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**Research Article**

# A New Approach for Hardware Control Procedure Used in Braille Glove Vibration System for Disabled Persons

[1]B.L. Shivakumar and [2]M. Rajasenathipathi
[1]Department of Computer Applications, Ramakrishna Engineering College, Coimbatore, India
[2]Department of Computer Applications, NGM College, Pollachi, India

**Abstract:** To help the deaf and blind people benefit from the latest computer technology, by means of a vibrating hand glove, this is connected to a computer using hardware control procedures and a screen input program for communication purposes. The vibrations in six different positions in the hand glove match the Braille code. So the blind person can understand the characters of English language. In this study it explains the software design of English text to Braille code conversion, Hardware design of Braille Hand glove, Braille equivalent vibrations in six different positions in the Braille glove using hardware control procedure numbers and how it is tested using Chi-square test. Braille is an important language used by the visually impaired to read and write. It is vital for communication and educational purposes. This study puts forward the new idea for the benefit of deaf and blind people, who prefer to work in computer environment.

**Keywords:** Electronic, finger tips, motor, sensation, signal, translator

## INTRODUCTION

All over the world, persons who are visually impaired have used Braille as the primary means of accessing information. Also, the concept of Braille has been accepted as a universal approach that works across the boundaries of the world. Different countries of the world have adapted the system of Braille to suit their languages. Irrespective of these changes or modifications, visually disabled persons understand standard Braille for the English language making it possible to exchange information in a consistent fashion across different countries. Standard Braille is an approach for creating documents which could be sensed through touch. This is accomplished through the concept of a Braille cell consisting of raised dots on thick sheet of paper. Also there are several communication methods that involve tactile sensation, such as Braille-Based touch screen Device (Parinyarat *et al*., 2013), Braille text on a finger using Braille pin method (Shahab and Violeta, 2013), portable Refreshable E-Braille (Raja *et al*., 2013) and Braille emulator method (Deepak and Mohammed, 2011). However, some problems arise in such conversion, like lack of privacy for deaf and blind people, complexity operation and mismatch for computer environment. Also visually impaired person having problem like long term diabetics often have a condition known's as "diabetic neuropathy" (Hassan and Mohammed, 2011), a circulatory problem causing many of the complications that the diabetics might encounter. Neuropathy causes not only insensitivity in the fingertips and toes; it causes more blindness, kidney failure, heart attacks and other related medical problems. The continuous readings in Braille produce swelling in the ankles which cause reading times to be very slow (Boaz, 2013). Up to now for reading and getting information the blind people have been relying on printed Braille sheets, which have protrusions on the printed sheet in a set pattern. This system intends to revolutionize the method of a communication for blind people by using the vibrating hand glove, which vibrates at six different places corresponding to the six positions in a Braille sheet used for denoting various characters. A normal person who wants to communicate with a blind person, types the keyset into an input screen of the software tool. The software program converts the text into ASCII values and activates the corresponding vibration in the hand glove. This procedure makes it an easy and fast method for blind people to receive information (Santanu *et al*., 2013).

**Characteristics Braille system:** People who have both sight and hearing impairments are known as deaf and blind. Because of their impairments they face many problems in their normal daily life. It is particularly difficult for totally deaf and blind people to acquire vital and sufficient information necessary for daily living, compared with sighted hearing people. In standard Braille, the concept of a Braille cell consisting

**Corresponding Author:** B.L. Shivakumar, Department of Computer Applications, Ramakrishna Engineering College, Coimbatore, India

Fig. 1: Braille sheet

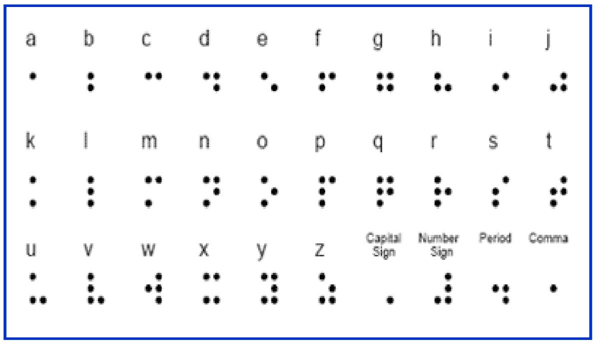


Fig. 2: English alphabets

of raised dots on thick sheet of paper as mentioned in Fig. 1. The protrusion of the dot is achieved through a process of embossing. A visually impaired person is taught Braille by training him or her in discerning the cells by touch, accomplished through his or her fingertips. The image below shows how this is done.

Each arrangement of dots is known as a cell and will consist of at least one raised dot and a maximum of six. The visually impaired person can touch the raised position of each Braille cell from left to right in the Braille sheet using their fingertips and understand the equivalent English letter value. Braille uses a group of six raised dots which are arranged in a matrix of three rows to two columns. Theses ixpositions (raisedor flat) are used in combination to give 64 ($2^6$) different Braille characters. This clearly means that there is a one to one correspondence between Braille characters and English text (Blenkhorn, 1995). The formation of English alphabets as follows:

The Fig. 2 represents the Braille symbols for English small letters. Similarly English capital letters, numbers and symbols are constructed using different combination Braille dots.

