Smart Gloves : Remote Monitoring of Differently-Abled Patients Using Cloud

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Abstract- *Differently-abled patients and old-age people who have difficulties in communication find it difficult to communicate with others. They usually use sign language and gestures to communicate with others, which might not be understood by everyone. Few seniors (old-age people) might hesitate to use such gestures to communicate and remain silent without expressing their feelings and pain. This project aims to provide them an IoT device which helps them to communicate in a more comfortable way. The device consists of a glove which has flex sensors attached to each finger and a pulse sensor connected to one of the fingers. Flex sensors are used to sense the gestures, while the pulse sensor is used to sense the heart rate of deaf and mute patients. Arduino Uno is used to collect the sensor values which is then, transmitted to the android application via Bluetooth. Flex sensor values are mapped to the appropriate voice in the android application which can be understood by doctors. The same application can be used to listen to the reply of doctors and display it as a text message which can be viewed by deaf patients. For automatic speech recognition, inverted alignment of end to end models is used. When an abnormal pulse rate is detected by the pulse sensor, an emergency message is transmitted to the nearby medical center via cloud services.*

Keywords- Flex sensor, Pulse sensor, ArduinoUno, Bluetooth, IoT(Internet of Things), end-to-end model, (ASR)Automatic Speech Recognition

I. INTRODUCTION

The basis of communication for people having difficulty to hear and speak is through Sign language. The deaf and dumb communities use the sign language to express their own feelings as well as for normal people to understand what they are expressing. **Sign language** [1] is the visual representation to communicate that is integrated with a series of manual and non-manual signs. The hand motions and positions are the common manual signs and the external appearance such as facial expressions and body movements are non-manual signs. Sign language is not standardized at a global level. Each and every country and the states in it have their own sign language such as American Sign Language (ASL) and Indian Sign Language (ISL). Integrating all types of sign languages as a single one that can be used worldwide is a challenging task. There are always slight variations in each of the sign languages developed within different places of the same country.

Sign language detection systems are used to convert the sign language to text or speech that helps the differently-abled person to communicate with other people. This type of system focuses on hand configurations that include position and movements of fingers. Sign language detection has three levels: finger spelling (alphabets), isolated words and continuous gesturing (sentences)[2]. These configurations are detected and their meanings are determined using two approaches: sensor-based approach and vision-based approach. The sensor based approach deals with wearable devices to detect the gestures which are simpler and accurate. The vision based approach uses cameras to capture the gestures which are less accurate and complex.

Vision based detection system [3] does not extract the characteristic features describing the hand and finger movements directly through video recordings. The video streams require image processing and multiple processing steps are required to extract the features. These additional levels of processing introduce problems and may lead to false conclusions about the feasibility of the gestures. Thus it is reasonable to use data that are directly related to features describing the gestures and movements. **Sensor based detection systems** recognise the gestures by using an instrumented glove [4]. The gloves are equipped with sensors that detect the gestures based on the shape, orientation, movement and location of the fingers. Typically this type of system uses a flex sensor to measure the finger flexion and orientation of the hand. Five flex sensors are attached to each finger of the glove to identify the gestures by matching the motions with those stored in the database. The captured motions are stored and mapped through the interfacing Arduino UNO where IoT is used.

Internet of Things (IoT) is the internetworking of physical devices ,buildings ,vehicles and other items embedded with electronics ,sensors ,software ,actuators and network connectivity that enable each objects to collect and exchange data. Typically, IOT is expected to offer advance connectivity of devices, systems and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains and applications. The gestures detected are transmitted as signal via Arduino UNO and are mapped with the user defined sentences that aids in continuous gesturing. An **Android application** is used to receive the mapped sentences as a voice that is easier for the normal people to interpret. The application is created with Android API. The same application can be used by the differently abled person to understand what the other person speaks that is displayed as text.

Several algorithms and training models have been proposed to Automatic Speech Recognition (ASR). Unlike traditional hidden markov model, which uses separate approaches for training and decoding, we have used end-to-end training approach. This is used for directly mapping acoustic frames to the output characters [6]. Major disadvantage of this model is lack of alignment method. Therefore, an idea of inverted alignment used in handwriting recognition [5] can be used.

End-to-end model is chosen, because this model can be used for both acoustic modeling and language modeling. i.e it can be used for obtaining the speech, convert it to acoustical frames and map them to appropriate output characters.

II. ARCHITECTURE DIAGRAM

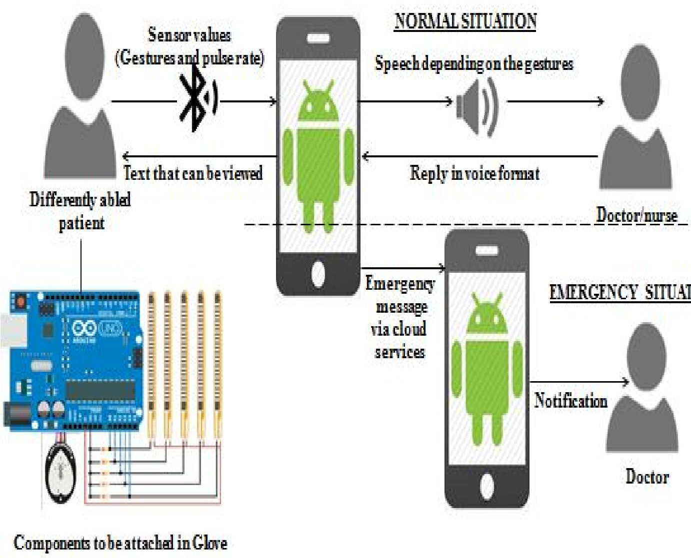

Fig 1: Overall Architecture

III. HARDWARE AND SOFTWARE DESCRIPTION

This device consists of two major parts:

1. Smart gloves
2. Andoid Application

Smart gloves consists of following hardware components:

- Flex Sensor
- Arduino UNO
- Bluetooth Module
- Pulse Sensor

Android application part is implemented in the smart phones.

Flex sensor:

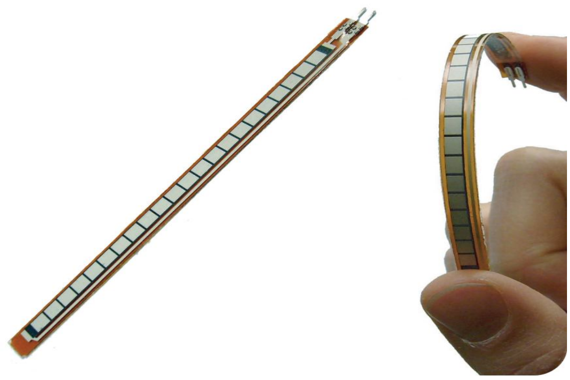

Fig 2: Flex sensor

Flex sensor is a type of sensor which is also said to be a variable resistor. This sensor is used to measure the angular displacement and detects the bending. The resistance increases with respect to the bend of flex sensor. Flat resistance of this sensor is 10k Ohms and it's bend resistance is minimum 2 times greater than the flat resistance.There are three types of flex sensors namely, conductive ink flex sensor, fibre optic flex sensor and capacitive flex sensor. The resistance is directly proportional to the amount of bend of the sensor.

Arduino UNO:

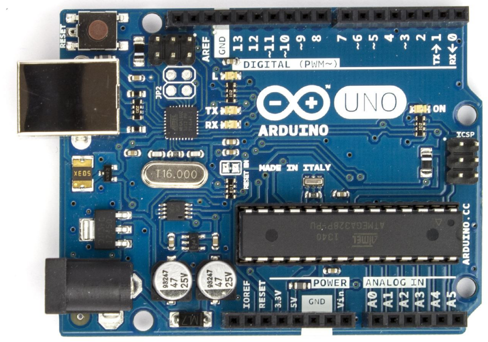

Fig 3: Arduino UNO board

The Arduino Uno is a microcontroller board based on the ATmega328. It can be connected to computer via USB cable. Batteries or AC-to-DC adapter can also be used to get started. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It has maximum of 12V power supply and minimum of 2.3V, but the recommended is 5V of supply. Arduino UNO IDE can be used to program the board for any device.

Bluetooth Module:

