A Paradigm Shift to Braille Data Entry System for The Visually Impaired

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Abstract: Most of the recent smart mobile and communication devices do not accommodate special indigent users to manage their wireless communication over long distance. A microcontroller based text entry system can be developed, built and tested to address such a missing functionality for visually impaired. The developed systems major contribution is that it is customized to provide the special needy persons a new mobile text entry method that relies on solely Braille alphabet and dismisses memorizing, offering visually impaired person an easy writing mechanism. With the enormous growth in the field of telecom it was urgent to offer visually impaired person this kind of text entry system for the communication purpose. To provide better and convenient lifestyle to disabled person, the microcontroller based system is programmed so that it can be configured to adjust customer's disability. To analyze the performance of developed system subjects with visually–partially impaired disability were chosen. The response for comfort level of subject while handling keypad matrix is analyzed, 80% user found it comfortable. The experiments were carried out, to detect the perfect distance of palm from Braille keypad matrix to sense the Braille code exactly, to avoid error. Total 20 trials were carried out for each user, basically 0.6 cm is considered to be null hypothesis and from the results it is acceptable at any significance level. However 0.4 and 0.8cm distance was not encouraging with almost null for 0.2 and 1 cm. Total data of visually–partially impaired subjects are summarized in performance analysis section providing identification score 97% for perfect palm distance and maximum 96% for the 40mm distance; indicating the preferable distance of studs.

***Index Terms* -** Braille matrix, Microcontroller, GSM modem, Relay, