with the bend sensors one by one. First of all the microcontroller checks the output of the first bend sensor, and calculates its pulse width, after the calculation of the pulse width of the first bend sensor the

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microcontroller saves its output, and then moves towards the second bend sensor and calculates its pulse width in the similar manner, and keeps on calculating the pulse width of the bend sensors one by one, having calculated the pulse width of the outputs of the five bend sensors, the microcontroller moves towards the next step of the module, i.e. gesture detection. Gesture detection is the most important part of this module. The pulse width calculation part of the module calculates the pulse width of the signal obtained from the bend sensors at a regular interval. Even a little bend of the finger is detected at this stage of the system, so the bending of the figure has infinite levels of bends, and the system is very sensitive to the bending of the finger. Now the bending of each finger is quantized into ten levels. At any stage, the finger must be at one of these levels, and it can easily be determined how much the finger is bended. So far the individual bending of each finger is captured. System knows how much each finger is bended. Now the next step is to combine the movement of each finger and name it a particular gesture of the hand. Now the system reads the movements of five fingers as a whole, rather than reading the individual finger. Having read bending of the fingers, the system checks whether the bend is some meaningful bend, or a useless or undefined bend.

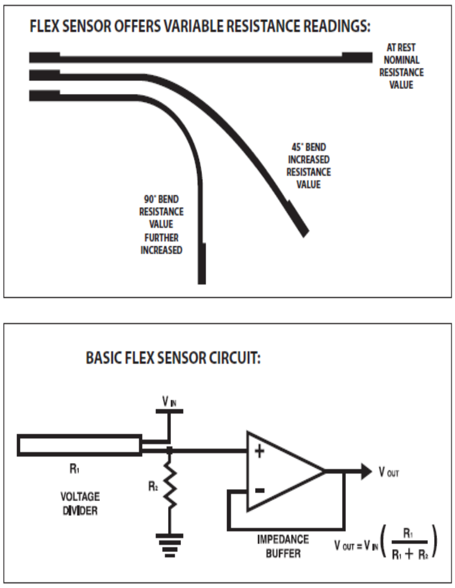

Fig.4: Circuit Diagram of Flux Sensor

If the bending of the fingers gives some meaningful gesture, then system moves towards the next step. In the next step the system checks the data, which was sent by tilt detection module at port one of the microcontroller. The data sent by this module shows whether the tilt of the hand is giving some meaningful gesture or it is undefined. If the tilt of the hand is also meaningful then it means the gesture as a whole is a meaningful gesture. So far it is detected by the system whether the gesture given by hand is some meaningful gesture, or a useless one. If the gesture is meaningful the system sends an eight bit data to the speech synthesis module. This eight bit data can represent 256 (2^8=256) different gestures. The gesture detection module assigns a different 8bit code to each gesture.

D) EEG Signal Analysis

EEG measurement is non-invasive and inexpensive, have a very high sensitivity to receive information about the internal (endogenous) changes of brain state these data are particularly suited for studies on brain mechanisms of cognitive-emotional information processing which occurs in the millisecond range.[12] Nonverbal information appearing in human facial expressions, gestures, and voice plays an important role in human communication. Especially, by using information of emotion and/or affection the people can communicate with each other more smoothly [13]. This means that non verbal communication is basis of human communication. In addition to this human-human communication, it is also important that human-human communication via computer and the communication between human - machines are more and more common one in the recent field of research. In order to understand the communication between man-machine, we discussed the emotion as interface between the human and machine through the EEG signals.

1) Emotions

Emotions and their expression are key element in social interactions, being used as mechanisms for signaling, directing attention, motivating and controlling interactions, situation assessment, construction of self- and other's image, expectation formation, inter subjectivity, etc[14]. Recently, a constellation of findings, from neuroscience, psychology, and cognitive science, suggests that emotion plays surprising critical roles in rational and intelligent behavior. When we are happy, our perception is biased at selecting happy events, likewise for negative emotions. Similarly, while making decisions, users are often influenced by their affective states. Reading a text while experiencing a negatively valence emotional state of often leads to very different interpretation than reading the same text while in a positive state [15]. It is not only tightly intervened neurologically with the mechanisms responsible for cognition, but that they also play a central role in decision making, problem solving, communicating, negotiating, and adapting to unpredictable environments. Emotion consists of more than its outward physical expression: it also consists of internal feelings and thoughts, as well as other internal process of which the person experiencing the emotion may not be aware [16]. Individual emotional state may be influenced by kinds of situations, and different people have different subjective emotional experiences even response to the same stimulus [17]. The human emotions are basically classified into three types: Motivational (Thirst, Hunger, Pain, Mood), Basic (Happy, Sad, Fear, Disgust, Anger, Surprise) and Self Conscious or Social (Shame, Embarrassment, Pride, Guilt)[16]. Pattern recognition efforts aimed at finding physiological correlates, focusing on t-tests or Analysis of Variance (ANOVA) comparisons and combining data over many subjects, where each was measured for a relatively small amount of time [18].

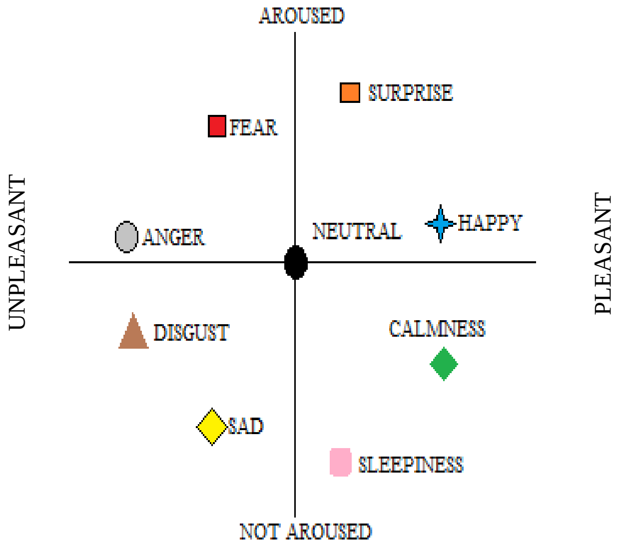

Fig 5 (a): Russel Model for Emotion

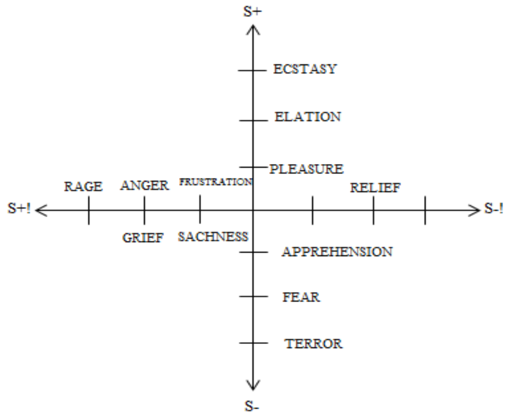

Fig 5 (b): Discussion Model for Rolls Theory of Emotion

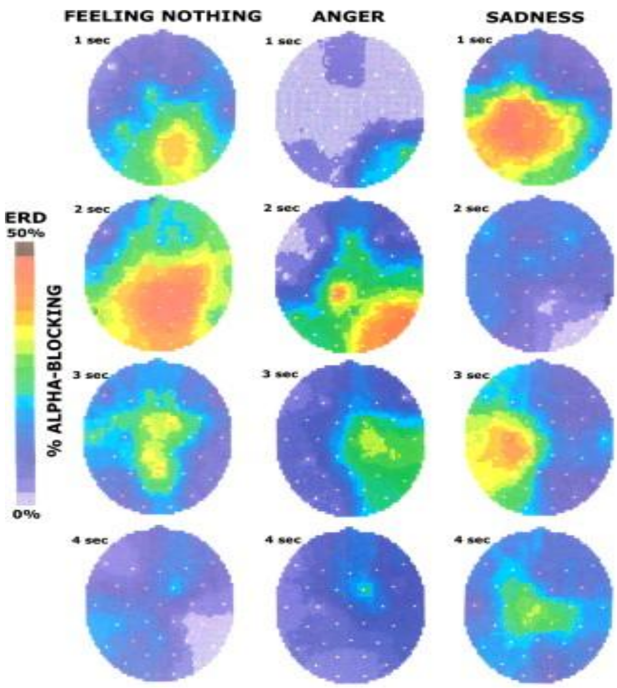

Fig.5(c): Brain Activity for Normal State, Angry and Sad.