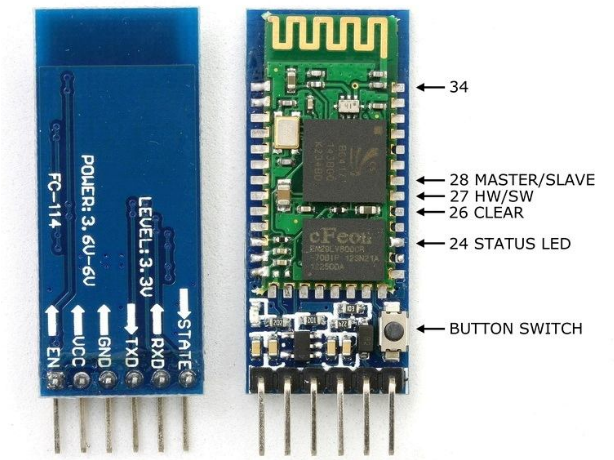

Fig 4: Bluetooth Module

Bluetooth is a type of technology used to transfer data between electronic devices without the help of cables. But the data can be transferred only to the devices which are at small distance from each other. Various Bluetooth devices available in market are PC cards, dongles, headsets, wireless mouse and keyboards. HC-05 Bluetooth module is used in this project. Modulation used by this type of module is GFSK(Gaussian Frequency Shift Keying) with the frequency of 2.4GHz ISM band.

Pulse sensor:

Fig 5: Pulse sensor

Pulse sensor is used to sense the heartbeat with the help of any type of microcontroller. Pulse sensor Amped is a plug-and-play heart-rate sensor usually used with Arduino UNO. It requires the power of 4mA current and hence can be connected to 3V or 5V pin. It is usually used in devices for monitoring heart patients. It combines optical heart rate sensor with amplification.

Smart Phones:

Fig 6: Android phones

Smartphones are type of personal computers with the facility of mobility and other wireless technologies. They have an additional facility of telephonic conversation and other text communications. They run a variety of software components which are called as apps (Application). Modern smart phones have touch-screen facility and better graphical user interfaces.

Arduino IDE:

Fig 7: ArduinoSoftware

The Arduino IDE is an Open-Source software used to provide instructions to microcontroller. It provides an environment where you can write code and upload it to your microcontroller. It is available for Windows, Linux and MAC operating system based computers.

Android Studio:

Android Studio is an Open-Source Integrated Environment for Developing Android Application.

Fig 8: Android studio platform

IV. CIRCUIT DIAGRAM

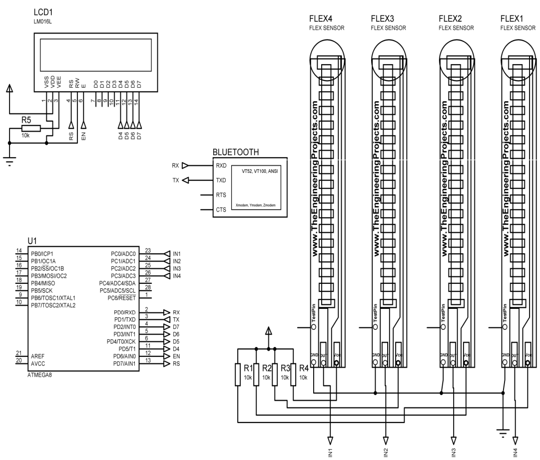

Fig 9: Overall circuit diagram

V. METHODOLOGY USED

The key technology used for implementing this device is to detect the gestures by flex sensor and send the sensor values to the android phone via Bluetooth facility. In an emergency case, pulse rate is detected by pulse sensor and an emergency message is sent to doctors via Cloud services. Fig shows the flowchart of this process. Both the technologies are highly efficient and simple to use. The main aim of the project is to provide communication facility to deaf and dumb patients at lower cost. The system also converts reply obtained to the text that can be viewed by deaf patients.

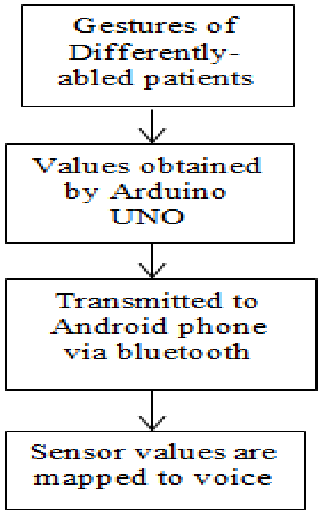

Fig 10: Gesture recognition Flowchart

The proposed method uses the Arduino UNO board as the main controller. It is programmed using Arduino IDE, which is a platform specifically designed for coding the projects run by Arduino UNO. This software can be downloaded for no cost from the official website of arduino. After download is complete, connect your board to laptop via USB cable. Select **Tools** -> **Board** menu according to the microcontroller being used. The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. ICSP (In-Circuit Serial Programming) header can also be used to bypass the bootloader and program the microcontroller.

Flex sensors to be used are attached to the fingers of the gloves. These sensors are connected to arduino UNO board with the resistors in between them. Before attaching these sensors to the gloves, flex rate of each sensor is determined by programming using arduino software and obtaining the values in the serial port. Once the flex value is obtained for each sensor, the program can be developed for all the four sensors connected to the glove.

