A Low Cost Wireless Braille System Hand Glove for Real Time Communication

Hasan U. Zaman, Khalida Sultana Shuravi, Muntasir Kabir Sakib, Mohammad Wasee Sarwar
Department of Electrical and Computer Engineering North South University, Dhaka, Bangladesh
hasan.zaman@northsouth.edu, khalida.shuravi@northsouth.edu,
muntasir.sakib@northsouth.edu, wasee.sarwar@northsouth.edu

***Abstract*—It is extremely difficult for people with visual impairment to acquire basic knowledge and vital information because of difficulty in communication. Out of 285 million visually impaired people, most are not able to get adequately involved socially because of poor access to knowledge and lack of easy communication. Braille is a worldwide accepted system for reading and writing for the visually impaired people. There are some electronic systems available for access to braille materials and literature, but most of them have lack of privacy issues and suitability for computer based interaction. In this paper, the design and implementation of a low cost wireless braille system hand glove have been described. Slot sensors and pager motors are used for writing and reading in Braille system, respectively, to communicate using computers with billions of people in the virtual world. Using this communicating device, by simple hand gestures or by sensing vibration on fingers, one can write to or read from a computer, respectively, all English Language characters in Braille system. The device is low cost and effective and operates in real time.**

Keywords— braille; hand glove; slot sensor; vibration motor; arduino nano

I. INTRODUCTION

Braille code language has got immense response since its invention in the 1800s for the visual impaired people. It was called Grade 1 Braille system back then. It took approximately one hundred years for the system to upgrade to Grade 2. To get involved in basic and vital information necessary for living, visually impaired people find it extremely hard. By adding another hundred years, we can say the internet has become a fast access to effective and essential tool for gaining vital educational information. Nowadays, the internet has become the most important and suitable education media in this fast developing modern world.

According to world blind union, about 285 million people over the world are blind, which ratio is a substantial part of the overall population around the globe. They encounter a lot of issues in their daily life because of blindness. But they also deserve equal rights to gain knowledge and take the highest degree in education. Whereas their learning capabilities about latest technologies are drastically low. They have to rely on very rigid techniques such as finger Braille, manual alphabets and the print on palm method etc. All of these conventional methods are inefficient, boring, and slow which are not suitable to cope up in the virtual world. As a result, they are still not able to get introduced to the information hub, the internet. Some of the most important parts of our live has become text messaging, internet blogging, emailing, reading e-books etc. and unfortunately the visual impaired people are discriminated from such facilities. Braille system has a wide range of different characters by which they can read texts only. Our attempt to have built this device is to not only read text but also for them to write in a very simple hand gesture.

Our concept of Braille reading and writing enhance the real time communication and this will help millions of visually impaired people to go beyond their capabilities. This system is wireless and can be used anywhere in the world.

II. RELATED WORK

Over the years, there have been about hundred or more electronic systems built with facilities and are developed to favor the visual impaired people. One of such devices includes the Electronic Progressive Braille Learning Kit for Blind. The authors N. Jadamali et al. have written in their paper about this braille keypad where the user can learn braille language by tapping the pad. It is a very small device where it is quite hard to press by one finger [1]. Compared to this system, our device is more prominent for the user to use because it is a hand glove which does not let the user to tap or hold anything to read or write.

Another system we can compare our device with is Text to Braille Converter. In their paper, the authors have mentioned that they have included PIC micro-controller, flex sensors and much other equipment to build their device. This device helps the user to bend their fingers so that their different combination of the finger gestures are converted to Braille code and then displayed as characters on the screen [2]. Whereas in our device, we have included Arduino micro-controller, which is the most available micro-controller, and slot sensors, which are low cost and efficient for writing the braille language and a little finger gesture is needed to initiate the process.

Our use of vibration motors to read texts are similar to another system about which has been written by the authors M. Rajasenathipathi et al. in their paper. They have explained that the system uses braille database to design the reading process of the braille hand glove [3]. However, their data storage system seems extremely clumsy and their techniques of converting the text to braille values are far different from ours. We have just simply coded our values.

