Low Cost Real-Time Communication Braille Hand-Glove for Visually Impaired Using Slot Sensors and Vibration Motors

Mukul Bandodkar, Virat Chourasia

Abstract—Visually impaired people find it extremely difficult to acquire basic and vital information necessary for their living. Therefore, they are at a very high risk of being socially excluded as a result of poor access to information. In recent years, several attempts have been made in improving the communication methods for visually impaired people which involve tactile sensation such as finger Braille, manual alphabets and the print on palm method and several other electronic devices. But, there are some problems which arise in such methods such as lack of privacy and lack of compatibility to computer environment. This paper describes a low cost Braille hand glove for blind people using slot sensors and vibration motors with the help of which they can read and write e-mails, text messages and read e-books. This glove allows the person to type characters based on different Braille combination using six slot sensors. The vibration in six different positions of the glove which matches to the Braille code allows them to read characters.

Keywords—Braille, Braille Hand-Glove, Slot sensors, Vibration motors.

I. INTRODUCTION

SOCIETY functions primarily through the smooth exchange of goods, services and companionship. However information and resources are made more readily available to the eye. The societal infrastructure and exchange network are designed to optimize the freedom, functioning, and enjoyment of sighted people - facing the visually impaired with exclusion from this network. The internet has become an effective, essential and a fast access tool for obtaining vital educational information. In this fast developing modern world internet has become the most important and reliable educational information hub.

About 37 million people across the globe are visually impaired which is a substantial proportion of the world's population. These visually impaired people face many problems in their day-to-day life because of their impairment. They also have an equal right to education and knowledge. But their ability to learn new stuff is drastically compromised.

They have to rely on conventional and orthodox methods [1] of obtaining information which includes tactile sensation such as finger Braille, manual alphabets and the print on palm method, but these methods are tedious, slow and inefficient

and are not suitable for the computer environment. As a result, they are unable to access the information hub i.e. the internet.

Emails, text messages, internet blogs, e-books etc. have become an integral part of our life and the visually impaired unfortunately are deprived of such facilities. They do a reading using Braille language which has a wide variety of characters. This is a small attempt by us to try to solve their problems by opening up the digital world to them. To obtain information necessary to carry out normal day-to-day activities, this low cost real-time communication braille hand glove is one device which can immensely benefit the visually impaired people, who work in the computer environment. This concept will go a long way in helping them learn on an equal footing with their sighted counterparts.

Nowadays, many systems have been developed which can be interfaced to a computer to read text online which have taken over the old systems which involved cumbersome systems like keyboards and printers [2].

In our work we present a low cost, efficient and portable hardware design of a Braille hand-glove and a software application which can be used by the visually impaired people to read and write e-mails, read blogs as well as e-books. We have developed this system on the Braille platform since the visually impaired people are well versed with the Braille language. Many systems have been designed previously in this area like the Braille embosser which is a special type of impact printer which prints text in the form of Braille cells [3]-[7]. But these printers are more expensive and bulky compared to normal printers and also a special type of Braille paper has to be used for printing which is thicker and expensive compared to normal paper.

There are systems which have developed in recent years, which eliminate the use of the bulky Braille embossers and are cheaper and efficient compared to them [8]-[18]. But these systems allow the visually impaired person only to read or interpret the online text and does not have the feature which allows the person to write online text messages. Furthermore the system described in [12] consists of a similar design, but makes use of bulky electronic components like relays and hence separate relay driver circuit has to be designed for each relay which increases the overall cost and the size of the system. This system also misses on an important feature which allows the blind person to write e-mails and online text messages. All these factors were the motivation behind our work in this paper.

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In this paper, we describe a low cost Braille hand glove which is made up of six vibration motors which are placed on the five fingers and on the palm. If a person wants to read a character from the PC, then the character corresponds to a Braille code which is matched to the six vibration motors on the Braille Hand glove. Hence the vibration motors corresponding to the Braille code of the particular character vibrates and the character is read efficiently by the reader.