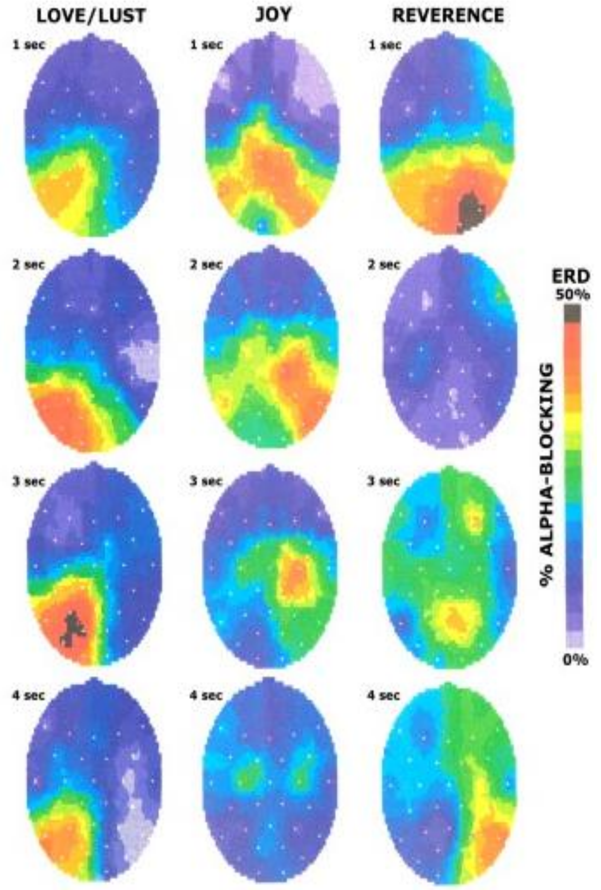

Fig.5 (d): Brain Activity for Love, Joy and Reverence.

The above Fig. 5(a) and Fig. 5(b) shows the region of relation between arousal with valence. The relation between physiological signals and arousal/valence is established due to the activation of the automatic nervous system when emotions are elicited [19]. After perceiving a stimulating event, an individual instantly and automatically experiences physiological changes, these response to this changes are called Emotion. Fig. 5(c) and Fig. 5(d) shows the various emotion states and its brain activity [20].

2) Recording of Emotional States Changes Through EEG

EEG was used to study the individual's emotional state for more than two decades. The useful information about the emotional state may be obtained as long as stable EEG patterns on the scalp are produced. EEG recordings capture neural activity on a millisecond scale from the entire cortical surface [21]. According to (Lee M, 2000) this study, the positive and negative emotions may or may not be estimated from the EEG signal using Skinner's Point –Wise Correlation Dimension (PD2) analysis. But this PD2 represents some of the mental activity in the brain areas. The Fig.7 simply shows the region of brain activated in emotion recognition. Where the Green color indicates the neutral, red color indicates the anger emotion and purple color indicates the happiness. At last the blue color indicates the sadness of the human [22]. The electrical activity of the human brain is recorded through the electrodes, which are placed on the scalp of the brain.

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These recorded brain waves are undergone for pre-processing [23].