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III. THEORY

The goal of our system is to help the blind people write as well as read texts instantly which enhances the real time communication. Braille symbols can form within the units of space which are called braille cells. Fig. 1 shows the representation of how we have synchronized the hand glove with the braille cell. The whole braille cell contains six raised dots arranged in two parallel rows. The rows have three dots each. By numbers from one through six, the dot positions can be identified. Using one or more of these six dots, sixty-four combinations can be created. To represent an alphabet, punctuation mark, number or even a whole word, a single braille cell is used.

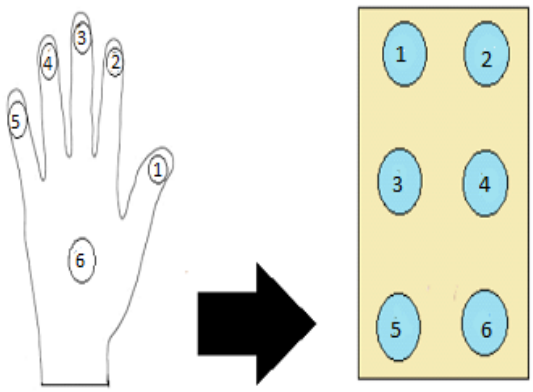

Fig. 1. Synchronization of the braille cell with the hand glove.

Our system has two modules: Reading and Writing. For the reading module, we have set up vibration motors on the hand glove in such a way so that the reader feels or senses the vibrations when the desired word or alphabet is to be read which synchronizes the combinations of the motors set to vibrate. For typing or writing messages, we have included slot sensors on the hand glove which give analog output to the micro- controller by different hand gestures and those values give different combinations of corresponding braille codes. Fig. 2 shows the Grade 1 Braille codes on which we have primarily worked.

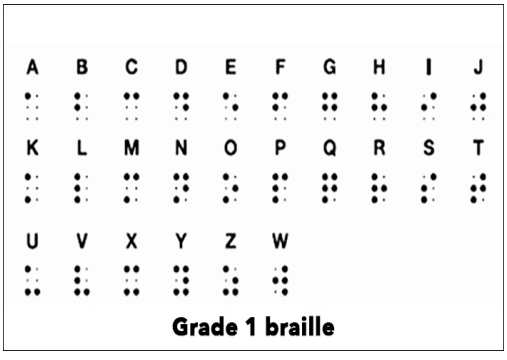

Fig. 2. Grade I Braille Code.

Fig. 3 shows the relation of ADC value with voltage. It shows how we have developed the simple equation by which basis we have prepared our code for the writing module of our system. We have developed this technique for our code such that when the obstacle is placed between the slots, the analog voltage we get is around 4 V to 4.7 V and when the obstacle is removed, the voltage becomes around 2 V to 2.9 V or below 3 V. So, we set up our code for writing in such a way that if any of the braille pins give output voltage bellow 3V and it satisfies any combination of word or letter then it prints the word or letter on the display of the screen.

Let,

ADC Reading = α V

Analog Voltage Measured = 434

Our equation developed is:

$$\frac{\text{System Voltage}}{\text{Resolution of the ADC}} = \frac{\text{ADC Reading}}{\text{Analog Voltage Measured}}$$

So,

$$\frac{5\ V}{1023} = \frac{\alpha}{434}$$

$$\alpha = 434 \times \frac{5\ V}{1023}$$

Therefore,

$$\alpha = 2.121\ V$$

Fig. 3. Equation with example showing the relation between ADC value to voltage prepared in Microsoft word.

The electronic components the hand glove contains are as follows:

- Micro-controller – Arduino Nano
- Hand glove – Gym glove
- Slot sensors – TCST 2103
- Vibration motors – Pager Motors
- LED lights – Green
- Transceiver – Bluetooth HC05 Module
- Power supplies – 9V Battery, wires etc

To carry out daily activities for obtaining various information, sensor based braille hand glove can highly benefit the blind people to work in modern era.

IV. SYSTEM DESIGN, IMPLEMENTATION & OPERATION

There are two types of modules consisting of the basic block diagrams. One of the modules is reading or receiving the text or characters which will end up with the pager motors or vibration motors [Fig. 4]. Another module is the writing or texting part which is done by the finger gestures with the help of slot sensors [Fig. 5]. The gestures will follow the Braille-1 standard form combination for every word.

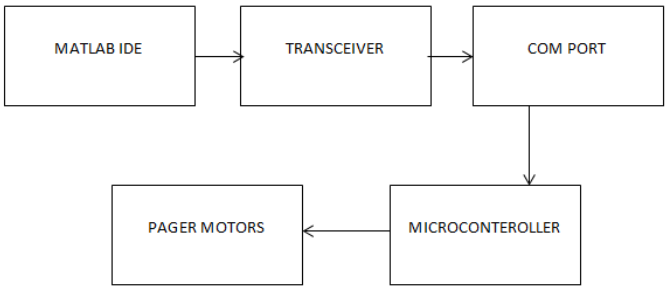

Fig. 4. The block diagram shows the Reading module.

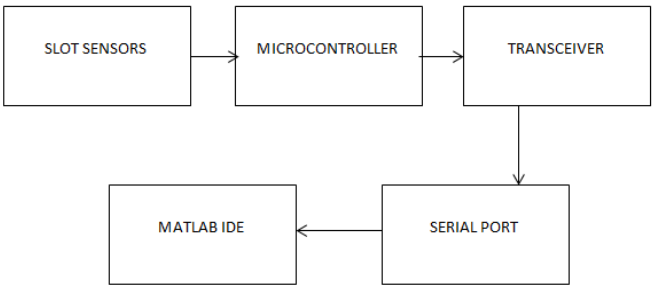

Fig. 5. The block diagram shows the Writing module.

We have drawn two necessary flow charts which include the reading [Fig. 6] and writing module [Fig. 7].

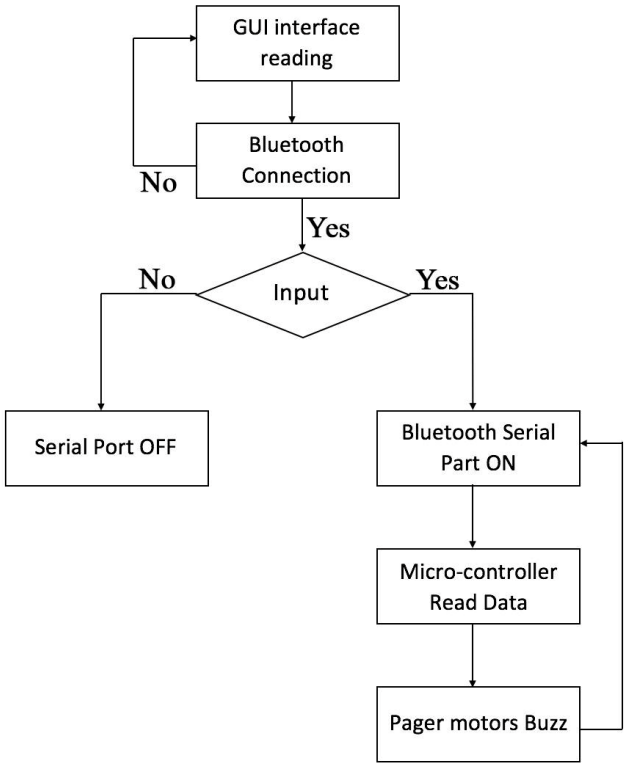

Fig. 6. The flow chart shows the Reading module.

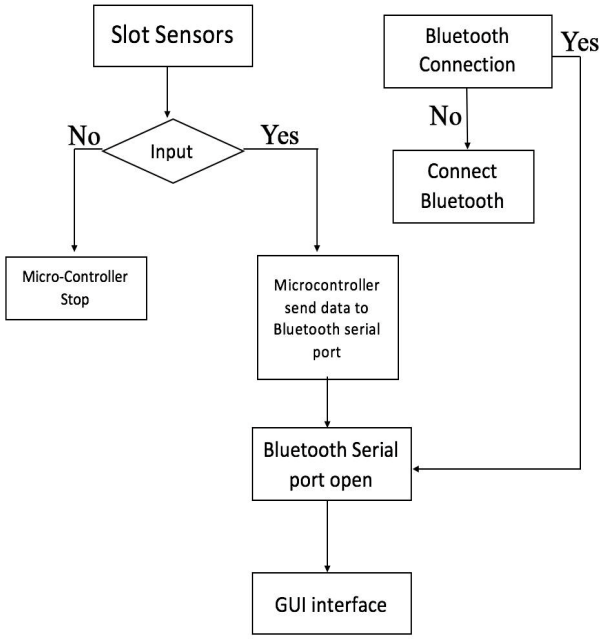

Fig. 7. The flow chart shows the Writing module.

V. COMPONENTS USED

Our innovation in this design is that, we are using Arduino as a micro-controller because it is a ready-made platform, very reliable and easy to use compared to few other micro-controllers. We are also using slot sensors instead of flex sensors to increase the efficiency of the device. Apart from these, we have tried to make the hand glove as light weighted as possible so that the user does not feel uncomfortable.

A. Micro-controller

Micro-controller is the intermediate CPU for the system which will save all the possible algorithms for the conversion that will take place. In this case, we used Arduino Nano. To form the main control unit, the pager motors and slot sensors need to be connected wirelessly with the micro-controller. Hence, this will be the main cell of our Braille System.

B. Slot Sensors

We have used TCST2103 slot sensors in this device. This change in the logic level will be sensed by the micro-controller or any other discrete hardware. The hand glove system contains six slot sensors in total. Each finger is being fixed with each slot sensor and sixth one is placed on the wrist. These slot sensors will provide analog outputs which are converted to the voltage values via the Arduino micro-controller. Depending on this voltage level we have mapped our alphabets.

Generally inside the Arduino micro-controller, there is a circuit called an analog to digital converter or ADC. It reads the change of the voltage and then converts it to a specific number between 0 and 1023. When the shaft is turned all the way in one direction, there is a 0 volt going to the pin and the

input value is also 0. When the shaft is turned all the way in the opposite direction, 5 volts go to the pin and the input value is then 1023. In between, the Arduino function "analogRead()" always returns a number which is in between 0 and 1023. This number depends on the amount of voltage being applied to the circuit [4]. The ADC reports a ratio-metric value which means that the ADC assumes 5V as 1023 and anything less than 5V will be a ratio between 5V and 1023 [5].

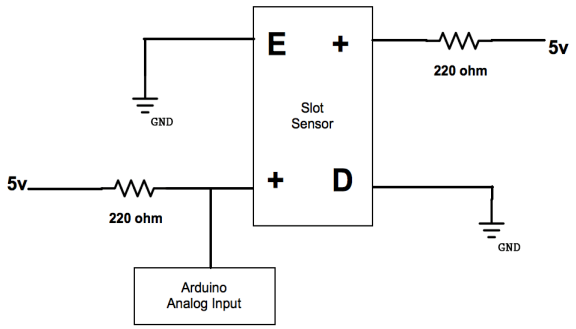

Fig. 8. Circuit connection of TCST 2103 Slot Sensor.

The slot sensor has D and E with two positive (+) sides [Fig. 8]. Both E and D are connected to the ground. The positive portion of D side is connected to the micro-controller's analog input via the 220ohm resister. Whereas, the other positive side is connected to the 5V pin via 220 ohm resistor. The ADC reports a ratio-metric value which means that the ADC assumes 5V as 1023 and anything less than 5V will be a ratio between 5V and 1023 [5].

C. *Vibration Motors*

The vibration motor is one of the main components for the reading part. We have implemented our project with cylinder type vibration motors. These motors have offset weights which help them to vibrate while spinning. Offset weights are attached with rotor that provides vibration at the time of operation. The total vibration amount is same as the applied voltage. Over all, six vibration motors are needed for reading module to work. The sixth one is placed on the palm.

D. *Transceiver Module*

For smooth and comfortable wireless transmission and reception between the computer and the hand glove, a Bluetooth module is used. For this device, HC-05 Bluetooth module is used. We have used 4 of its pins. GND and VCC used power transfer. Txd is used for transmitting data and Rxd is used for receiving data.

E. *LED lights*

We are attaching the LED lights with the vibration motors to know whether all our connections to the pager motors are working properly. However, this mechanism only favors the people who can fix any problem with the device. This is not applicable for the blind people.

F. *Power Supply*

For power supply we have used 5V from the Arduino for most of the equipment such as pager motors and slot sensors. The 5V power actually comes from a 9V battery attached in the circuit board of the device.

G. *Software Implementation*

We have used a MATLAB Graphical User Interface (GUI) for both of the reading and writing parts. The microcontroller is connected to the GUI interface via the Bluetooth module. In our interface there is a button named "CONNECT" which connects the GUI interface with Bluetooth Component.

For wireless transmission of data for the reading portion, whenever any character is sent from the interface, 8 bits of the character go to the serial port of Bluetooth module as an ASCII value and the Rxd pin of the Bluetooth chip immediately reads the data and sends it to the microcontroller. The microcontroller converts the ASCII value in character value automatically and checks which character has been sent. Depending on the character input, the microcontroller sends the character combination of the braille system to the pager motors. Depending upon the combinations, the pager motors vibrate and the user knows which word has been sent.

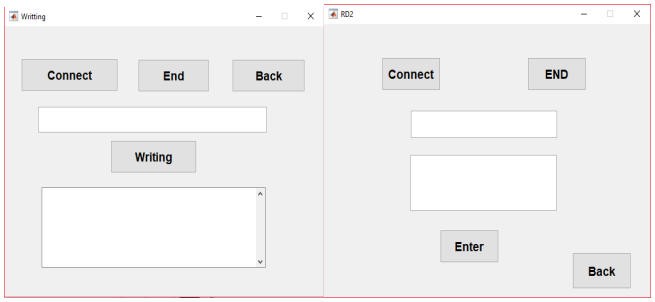

Fig. 9. Graphical Interface Unit (GUI) for the Reading (right) and Writing (left) system.

The writing module starts from the slot sensors and ends up in GUI interface. Slot sensors give their outputs in Analog. When the user provides hand gestures, the microcontroller reads the analog input and converts it to a voltage value. It then checks which pins are below 3.00 and whether any pin satisfies the character combinations for the the braille system that are programmed in our microcontroller. This module also communicates via the Rxd and Txd port of the Bluetooth chip. Before the communication takes place, the GUI interface has to be connected with the Bluetooth chip. As the GUI ensures secure connection, the whole module gets ready to communicate. If any combination satisfies the input then the microcontroller sends the corresponding character to Txd pin of Bluetooth chip in ASCII 8 bit form. This Txd sends the 8 bit form of the character to PC Bluetooth serial port. From the serial port GUI interface scans the ASCII value and transforms it to character. In the end, it prints the character in the textbox.

VI. Results and Discussion

The user can use the hand glove for reading and writing any character or word based on different Braille system.

Micro-controller will decide which word to be printed or which word combination is to be buzzed. For the reading part first micro-controller will read the serial input and convert it to the standard Braille-1 combination form, and depending on the word combination it will signal the corresponding pager motor. User will sense the pager motor buzz and realize the combination of the word.

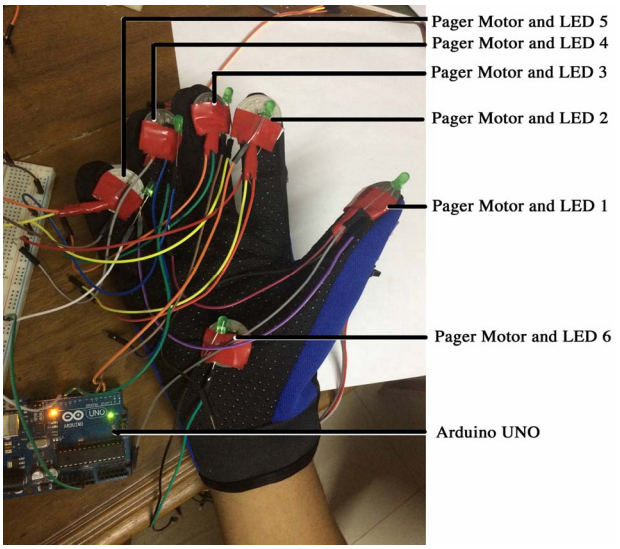

Fig. 10. This prototype of the reading module shows the vibration motors connected with the micro-controller mounted on the hand glove.

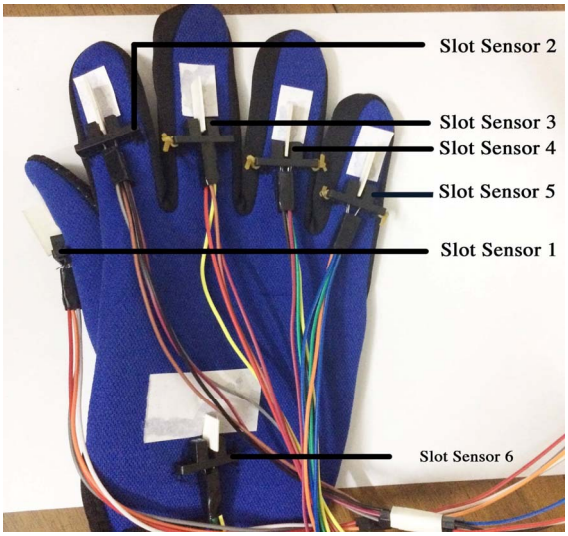

Fig. 11. This prototype of the reading module shows the slot sensors connected with the micro-controller mounted on the hand glove..

On the other hand, the writing part is little bit complex then reading part. For writing user will have to give input pin combination of any word from Braille-1 standard chart. User has to bend their finger depending on word combination and the slot sensor will read the input. Then it will read by the micro-controller which will immediately print the word in PC monitor.

For example, in Fig. 13, the Pager Motors and LED 2, 3 and 5 vibrate and lit respectively when the character "S" appears on the display [Fig. 12]. In Fig. 14, the fingers 2, 3 and 4 is bent for the respective slot sensors to send information in the PC to display the character "J" [Fig. 15].

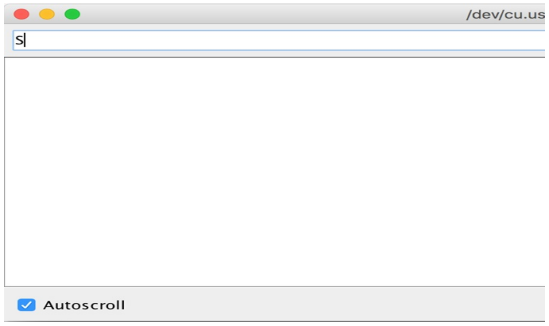

Fig. 12. This display shows the character "S" being entered.

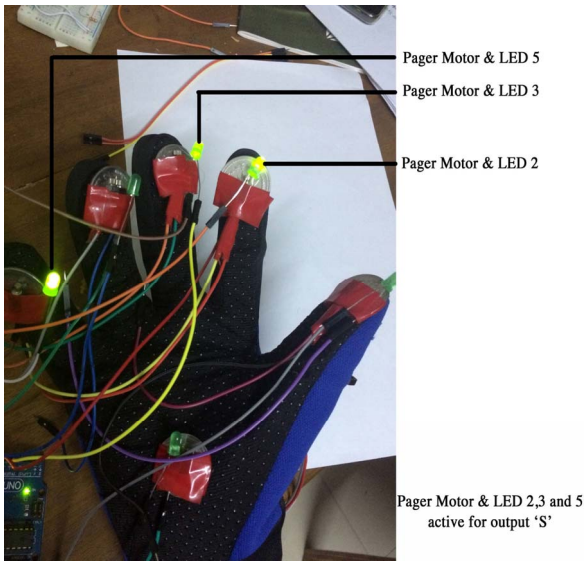

Fig. 13. This prototype of the reading module shows the LED lights 2, 3 and 5 lit for for the respective vibration of the motors for the character "S".