The innovative idea in this design is the reverse engineering process for the above problem i.e. it has a unique feature of typing messages through hand gestures of all the Braille codes. This is accomplished by using slot sensors on the five fingers of the glove and one on the wrist. Hence different hand gestures correspond to different Braille codes. These Braille codes are sent wirelessly to the PC where they are converted to display the corresponding alphabets, words and sentences. This acts as an effective two way communication tool in online chatting and new effective teaching methodology for visually impaired people.

This article is organized as follows. Section II deals with the matching of the Hand glove and the Braille cell; Section-III deals with a description of the proposed system; Section IV deals with the implementation of the system design; Section V provides the results; and finally Section VI states all Concluding Remarks followed by references.

II. MATCHING OF THE HAND GLOVE AND BRAILLE CELL

A braille cell is a rectangular cell consisting of six dots arranged in the form of a 3x2 matrix. These six dots allow sixty four different patterns of dot arrangement. Therefore, these dots arrangements can be used to represent sixty four different characters. The hand glove comprises of six slot sensors, five which are placed on the fingers and one placed on the wrist and six vibration motors, five of which are placed on the fingers and one is placed on the palm. Fig. 1 shows the one to one correspondence between the Braille cell and the hand glove.
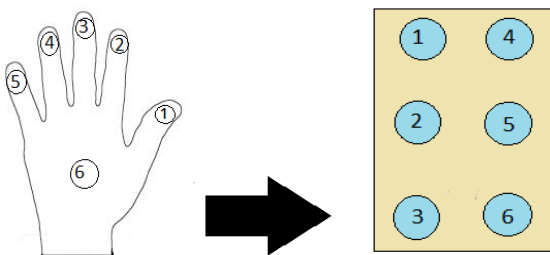

Fig. 1 Comparison between Hand glove and Braille cell

Now if the user wishes to read a character, say for example the letter to be read is 'c'. This letter is represented by the first and the fourth dot on the standard Braille cell. So the vibration motors placed on the first and the fourth finger of the hand glove will vibrate and the user will be able to read the letter 'c'. If the user wants to type a letter 'e', this is represented by the first and the fifth dot on the Braille cell. So the user will bend only his/her thumb and the last finger to type the letter

'e' successfully. Therefore the user does not require any special training for the hand gestures and the vibration pattern of the motors.

Fig. 2 shows the standard Braille chart which we have use the conversion of Braille to text. This is the basic Grade 1 Braille, which we have used here. This chart has all the alphabets both in the uppercase and lowercase, it has numbers ranging from zero to nine, comma and full stop. A space between characters is represented by no dotes on the Braille cell. Correspondingly on the hand glove it is sensed by vibration of none of the motors. To avoid inconvenience and confusion between the timing of the character and a space a time delay of five seconds is kept between two consecutive characters and the character is available for sensing for ten seconds. These time delays can be altered according to the requirement of the user.

Fig. 2 Standard Braille chart

III. DESCRIPTION OF THE PROPOSED SYSTEM

The proposed system can be divided into two modules. The first module is for receiving or reading online text from the PC which is done using the six vibration motors. The second module is for writing online text messages and emails which are accomplished by different hand gestures corresponding to the Braille code of the particular character to be typed using lower cost and effective slot sensors.

Fig. 3 shows the block diagram of the first module of the system. In this module the e-mails and online text is sent to the Graphical User Interface (GUI) on the PC. The American Standard Code for Information Interchange (ASCII) value of the character to be read is sent wirelessly from the PC to the Micro-controller using the wireless CC 2500 Radio Frequency (RF) Tran receiver module. The American Standard Code for Information Interchange (ASCII) value of the character sent from the PC is converted to the corresponding Braille code using a conversion algorithm. This conversion program is

written in an Embedded C language and it is recorded in micro controller of the hand glove.
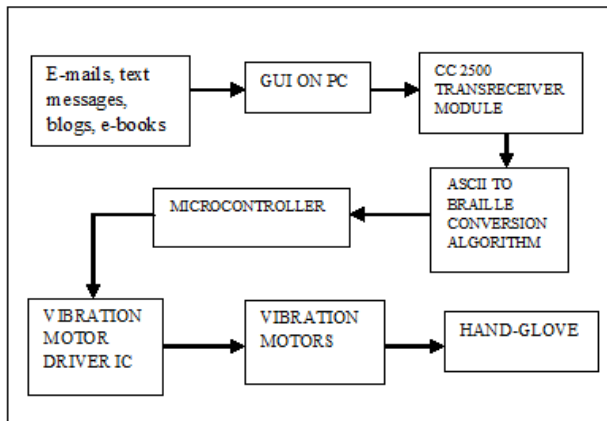