The flex sensor value obtained by the arduino board is transmitted to Android application via Bluetooth module. Bluetooth is connected to Arduino UNO and programmed to obtain the sensor values and transmit it to the android application. Android application is programmed using Android studio, a software used to develop applications for Android phones. Values obtained via Bluetooth module is mapped to the appropriate voice track using in-built libraries in Android studio.

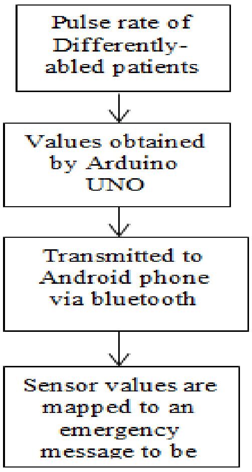

Fig 11: Gesture recognition Flowchart

Pulse sensor is attached to one of the fingers of the gloves. These sensors are connected to arduino UNO board to continuously monitor the pulse rate of the deaf and dumb patients. Before attaching this sensor to the gloves, normal and abnormal pulse rate of sensor is determined by programming using arduino software and obtaining the values in the serial port. Once the abnormal value is identified for the sensor, the program can be developed for sending an emergency message via cloud services.

The pulse sensor value is initially obtained by the arduino board and transmitted to Android application via Bluetooth module. Bluetooth is connected to Arduino UNO and programmed to obtain the sensor values and transmit it to the android application. Android application is programmed to identify the nearby hospitals via cloud services and transmit them an emergency message.

Initial flowcharts represent the methodology for differently abled patients to communicate with the doctors and other abled patients, whereas the following flowchart represents the idea of how the reply from doctors can be understood by those patients. We have also studied the various approaches of ASR in the following table.

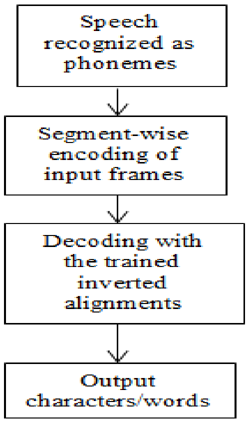

Fig 12: Flowchart for speech-to-text conversion

End-to-end model with an inverted alignment approach is used to recognize the speech and map it to the text. This model is opted because both training and decoding can be done by the same algorithm. Segment-wise approach is used to encode the input frames, which are aligned to the output labels. Decoding can be done by mapping those aligned labels to the text.

Approach/ Model	Strength	Weakness
Hidden Markov Model	Good abstractions for sequences compared or recognized. Easy to decode the sequences recognized.	It is not completely automatic. It needs a manual mark up. It is used only for speech recognition
Connectionist Temporal Classification	Do not have the overhead of frame-level conditional independence	Decoding is not included. Cannot be used for aligning end-to-end models
Attention Mechanism	Directly operate on label positions. Uses fully stochastic approach.	Not suitable for long sequence input.
End-to-End Model	Can be used for both training and decoding. Can be used for large vocabulary continuous speech recognition. Uses fully stochastic approach.	Does not use any alignment model.
Inverted Alignment for end-to-end model	Have all the advantages of end-to-end model. Inverted Alignment eases the decoding and classification of labels.	An additional alignment methodology must be studied for using this approach.