## METHODOLOGY OF THE SYSTEM

Braille is a method of representing characters through a pattern of raised dots so that the blind can read by the sensation of touching. Written communication between two people is an easy task provided that they can both read and write the same language. So the methodology of the system is "To design a translator for converting English text to Braille code and this Braille code into vibration signal". The methodology of invention for Braille Hand Glove vibration is to investigate a novel approach to computerize the conversion of English text to Braille Code and on to vibration. The software screen design is used to get the input of visible person typed information.

It can be designed as follows:

Figure 3 shows the Braille Input screen. It accepts the user typed information as input and converts input English text to Braille code using Braille database. The converted Braille code is passed to hardware algorithm and is written in HIGH TECH C language.


Fig. 3: Screen layout for Braille code

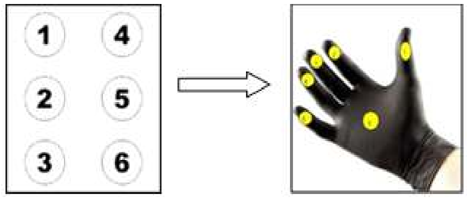


Fig. 4: Hand glove with six positions

**Braille hand glove vibration system:** The design of a Braille Hand glove, comprises of a majority of electrical components, the design aims to produce a product to perform vibrations in six positions of a blind person's right hand. A low cost and robust design will provide the blind person with an affordable and reliable tool as it gives a new technique and communication method for blind persons.

The Braille glove is constructed with six vibration motors. These are fixed in five fingers and the centre of the palm positions of the glove as mentioned in the Fig. 4 (Thumb finger is assigned to Braille value 1, fore finger is assigned to Braille value 2, Centre finger is assigned to Braille value 3, Ring finger is assigned to Braille value 4, little finger is assigned to Braille value 5 and centre palm is assigned to Braille value 6). The basic technique used in the hand glove is based on retrieving value of the English letter typed in the keyboard. It is converted into ASCII value and it is passed to a hardware program. This program matches the corresponding procedure number and activates the

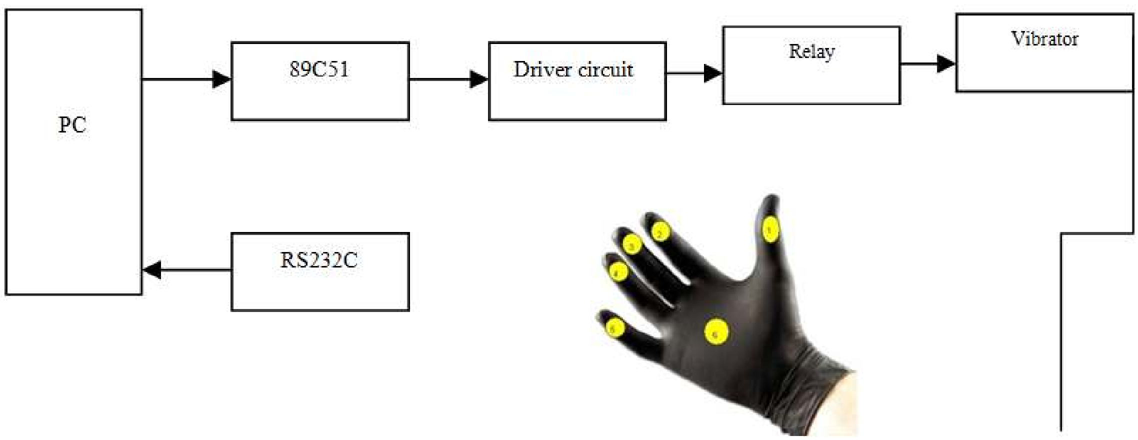


Fig. 5: Block diagram of hand glove vibration system

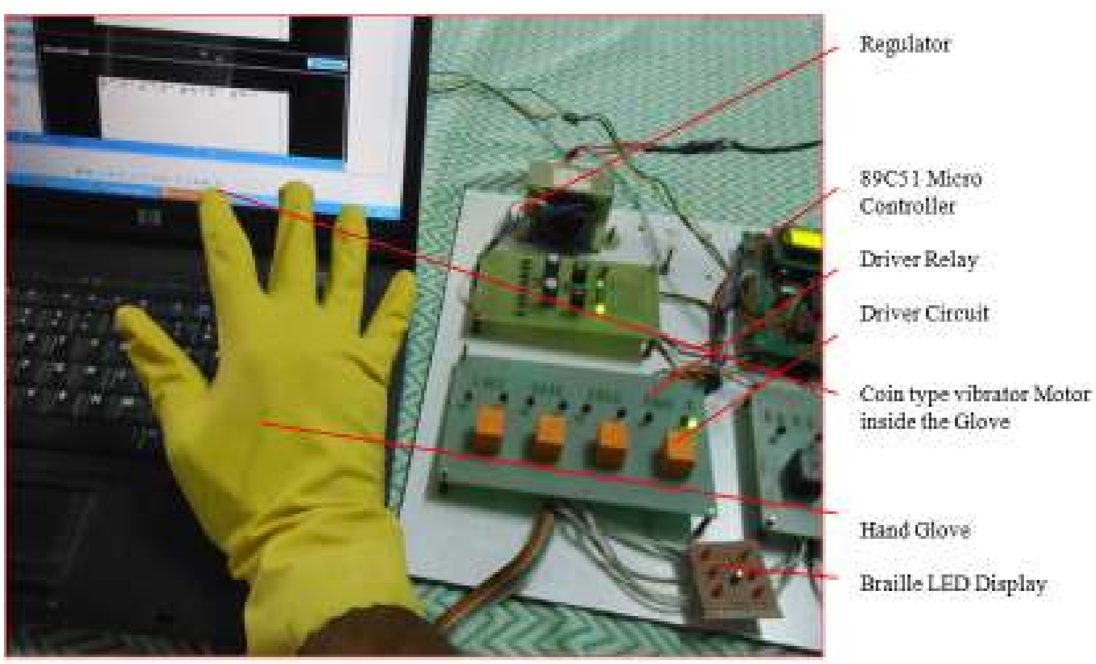


Fig. 6: Hardware prototype for Braille hand glove

binary number. The presence of 1's in a six digit binary value is nothing but rising position of the Braille symbol. So based on the position of vibration the blind person can sense the value of the letter. This conversion program is written in HIGHTECH C language and it is recorded in the micro controller of the hand glove. Any blind person can wear this glove in right hand and understand the English letters through vibration instead of touching the Braille sheet. Similarly the whole word or sentence is converted into Braille vibration and sent to the blind person. Based on this method the visible person and deaf and blind person can communicate effectively.

The Braille Hand glove comprises of the following key components (Fig. 5):

- Transformer (power supply)
- Voltage regulator-LM78XX
- RS232C -DB9
- 4.89C51 micro controller
- Driver circuit
- Driver relay
- Vibrator motor

Based on the key components Braille glove is constructed and its hardware prototype is mentioned in Fig. 6.

**Hardware algorithm used in Braille hand glove:** The Hardware algorithm used in the hand glove is based on the retrieval value of the English letter as an ASCII value from what the user types in the software tool as mentioned in Fig. 3. The ASCII value is applied to 89 procedures and it activates the corresponding vibration motors as follows:

- Store the mode of vibration (serial/parallel), default mode is serial mode.
- Read the input values one by one and convert it into corresponding ASCII value up to the NULL (enter key) value.
- Converted ASCII value is applied to 89 procedures as per the following conditions:
    - If the Input value is between 'a' to 'z' (ASCII Value 97 to 122) then corresponding ASCII procedure number is activated and the appropriate vibration is produced in the hand glove.
    - If the Input value is in special symbol list (ASCII Value 33-47, 58-64 and 123-126) then corresponding ASCII procedure number is activated and the appropriate vibration is produced in the hand glove.
    - If the Input value is between 'A' to 'Z' (ASCII Value 65 to 90) then procedure number 44 and corresponding ASCII procedure number is activated and the appropriate vibration is produced in the hand glove. (Capital letters are initiated by placing a dot in the 6th position of the Braille cell so procedure number 44 vibrates the 6th position of the hand glove).
    - If the Input value is between '0'to '9' (ASCII Value 48 to 57) then procedure number 35 and corresponding ASCII procedure number is activated and the appropriate vibration is produced in the hand glove. (Numbers are initiated by placing a dot in the 3, 4, 5 and 6th position of the Braille cell so procedure number 35 vibrate the 3, 4, 5 and 6th position of the hand glove).
    - If the Input value is blank (ASCII value 32) then corresponding ASCII procedure number is activated and the appropriate vibration is produced in the hand glove.
- Repeat step 3 until all the characters of input values are matched with ASCII procedure numbers.

Table 1: ASCII-Procedure number for lowercase alphabets

| | | | Binary Braille representation | | | | | |
|---|---|---|---|---|---|---|---|---|
| P. No. | Char. | ASCII value | D6 | D5 | D4 | D3 | D2 | D1 |
| 1 | a | 97 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2 | b | 98 | 0 | 0 | 0 | 0 | 1 | 1 |
| 3 | c | 99 | 0 | 0 | 1 | 0 | 0 | 1 |
| 4 | d | 100 | 0 | 0 | 1 | 0 | 1 | 1 |
| 5 | e | 101 | 0 | 0 | 1 | 0 | 0 | 1 |
| 6 | f | 102 | 0 | 0 | 1 | 0 | 1 | 1 |
| 7 | g | 103 | 0 | 1 | 1 | 0 | 1 | 1 |
| 8 | h | 104 | 0 | 1 | 0 | 0 | 1 | 1 |
| 9 | i | 105 | 0 | 0 | 1 | 0 | 1 | 0 |
| 10 | j | 106 | 0 | 1 | 1 | 0 | 1 | 0 |
| 11 | k | 107 | 0 | 0 | 0 | 1 | 0 | 1 |
| 12 | l | 108 | 0 | 0 | 0 | 1 | 1 | 1 |
| 13 | m | 109 | 0 | 0 | 1 | 1 | 0 | 1 |
| 14 | n | 110 | 0 | 1 | 1 | 1 | 0 | 1 |
| 15 | o | 111 | 0 | 1 | 0 | 1 | 0 | 1 |
| 16 | p | 112 | 0 | 0 | 1 | 1 | 1 | 1 |
| 17 | q | 113 | 0 | 1 | 1 | 1 | 1 | 1 |
| 18 | r | 114 | 0 | 1 | 0 | 1 | 1 | 1 |
| 19 | s | 115 | 0 | 0 | 1 | 1 | 1 | 0 |
| 20 | t | 116 | 0 | 1 | 1 | 1 | 1 | 0 |
| 21 | u | 117 | 1 | 0 | 0 | 1 | 0 | 1 |
| 22 | v | 118 | 1 | 0 | 0 | 1 | 1 | 1 |
| 23 | w | 119 | 1 | 1 | 1 | 0 | 1 | 0 |
| 24 | x | 120 | 1 | 0 | 1 | 1 | 0 | 1 |
| 25 | y | 121 | 1 | 1 | 1 | 1 | 0 | 1 |
| 26 | z | 122 | 1 | 1 | 1 | 1 | 0 | 1 |

**Implementation of hardware control procedure in Braille hand glove vibration system:** Each 89 ASCII hardware procedure numbers are linked with six digit binary numbers in an array. The presence of 1's in a six digit binary value is nothing but rising position of the Braille symbol. So the presence of 1's in a six digit binary value activates the corresponding vibration motors in the hand glove.

The 89 hardware procedures are classified as follows:

- Lowercase values 'a' to 'z' ----- 26 procedures
- Simples ----- 26 procedures
- Digits '0' to '9' ----- 10 procedures
- Uppercase 'A' to 'Z' ----- 26 procedures
- Blank space ----- 01 procedure
- Total ----- 89 procedures

Table 2: ASCII-procedure number for symbols

| | | | Binary Braille representation | | | | | |
|---|---|---|---|---|---|---|---|---|
| P. No. | Char. | ASCII value | D6 | D5 | D4 | D3 | D2 | D1 |
| 27 | ! | 33 | 1 | 0 | 1 | 1 | 1 | 0 |
| 28 | " | 34 | 0 | 1 | 0 | 0 | 0 | 0 |
| 29 | # | 35 | 1 | 1 | 1 | 1 | 0 | 0 |
| 30 | $ | 36 | 1 | 0 | 1 | 0 | 1 | 1 |
| 31 | % | 37 | 1 | 0 | 1 | 0 | 0 | 1 |
| 32 | & | 38 | 1 | 0 | 1 | 1 | 1 | 1 |
| 33 | ' | 39 | 0 | 0 | 0 | 1 | 0 | 0 |
| 34 | ( | 40 | 1 | 1 | 0 | 1 | 1 | 1 |
| 35 | ) | 41 | 1 | 1 | 1 | 1 | 1 | 0 |
| 36 | * | 42 | 1 | 0 | 0 | 0 | 0 | 1 |
| 37 | + | 43 | 1 | 0 | 1 | 1 | 0 | 0 |
| 38 | , | 44 | 1 | 0 | 0 | 0 | 0 | 0 |
| 39 | - | 45 | 1 | 0 | 0 | 1 | 0 | 0 |
| 40 | . | 46 | 1 | 0 | 1 | 0 | 0 | 0 |
| 41 | / | 47 | 0 | 0 | 1 | 1 | 0 | 0 |
| 42 | : | 58 | 1 | 1 | 0 | 0 | 0 | 1 |
| 43 | ; | 59 | 0 | 0 | 0 | 0 | 1 | 0 |
| 44 | < | 60 | 1 | 0 | 0 | 0 | 1 | 1 |
| 45 | = | 61 | 1 | 1 | 1 | 1 | 1 | 1 |
| 46 | > | 62 | 1 | 0 | 0 | 1 | 0 | 0 |
| 47 | ? | 63 | 1 | 1 | 1 | 0 | 0 | 1 |
| 48 | @ | 64 | 1 | 1 | 1 | 0 | 0 | 1 |
| 49 | { | 123 | 1 | 0 | 1 | 0 | 1 | 0 |
| 50 | : | 124 | 1 | 1 | 0 | 0 | 1 | 1 |
| 51 | } | 125 | 1 | 1 | 1 | 0 | 1 | 1 |
| 52 | ~ | 126 | 0 | 1 | 1 | 0 | 0 | 0 |

Table 3: ASCII-procedure number for numbers

| | | | Binary Braille representation | | | | | |
|---|---|---|---|---|---|---|---|---|
| P. No. | Char. | ASCII value | D6 | D5 | D4 | D3 | D2 | D1 |
| 53 | 0 | 48 | 0 | 1 | 1 | 0 | 1 | 0 |
| 54 | 1 | 49 | 0 | 0 | 0 | 0 | 0 | 1 |
| 55 | 2 | 50 | 0 | 0 | 0 | 0 | 1 | 1 |
| 56 | 3 | 51 | 0 | 0 | 1 | 0 | 0 | 1 |
| 57 | 4 | 52 | 0 | 0 | 1 | 0 | 1 | 1 |
| 58 | 5 | 53 | 0 | 0 | 1 | 0 | 0 | 1 |
| 59 | 6 | 54 | 0 | 0 | 1 | 0 | 1 | 1 |
| 60 | 7 | 55 | 0 | 1 | 1 | 0 | 1 | 1 |
| 61 | 8 | 56 | 0 | 1 | 0 | 0 | 1 | 1 |
| 62 | 9 | 57 | 0 | 0 | 1 | 0 | 1 | 0 |

Table 4: ASCII-procedure number for uppercase alphabets

| | | | Binary Braille representation | | | | | |
|---|---|---|---|---|---|---|---|---|
| P. No. | Char. | ASCII value | D6 | D5 | D4 | D3 | D2 | D1 |
| 63 | A | 65 | 0 | 0 | 0 | 0 | 0 | 1 |
| 64 | B | 66 | 0 | 0 | 0 | 0 | 1 | 1 |
| 65 | C | 67 | 0 | 0 | 1 | 0 | 0 | 1 |
| 66 | D | 68 | 0 | 0 | 1 | 0 | 1 | 1 |
| 67 | E | 69 | 0 | 0 | 1 | 0 | 0 | 1 |
| 68 | F | 70 | 0 | 0 | 1 | 0 | 1 | 1 |
| 69 | G | 71 | 0 | 1 | 1 | 0 | 1 | 1 |
| 70 | H | 72 | 0 | 1 | 0 | 0 | 1 | 1 |
| 71 | I | 73 | 0 | 0 | 1 | 0 | 1 | 0 |
| 72 | J | 74 | 0 | 1 | 1 | 0 | 1 | 0 |
| 73 | K | 75 | 0 | 0 | 0 | 1 | 0 | 1 |
| 74 | L | 76 | 0 | 0 | 0 | 1 | 1 | 1 |
| 75 | M | 77 | 0 | 0 | 1 | 1 | 0 | 1 |
| 76 | N | 78 | 0 | 1 | 1 | 1 | 0 | 1 |
| 77 | O | 79 | 0 | 1 | 0 | 1 | 0 | 1 |
| 78 | P | 80 | 0 | 0 | 1 | 1 | 1 | 1 |
| 79 | Q | 81 | 0 | 1 | 1 | 1 | 1 | 1 |
| 80 | R | 82 | 0 | 1 | 0 | 1 | 1 | 1 |
| 81 | S | 83 | 0 | 0 | 1 | 1 | 1 | 0 |
| 82 | T | 84 | 0 | 1 | 1 | 1 | 1 | 0 |
| 83 | U | 85 | 1 | 0 | 0 | 1 | 0 | 1 |
| 84 | V | 86 | 1 | 0 | 0 | 1 | 1 | 1 |
| 85 | W | 87 | 1 | 1 | 1 | 0 | 1 | 0 |
| 86 | X | 88 | 1 | 0 | 1 | 1 | 0 | 1 |
| 87 | Y | 89 | 1 | 1 | 1 | 1 | 0 | 1 |
| 88 | Z | 90 | 1 | 1 | 1 | 1 | 0 | 1 |

Table 5: ASCII-procedure number for blank value

| | | | Binary Braille representation | | | | | |
|---|---|---|---|---|---|---|---|---|
| P. No. | Char. | ASCII value | D6 | D5 | D4 | D3 | D2 | D1 |
| 89 | Blank | 32 | 0 | 0 | 0 | 0 | 0 | 0 |

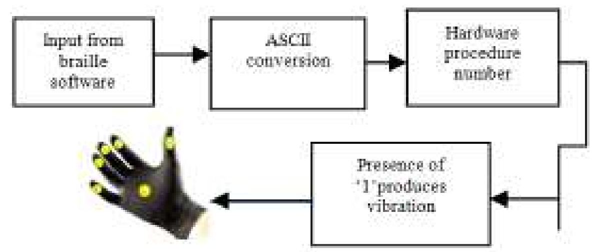


Fig. 7: Conversion steps for Braille code

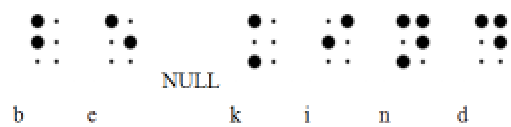


Fig. 8: Example for procedure number in hand glove vibration system

These 89 procedure numbers are linked with six digit binary number and ASCII value of English small letters, capital letters, numbers and symbols which are tabulated in Table 1 to 5 as follows:

These 89 procedures plays an important role in Braille vibration in the hand glove. The input character from software tool as mentioned in Fig. 7 is converted to ASCII value and it is passed to a hardware algorithm which is coded in HITECH C language in a Micro controller. This program matches the corresponding procedure number and activates the binary number. The presence of 1's in a six digit binary value is nothing but rising position of the Braille symbol. So the presence of 1's in a six digit binary value activates the corresponding vibration motors in the hand glove. It is diagrammatically represented as follows (Fig. 8):

For example if the user types the letter "r" then ASCII value for r is 114. The ASCII 114 is linked with procedure number 18 as mentioned in Table 1 and it corresponds to the binary number 0 1 0 1 1 1 which is stored already in an array. The presence of 1's in this value is 1, 2, 3, 5 positions (assigning the numbers from left to right in the binary number). So it activates 1, 2, 3, 5 position motors in the Braille hand glove. The 1, 2, 3, 5 position is nothing but raised dots position of Braille cell value 'r'. So instead touching and reading the Braille sheet the blind person can understand the Braille position through vibration.

**Example of hand glove vibration method using hardware procedure number:** Suppose the visible user can type the input value as "be kind" then it is converted in Braille symbols in output screen. The same value is sent to the vibration glove that is worn by the blind person as in Fig. 8:

Table 6: Procedure number for Braille example

| Input character | Braille value | ASCII value | P. No. | Binary Braille representation | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | D6 | D5 | D4 | D3 | D2 | D1 |
| b | ⠃ | 98 | 02 | 0 | 0 | 0 | 0 | 1 | 1 |
| e | ⠑ | 101 | 05 | 0 | 1 | 0 | 0 | 0 | 1 |
| Null | | 32 | 89 | 0 | 0 | 0 | 0 | 0 | 0 |
| k | ⠅ | 107 | 11 | 0 | 0 | 0 | 1 | 0 | 1 |
| i | ⠊ | 105 | 09 | 0 | 0 | 1 | 0 | 1 | 0 |
| n | ⠝ | 110 | 14 | 0 | 1 | 1 | 1 | 0 | 1 |
| d | ⠙ | 100 | 04 | 0 | 1 | 1 | 0 | 0 | 1 |

In this example, the user can type the input "be kind ". Each character is initially translated into Braille code by using Braille translation algorithm which is coded in Visual Basic and is displayed in the output screen by the software tool as designed in Fig. 3. Then each character of Braille code is converted into ASCII value. It is sent to the micro controller of the Braille glove through the computer port (RS 232) one by one up to Null value. The ASCII value of each character is passed by the hardware algorithm which is coded in HITECH C language in Micro controller. This hardware programs contains 89 ASCII procedure numbers and each procedure is linked with six digit binary numbers. It is tabulated from Table 1 to 5. In this example first Braille value is 'b'. The ASCII value for 'b' is 98, is applied to 89 procedures and assigned the procedure number 2. It is stored with the binary number 0 0 0 0 1 1 already in an array. The presence of 1's in this value is in positions numbers 1, 2 (assigning the numbers from right to left in the binary number). So it activates 1, 2 position motors in Braille hand glove. The 1, 2 positions is nothing but raised dots position of Braille cell value 'b'. The same procedure is applied to all input characters up to NULL key. It is tabulated in Table 6 as follows.

Here the presence of 1's in Binary Braille representation activates the corresponding position motors in Braille hand glove for the input value. So instead of touching and reading the Braille sheet, the blind person can understand the English letters Braille value through vibration using Braille hand glove. At the end of the process the blind people can understand the visible Conway message is "be kind". Similarly any type of message is passed to blind people as an input in the software screen.

## TESTING OF THE SYSTEM

Ten blind users, two deaf-blind users and ten visible users have participated in testing of the Braille hand glove operation as designed in Fig. 6. The average age of participants was 29.07 and ranged from 18 to 45. Participants read at an average rate of 11.13 words per minute with a standard deviation of 37.81 and a range of 22.91 to 26.75. Half of the participants learned Braille in public schools and 13.3% learned Braille from training for a few days. Half of the participants (51%) were completely blind, 13% had less sight in vision and 5% were visually impaired.

To test the accuracy of the working principle of the hand glove as mentioned in Fig. 7, it was applied to different categories of people as follows:

- Blind employee
- Blind student
- Blind and Deaf
- Visible Employee
- Visible student

From each group, five users were identified for sampling except blind and deaf. Two users were identified in blind and deaf group due to the less availability of persons. In this experiment all blind people had fundamental knowledge in Braille, but visible users had little knowledge in Braille. So totally Braille hand glove was worn by 22 different persons. Before starting the experiments software input screen as designed in Fig. 1 and working procedure of Braille Glove as designed Fig. 6 were clearly explained to the users. School students, college students, employers and lecturers were made use of in this experiment. The experiments were conducted based on the following manner:

- Letters test
- Digits test
- Words test
- Simple Sentence test

A questionnaire was prepared and the answer from the user was recorded. The questionnaire was conducted in different places and on different dates depending upon the availability of users. Name, age, qualification, Input Question, Answer from the user after using Braille was recorded. But people without knowledge in Braille felt difficult to recognize the positions in Braille Hand glove. In that case the Braille vibration procedure was repeated several times up to their satisfaction and the numbers of attempts were also noted in questionnaire.

Table 7: Contingency table for Braille users

| User type | Letters test | Digits test | Words test | Sentence test | Total |
|---|---|---|---|---|---|
| Blind employee | 5 | 5 | 5 | 4 | 19 |
| Blind student | 5 | 5 | 3 | 2 | 15 |
| Blind and deaf | 2 | 2 | 0 | 0 | 4 |
| Visible employee | 5 | 5 | 2 | 1 | 13 |
| Visible student | 5 | 4 | 2 | 0 | 11 |
| Total | 22 | 21 | 12 | 7 | 62 |

Table 8: Cross tabulation for Braille users

| | VAR00002 | | | | |
|---|---|---|---|---|---|
| Braille testing (VAR00001) | Type of testing | Count (O) | E. count (E) | $(O-E)^2$ | $(O-E)^2/E$ |
| Blind employee | Letters test | 5 | 6.7 | 2.89 | 0.4313 |
| | Digits test | 5 | 6.4 | 1.96 | 0.3063 |
| | Words test | 5 | 3.7 | 1.69 | 0.4566 |
| | Sentence test | 4 | 2.1 | 3.61 | 1.7190 |
| Blind student | Letters test | 5 | 5.3 | 0.09 | 0.0170 |
| | Digits test | 5 | 5.1 | 0.01 | 0.0019 |
| | Words test | 3 | 2.9 | 0.01 | 0.0035 |
| | Sentence test | 2 | 1.7 | 0.09 | 0.0529 |
| Blind and deaf | Letters test | 2 | 1.4 | 0.36 | 0.2572 |
| | Digits test | 2 | 1.4 | 0.36 | 0.2571 |
| | Words test | 0 | 0.8 | 0.64 | 0.0008 |
| | Sentence test | 0 | 0.5 | 0.25 | 0.0005 |
| Visible employee | Letters test | 5 | 4.6 | 0.16 | 0.0347 |
| | Digits test | 5 | 4.4 | 0.36 | 0.0818 |
| | Words test | 2 | 2.5 | 0.25 | 0.1000 |
| | Sentence test | 1 | 1.5 | 0.25 | 0.1667 |
| Visible student | Letters test | 5 | 3.9 | 1.21 | 0.3101 |
| | Digits test | 4 | 3.7 | 0.09 | 0.0243 |
| | Words test | 2 | 2.1 | 0.01 | 0.0048 |
| | Sentence test | 0 | 1.2 | 1.44 | 1.2000 |
| $\sum (O-E)^2/E$ | | | | | 6.7040 |

**Formation of contingency table:** The experimental results of 22 different category participants have been recorded in a table; one by one. It is mentioned in Table 7. Here 1 means answer from the participant is right and 0 means wrong answer. The summary of all 22 users results and types of test are tabulated as follows:

**Testing the data using statistical analysis tool:** There are several types of statistical test available but this problem falls in chi square test depending on the way the data was collected and the hypothesis being tested. The simplest case is 2×2 contingency table. If we set the 5×4 table to the general notation, then it can be solved by chi-squared test as follows:

**Chi-squared test definition:** Chi-squared test is used to assess two types of comparison: tests of goodness of fit and tests of independence:

- **A test of goodness of fit:** Establishes whether or not an observed frequency distribution differs from a theoretical distribution.
- **A test of independence:** Assesses whether paired observations of two variables, expressed in a contingency table are independent of each other.

The first step in the chi-squared test is to calculate the chi-squared statistic. In order to avoid ambiguity, the value of the test-statistic is denoted by $\chi^2$. The chi-squared statistic is calculated by finding the difference between each observed and theoretical frequency for each possible outcome, squaring them, dividing each by the theoretical frequency and taking the sum of the results. A second important part of determining the test statistic is to define the degrees of freedom of the test. This is essentially the number of observed frequencies adjusted for the effect of using some of those observations to define the theoretical frequencies.