Fig. 3 Block diagram of the module for reading text

The microcontroller board used here is the ATmega8 development board by Technophillia Systems. The output of the microcontroller is taken from the general purpose input/output pins of the development board in the form of voltages that is either 0 Volts or 5 Volts. Since six vibration motors are used and the Braille cell contains only six dots, only six of the Input/output pins of the development board are used. A six bit number in binary/hexadecimal form is obtained from the output of the microcontroller corresponding to the Braille code of the character. The output from the six Input/output pins is further given to the vibration motor driver IC. This driver IC is used for voltage conversion which will be suitable for the safe operation of the vibration motor. The output from the driver IC is given to the six vibration motors fixed on the hand glove. Any visually impaired person can wear this glove and understand the English characters through the vibration of the motors. Similarly the whole word or sentence is converted into Braille vibration codes and sent to the hand glove.

Fig. 4 shows the block diagram of the second module of the proposed system. This module is meant for writing online text and replying to e-mails. This accomplished by using the low cost slot sensors for typing characters. To type a character, particular hand gesture is made corresponding to the Braille code of that particular character. The slot sensors are placed on the five fingers and one on the wrist so a total of six slot sensors are used which represent the six dots of the Braille sheet.

A mechanism is developed for the slot sensors such that when a finger is bent the slot sensor which is placed on the finger gets activated and produces an output high which is approximately 5 Volts. When the finger is in the relaxed state the sensor produces an output low which is 0 Volts. This slot sensor is connected in a resistor circuit which will be described in the later section. So if the user wants to type the letter 'a', which is represented only by the first dot on the Braille sheet, then the user will have to bend only his thumb to type the letter 'a'. Since the slot sensors give an analog output, the output is digitized by feeding the output to a comparator IC which is connected in a voltage divider configuration. Here the analog input to the comparator IC is compared with fixed reference voltage value and output given is either 1 or 0. Hence all the six slot sensors are connected to the comparator circuit and the output of the comparator circuit is a six bit number. These six digital values are further fed to the six Input/output pins of the ATmega8 development board. The microcontroller convert these six bits into the American Standard Code for Information Interchange (ASCII) value of the character to be typed. This is done using a conversion algorithm which is fed in the microcontroller. These values are wirelessly transmitted by using the wireless CC 2500 Radio Frequency (RF) module to the PC which is displayed on the Graphical User Interface (GUI) which is linked to the web pages and the internet. Hence the user can comfortably type text online and reply to his mails online.
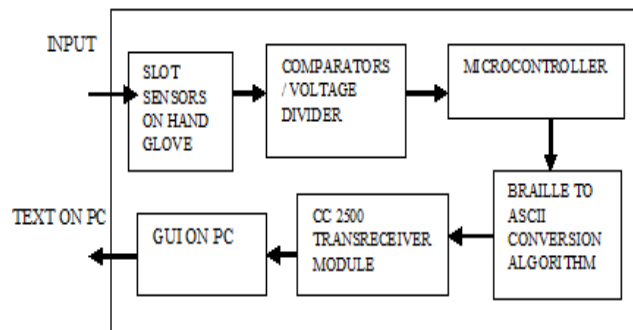

Fig. 4 Block diagram of the module for typing text

IV. IMPLEMENTATION OF THE PROPOSED SYSTEM

A. Hardware Implementation

The main challenge in this work was coming up with an innovative and low cost design of the hardware for the hand glove which would enable the visually impaired person to read as well as write online text and e-mails. Initially the idea was to use flex sensors for writing text and vibration motors for sensing the characters. But due to the lack of availability of 'velostat' a peizoresistive used for making flex sensors. Therefore the idea of using flex sensors had to be discarded and developing an alternate design for typing text was the main hurdle in our work. This was overcome by developing a simple and unique mechanism using slot sensors which could sense the bend in the fingers and would correspondingly change the output voltage. An electronic circuit for these slot sensors was developed.