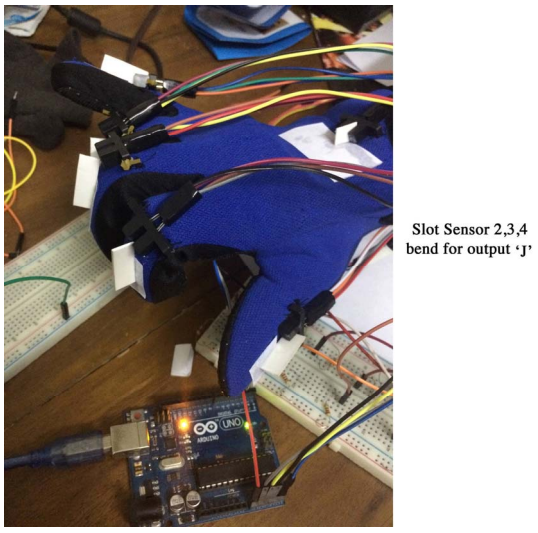

Fig. 14. This prototype of the writing module shows the hand gestures for the character "J" to be appeared ont the screen.

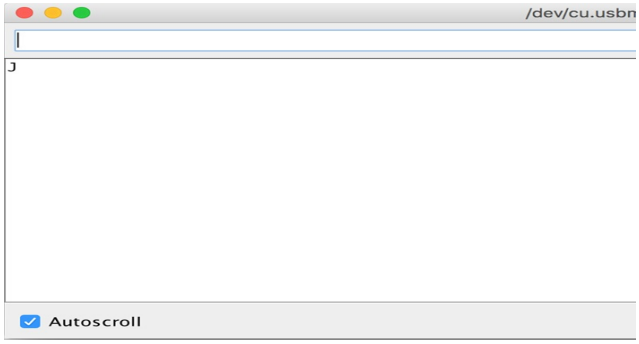

Fig. 15. This display shows the output character "J" coming out as a result of the hand gestures.

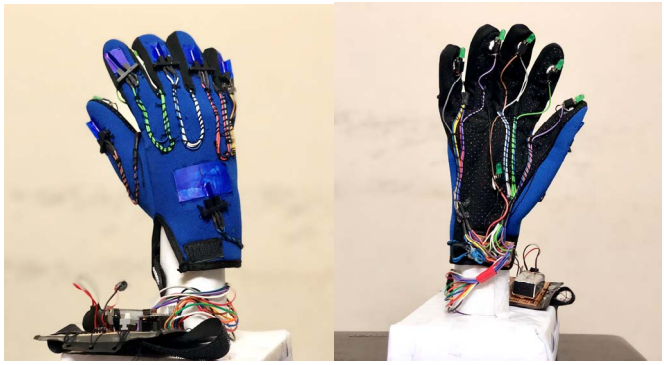

Fig. 16. The final design of the whole system with wireless connectivity (Wired connections removed). Back view (left) and Front view (right).

Braille hand glove will work as an intermediate media for communicating via PC. It will make communications easier for the people who are visually impaired. Hand Glove Braille System might be complex at the beginning but it will be easier to use day by day. Depending on the efficiency and ability of the users, they can use higher version of the Braille Codes.

VII. Conclusion

The Braille System Hand Glove can be very useful for implementing different standard Braille combination, which will receive and transmit data from glove to the computer and vice versa. We have used basic Grade-1 Braille system for our project. The Glove will be more efficient by implementing Grade-2 Braille combination in which user can receive and transmit data of individual Braille text pattern and the speed of the transmission and reception of data will be increased depending on user efficiency. We also implement a Graphical User Interface (GUI), which will help the blind people can use the hand glove for reading e-books or opening browser pages independently.

VIII. Future Work

We will look forward to make this system work for Grade 2 and Grade 3 Braille codes. We will plan for making this system more flexible to the users, especially for the alignment of slot sensors on the hand glove. We will be designing a cover which will protect the obstacles from any risk of breaking or damaging. Since this device is maintained to be low cost, we will also try to maintain these criteria.

Acknowledgment

We would like to express our special thanks to our faculty Dr. Hasan U. Zaman sir without whom this project would never have been successful.

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