**Calculating the chi-square test-statistic:** The value of the test-statistic is:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

where,

$O_i$ = An observed frequency

$E_i$ = An expected (theoretical) frequency, asserted by the null hypothesis

$n$ = The number of cells in the Table 8

The number of degrees of freedom is calculated as (n-1) x (m-1) where n is the total number of rows and m is the total number of columns in the contingency table.

The goodness of fit test uses the chi-square distribution to determine if a hypothesized probability distribution for a population provides a good fit. Acceptance or rejection of the hypothesized population distribution is based upon differences between observed

Table 9: Chi-square tabulated value for Braille users

| | $\chi^2$ | d.f | 1% LS | 2% LS | 5% LS | 10% LS | 20% LS |
|---|---|---|---|---|---|---|---|
| Tabulated value | 6.704 | 12 | 26.22 | 24.05 | 21.02 | 18.55 | 15.81 |

frequencies in a sample and the expected frequencies obtained under null hypothesis.

**Decision rule:** Accept $H_0$ if $\chi^2 <= \chi^2_\alpha$ (n-1) x (m-1) and reject $\chi^2 >= \chi^2_\alpha$ (n-1) x (m-1) where:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Calculated value of chi-squre obtained on using above formula and $\chi^2_\alpha$ (n-1) x (m-1) is the tabulated value of chi-square for (n-1) x (m-1) degree of freedom and level of significance $\alpha$ where n is the number of rows and m is the number of columns in the contingency table. It is solved by the IBM SPSS tool. SPSS stands for Statistical Package for the Social Sciences. This tool can be used to analyze data collected from surveys, tests, observations etc. Here it calculates the chi-square test very accurately and compare the result with tabulated value.

## RESULTS AND DISCUSSION

A value of $\chi^2$ cannot be evaluated unless the number of degrees of freedom associated with it is known. The expected value is calculated from contingency Table 7 as follows: (Column total×row total) /Grand total i.e., 22×19/62 = 6.7 similarly the results for other expected values are calculated:

**Step 1:** Calculation of chi-square test from Contingency table as mentioned in Table 7 is as follows. Also observed and expected value generated by IBM SPSS tool for all testing is tabulated.

**Step 2:** Calculation of Tabulated value for Different degree of freedom is tabulated in Table 9.

**Step 3:** Degrees of freedom = (n-1) x (m-1) where n is the number of rows and m is the number of columns in the contingency table.

From the Contingency table as tabulated in Table 7, Degrees of freedom = (n-1) × (m-1) = (5-1) × (4-1) = 12.

The tabulated $\chi^2_{0.05}$ for 12 degrees of freedom i.e., $\chi^2_\alpha$ (n-1) × (m-1) = 21.02.

So the final results are:

$$\chi^2 = 6.704$$

$$\chi^2_\alpha (n-1) \times (m-1) = 21.02$$

According to decision rule.

Accept $H_0$ if $\chi^2 <= \chi^2_\alpha$ (n-1) x (m-1) and reject $\chi^2 >= \chi^2_\alpha$ (n-1) x (m-1). In this research Since calculated value of $\chi^2$ is less than the tabulated value i.e., 6.704 <21.02.

We conclude that it is not significant and the null hypothesis is accepted at 5% level of significance's that Braille hand glove is working with good results and best suited device for visually impaired people.

## CONCLUSION

The software algorithm which is coded in Visual Basic 6.0 reads the sentence from the Input box of the Braille software tool and breaks them into characters and are counted up to the value of the enter key. The Braille code equivalent of each character is generated in the output box of the tool. The hardware algorithm which is coded in Hi-Tech C language reads each character from the Input box of the Software tool and converts into ASCII value. The Hardware procedure for the corresponding ASCII value is called and each procedure number is linked with a six digit binary number. The presence of 1's in a six digit binary value is nothing but raised a position on the Braille symbol. This activates the corresponding vibration motors in the hand glove. Through this vibration signal the blind person can infer the corresponding English letter. In order to interact with the blind or blind and deaf person, the visible person types on the Input box of the software tool and this interaction is sent as vibrating signal to the blind or blind and deaf. The statistical analysis of Braille glove reports that it is a suitable kit for blind people because they start their education with Braille code notations. At the same time it is little difficult for visible and deaf and blind people, because the vibration is initially felt difficult to recognize the six positions inside the hand glove, but once they get experience or few repetitions, anyone can use this system for effective communication purpose. Most of the blind users feel that no significant is found between the Braille cell position inside the glove and Braille impressed sheet. The Braille code vibration process is a single step and the data transfer rate is normal and it is controllable. It is the best tool for visually impaired people to have more accurate sensing, low error rate, small electronic product and it proposes a new approach to blind persons to know about computer oriented technologies.

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