Another problem which was faced was the interfacing of the vibration motors with the microcontroller development board. Since the operating voltage of the vibration motors is low, a circuit for safe operation of the motors had to be designed. This was taken care of by using the vibration motor driver IC DRV777 which gave a proper operating voltage for the vibration motors.

The electronic circuitry of the hand glove comprises of the following components and modules

1. Slot sensors
2. Vibration motors
3. Vibration motor driver IC
4. Comparator IC circuit
5. AVR Micro controller development board
6. CC 2500 Trans receiver (Radio Frequency module)
7. Power supplies

1. Slot Sensors:

The slot sensor used here is MOC7811. A slot sensor is an Opto-isolator module, with an Infrared (IR) transmitter & a photodiode mounted on it. It performs Non-Contact Object Sensing. This is normally used as a position sensor switch (limit switch) or as Position Encoder sensors used to find the position of the wheel. It consists of Infrared (IR) LED and Photodiode mounted facing each other, enclosed in plastic body as shown in Fig. 5.
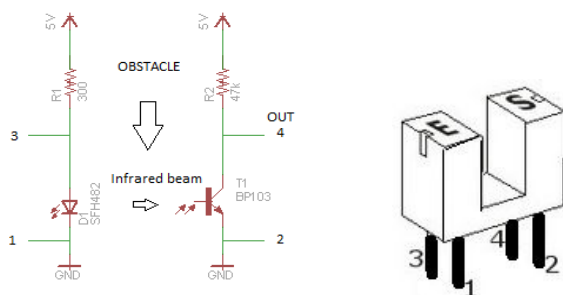

Fig. 5 Circuit diagram and pin configuration of slot sensor

When the light emitted by the Infrared (IR) LED is blocked by an obstacle logic level of the photo diode changes. This change in the logic level can be sensed by the microcontroller or by discrete hardware. The output given by the slot sensor is an analog output. One of the reasons for choosing these slot sensors was their low cost and simple design. A mechanism was developed for the slot sensors and mounted on each finger and the wrist which could sense the bends of the fingers and the wrist, which would eventually result in a change in the output voltage which was sensed by an external circuit.

2. Vibration Motors:

One of the main components is the vibration motor placed on the gloves. It is configured in two basic varieties i.e. coin (or flat) and cylinder (or bar). Here we have used the bar type vibration motors. These tiny motors have offset weights that make them vibrate when they spin. Movement of the weight attached to the rotor provides vibrations during operation. The amount of vibration produced is fairly proportional to the applied voltage. These motors are fixed on a coin for better mounting on the hand glove and are placed on each of the fingers and the palm.

They are normally called "pager motors" because they are the type found in pagers and cell phones that have a "vibrate" feature. They have wire leads attached that are color coded and pre-stripped on the ends. Since they are brushless motors they have a long life. Each one comes with a removable rubber boot that has one flat side for easy mounting.

The nominal voltage for these motors is about 3 V. The normal operating voltage for these motors is about 2.0~3.5 V and the rated current is about 85 mA. The nominal rotation speed of these motors is around 12000 RPM which is very effective. The very low voltage ratings of the motors results in less power consumption, which is one advantage of using these motors.

3. Motor Driver IC:

Since the vibration motors have a very low operating voltage a proper circuitry has to be designed to drive these motors without causing any damage to them. Since the motors are driven by the output of the microcontroller voltage has to be converted to a level suitable for driving the motors. Previous work suggests the use of relays and relay driver circuit for driving the motors as relays are used as switches [12]. Since we are using six vibration motors, six relays and six relay drivers have to be used which increases the overall cost and the size of the device.

To reduce the size and cost we have made use of DRV777 motor driver IC to drive the six vibration motors. This is available at a low cost and is very small in size. It is a 16 pin Surface mount device (SMD) package which has seven input and seven output pins. Hence all six motors can be driven by a single IC. Also the power consumption of the IC is on the lower side.