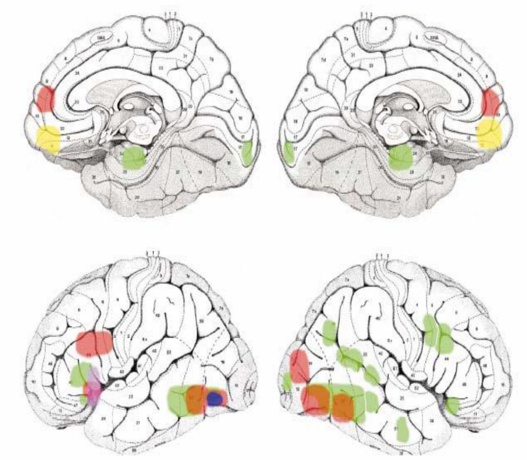

Fig.6: Localization of Brain Region for Emotion Recognition

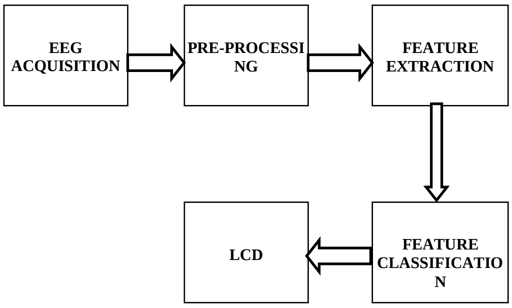

Fig.7: Basic Diagram for Human Emotion Recognition using EEG signals

Dimension reduction can be done by several methods such as, Principal Component Analysis (PCA), Independent Component Analysis (ICA) [24]. These extracted features are classified for seven different kinds of emotions say, Happy, Anger, Joy, Disgust, Fear, Relax, and Neutral through artificial intelligence techniques such as Neural Network, Genetic Algorithm, Support Vector Machine, Fuzzy Logic, and Hybrid Structure of the above method [25].

E) Speech Synthesis

This module of the system is consisted of a microcontroller (ATMEGA), a SP0256 (speech synthesizer) IC, amplifier circuitry and a speaker. The function of this module is to produce voice against the respective gesture. The microcontroller receives the eight bit data from the "bend detection" module. It compares the eight bit data with the predefined values. On the basis of this comparison the microcontroller comes to know that which gesture does the hand make. Now the microcontroller knows that which data is send by the bend detection module, and what the meaning of this data is. Meaning means that the microcontroller knows, if the hand is making some defined gesture and what should the system speak. The last step of the system is to give voice to the each defined gesture. For this purpose a speech synthesizer IC, SPO256 is used. Each word is consisted of some particular allophones and in case of Speech synthesizer IC each allophones have some particular addresses. This address is to be sent to the SPO256 at its address lines, to make the speaker, speak that particular word. The summary of the story is that we must know the address of each word or sentence, which is to be spoken by this module. Now these addresses are already stored in the microcontroller. So far, the microcontroller knows what is the gesture made by the hand, and what should be spoken against it. The microcontroller sends the eight-bit address to SPO256. This eight-bit address is representing the allophones of the word to be spoken. SPO256 gives a signal output. This signal is amplified by using the amplifying circuitry. The output of the amplifier is given to the speaker.

F) LCD Display

By using the gesture vocalizer the dumb people can communicate with the normal people and with the blind people as well, but the question arises that how can the dump people communicate with the deaf people. The solution to this problem is to translate the gestures, which are made by the hand, into some text form. The text is display on LCD. The gestures are already being detected by the "Gesture Detection" module. The block diagram of the LCD display module is shown in the Fig.8.

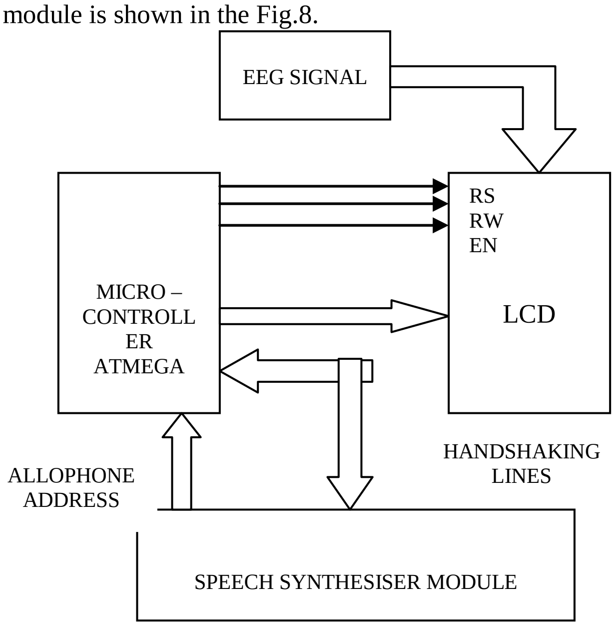

Fig. 8: Block Diagram LCD Display Module

This module sends signal to the speech synthesis module, the same signal is sent to the LCD display module. The LCD display module is consisted of a microcontroller and an LCD. The microcontroller is controlling the LCD. A signal against each gesture is received by LCD display module. The LCD display module checks each signal, and compares it with the already stored values. On the basis of this comparison the microcontroller takes the decision what should be displayed, having taken the decision the microcontroller send an eight bit address to the LCD, this eight bit address, tells the LCD, what should be displayed. The EEG signal output is given to the LCD to display the emotion of the person in order to know his state of speech. Using the information's from EEG signal (emotion) the person can communicate with each other more smoothly.