VI. IMPLEMENTATION

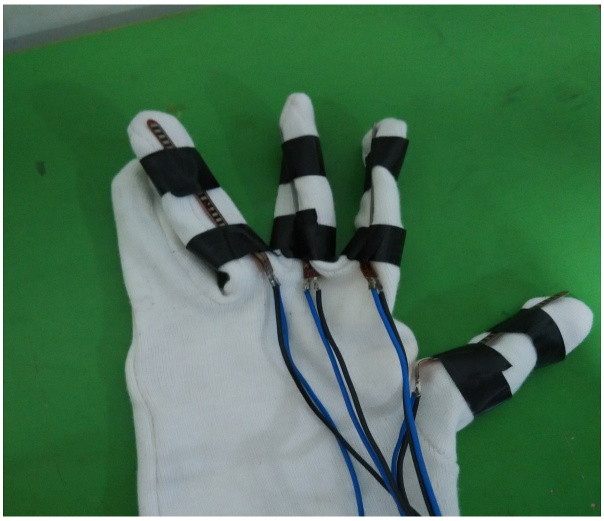

Fig 13: Smart gloves

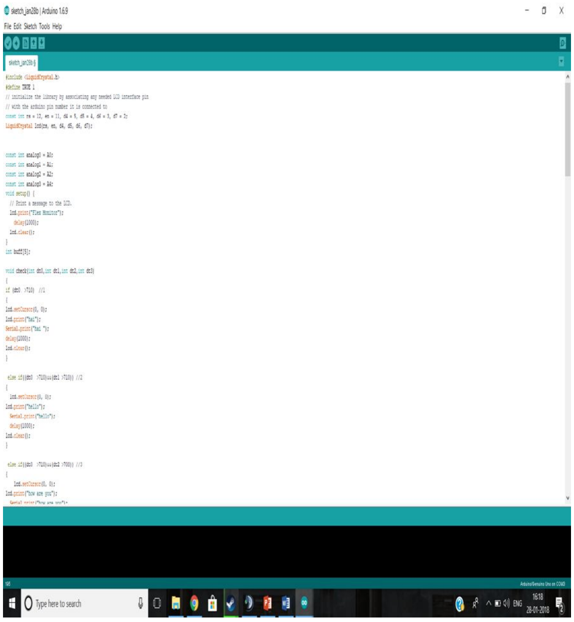

Fig 14: Arduino coding

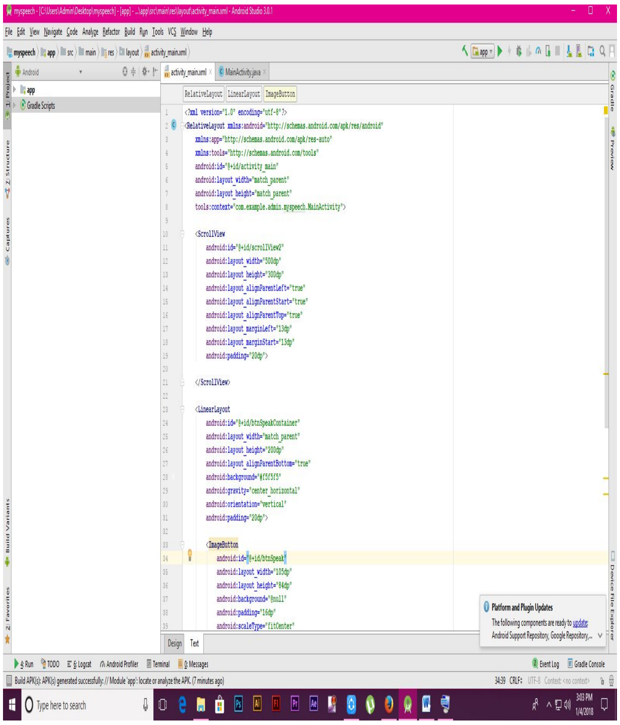

Fig 15: Java coding

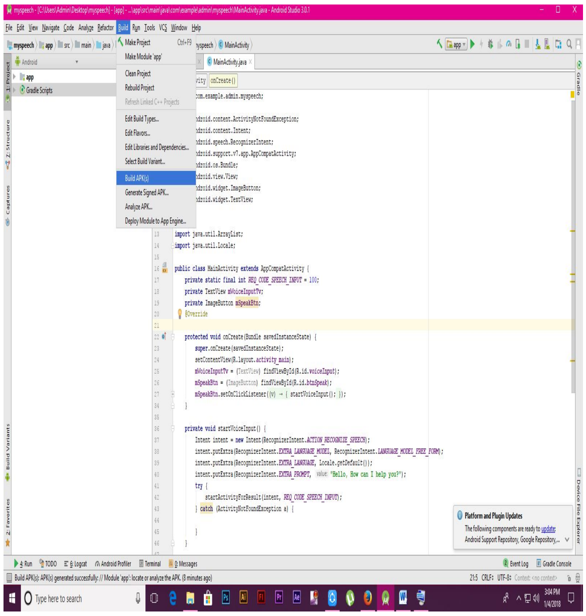

Fig 16: Building APK file

Fig 17: Android Application

VII. CONCLUSION

An IoT device developed on the foundation of algorithms and cloud services facilitated by Arduino UNO and Android application is an enhanced development for the communication of differently-abled patients. Smart glove is capable of translating the gestures into speech through android phone and continuously monitor the pulse rate of patients. It also converts the reply from normal person to text. This provides easy understandability to doctors and provides immediate response from hospitals in case of emergencies with the help of cloud services. This glove is a highly accurate, cost effective and an independent glove designed for deaf and dumb patients. This device also favors old age people and other serious patients who lose their speaking ability.

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