4. Comparator IC Circuit:

The slot sensors used here give an analog output. Since the slot sensors are to be interfaced to the microcontroller the output of the slot sensors is digitized by using comparator IC lm324. The output voltage of the slot sensor is compared with the fixed reference voltage which can be varied using a voltage divider circuit with a 100k ohm variable resistor. Fig.6 shows the schematic of the comparator circuit which is implemented with Eagle software. Therefore the output of the IC is either logic high or logic low. Another alternative to digitize the output was to use analog to digital converters, but these are very expensive, hence we opted for the former option.

5. AVR Microcontroller Development Board:

The AVR development board used in the proposed system is by Technophilia Systems. This board includes the following features.

- Atmel's ATmega8 Microcontroller with 8kb flash memory working at 16MIPS.
- On-board LCD interface (it can also be used for any other general purpose application).
- On-board Motor Driver for connecting 4 DC motors or 2 Stepper motors.
- On-board servo interface.
- PC interface through Universal Asynchronous Receiver Transmitter (UART).
- 21 general purpose Input/output pins.

- On board USB programmer.
- Dual or single power supply option.
- Exposed ISP pins for programming.
- MAX232 IC which takes care of voltage conversion needed for the communication between the PC's RS-232 (Serial/COM) port and AVR Development board.

The microcontroller development board is the processing unit of the proposed design. All the conversion algorithms for the system are stored in the microcontroller. This forms the control unit of the system. The slot sensors and the vibration motors have to be interfaced to this development board. Therefore, this is the most important component of the system.
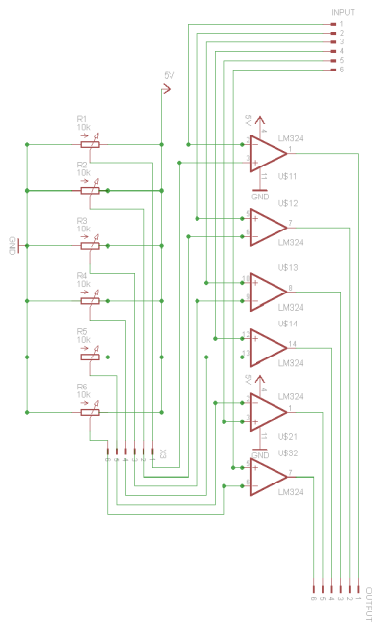

Fig. 6 Schematic of the comparator circuit

6. CC 2500 Trans Receiver (Radio Frequency Module):

The CC 2500 Trans receiver module is used for transmitting data wirelessly from the PC to the hand glove and vice versa. This wireless module has a range of up to 100 meters. This makes the hand glove portable, comfortable to use and eliminates the use of unnecessary wires and cables for interfacing the hand glove to the PC. The module consists of two parts, one is the transmitter and the other is the receiver. Both the transmitter and the receiver can be interchanged. This module transmits characters in the form of its American Standard Code for Information Interchange (ASCII) values.

7. Power Supply:

Power supply used in the circuit is a 9V DC battery. The microcontroller development board requires an operating voltage of 3.3 Volts and other electronic circuits involving different ICs like the comparator IC and the motor driver IC require a voltage of about 5 Volts. Therefore, we have designed voltage regulator circuits using some passive components and special voltage regulator ICs.

Fig. 7 shows the circuit diagram of a 5 Volt voltage regulator circuit. The IC used here is the LM7805 5 Volts, 3 pin voltage regulator. This is a low power, low cost IC.
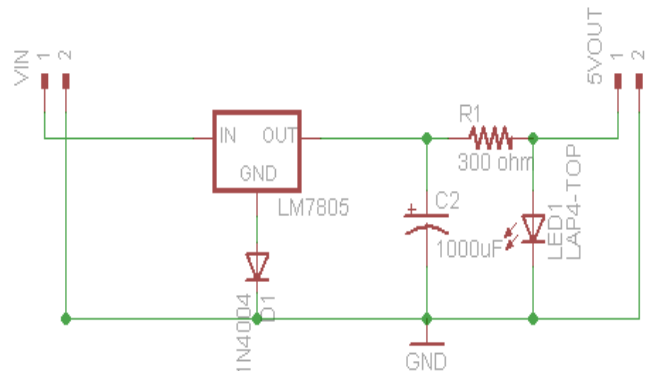