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V. RESULT AND ANALYSIS

Thus the effective communication device for the differently-abled persons is designed and their emotions are determined with the help of EEG using which they are able to communicate like ordinary people. The flex and accelerometer sensors determines the Gesture (sign language), it is then converted into speech and text using Microcontroller and PC Interface. The electrodes are used for analysing the EEG signals for detecting the emotion of the people during his conversation. By combining this a new "SMART DEVICE" is developed for Gifted Aspirants.

VI. OVERALL KIT DESIGN

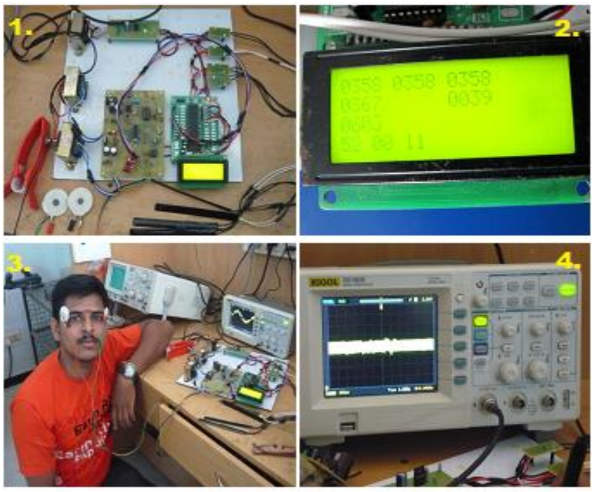

Fig.9: Photo shot of our Design module.

- Embedded Kit along with Sensors and Electrodes.
- LCD Module.
- Analysis of EEG Signal.
- EEG Output.

VII. ADDITIONAL ENHANCEMENT

In this system we have a voice output that comes from the computer. Which have to be transmitted to the receiver using a smart phone, receiver should be able to hear the voice and when he replies the voice data which reaches the smart phone should be converted into text format and displayed in the smart phone itself or in the computer connected to it.

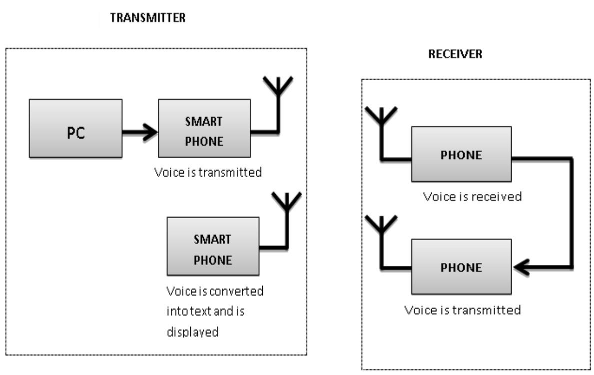

Fig.10: Block Diagram of Additional Enhancement

VIII. CONCLUSION AND FUTURE ENHANCEMENTS

This research paper describes the design and working of a system which is useful for dumb and deaf to communicate with one another and with the normal people. The dumb people use their standard sign language which is not easily understandable by common people and blind people cannot see their gestures. This system converts the sign language into voice which is easily understandable by blind and normal people. The sign language is translated into some text form, to facilitate the deaf people as well. This text is display on LCD. There can be a lot of future enhancements associated to this research work, which includes:

- Designing of wireless transceiver system for "Differently –Abled persons using sensors"
- Perfection in monitoring and sensing of the dynamic movements involved in "Sensors and Gesture Vocalizer".
- Designing of a whole jacket, which would be capable of vocalizing the gestures and movements of Human.
- 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.

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