Fig. 7 Schematic of 5 Volt voltage regulator

Fig. 8 shows the circuit diagram of a 3.3 Volt voltage regulator circuit. This circuit comprises of capacitors and a special IC TLV1117 by Texas Instruments. This IC is an adjustable positive low-dropout voltage regulator capable of producing different output voltage levels, but we have used this for generating 3.3 Volts.
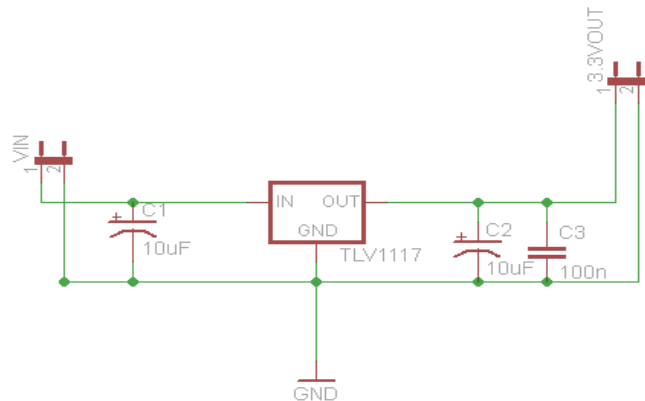

Fig. 8 Schematic of 3.3 Volt voltage regulator

B. Software Implementation

The Integrated Development Environment (IDE) used for the proposed system is AVR Studio for compiling and running the code on the ATmega8 development board. The conversion code for converting Braille to text and vice versa is written in Embedded C. The boot loader flashing tool used for burning the code on the development board is HID boot flash as shown in Fig.9. The HyperTerminal used for displaying the text is the FLASH MAGIC terminal with the help of which the RF module can transmit the text data in the form of its American Standard Code for Information Interchange (ASCII) values. This terminal displays the text to be read/written using the hand glove. This HyperTerminal is linked with Graphical User Interface which enables the user to link the text read/written to the internet.
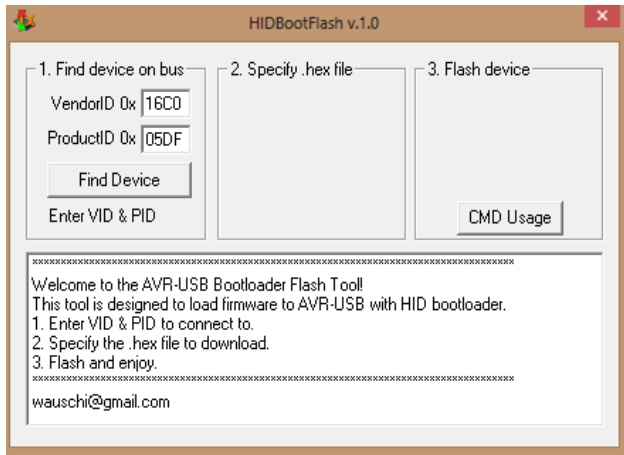
Fig. 9 HID Boot Flash for burning the code on the microcontroller

Fig. 10 shows the Graphical User Interface which is developed using MATLAB for reading as well as writing text online. This is linked to web pages and internet. The Graphical User Interface can also be made by using Code Composer Studio but using MATLAB is very easy and convenient.
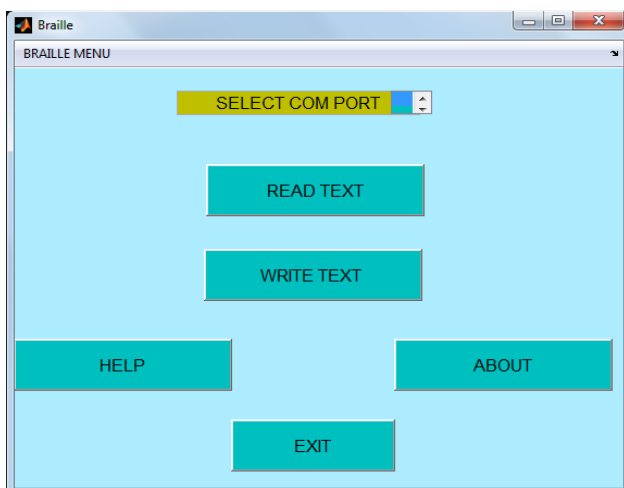

Fig. 10 Graphical User Interface for the system

V. RESULTS

The low cost Braille hand glove was tested visually impaired students from an NGO and they found it very comfortable to use it. Few students had some difficulties initially in reading the text because of the delay between the characters. Then the delay was increased slightly and the users found it very comfortable and accurate. The text transmitted from the PC can be received on the glove and the alphabet corresponding to the different combination of vibration motors can be easily identified. Similarly, according to the different braille hand gestures using slot sensors the corresponding alphabet is efficiently transmitted to the hyper terminal on the PC.

Figs. 11 and 12 show the prototype of the Hand glove which shows the vibration motors and the slot sensors respectively.

Fig. 11 Prototype of the Hand glove showing the vibration motors

Fig. 12 Prototype of the glove with the slot sensors

Fig. 13 shows the different electronic components and modules which are used in the developed system. The microcontroller development board, wireless Trans-receiver module and the Printed Circuit Board (PCB) for various electronic components used is shown.
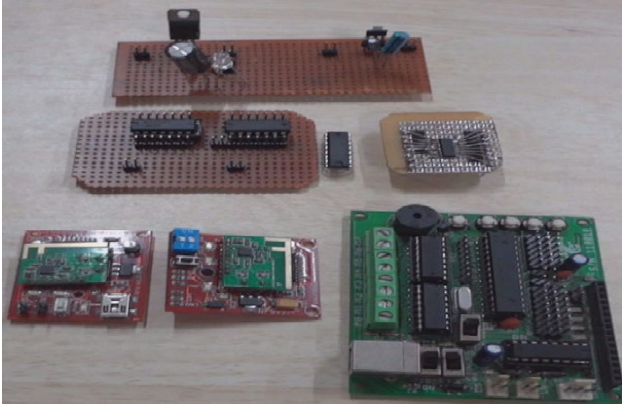
Fig. 13 Electronic components and modules used in the proposed system.

Fig. 14 shows the hardware implementation of the developed system. The prototype of the hand glove seen below is interfaced with the microcontroller and the computer.
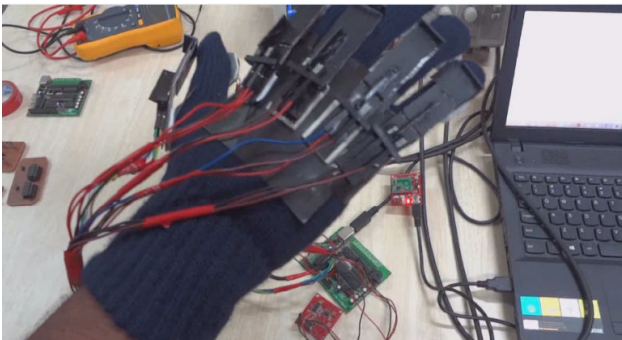

Fig. 14 Implementation of the proposed system

The complete working of the prototype hand glove can be seen from the following video link: http://www.youtube.com/watch?v=YayaQAAZCz0&feature=youtu.be

VI. CONCLUSION

The Braille Hand Glove can be successfully used to receive as well as transmit text data from the PC to the glove and vice versa based on the different standard Braille combination. In this project we have used Grade 1 Braille conversion chart. The efficiency of the glove can further be improved by using the Grade 2 Braille conversion chart, in which we transmit and receive an entire word for a particular Braille pattern and hence increase the speed of receiving and transmitting text with very good efficiency. This Braille Hand glove can also be used by blind people for other applications like opening web pages and reading E-books independently with the help of Graphical User Interface (GUI) from MATLAB and other Integrated Development Environment (IDE) like Code Composer Studio.

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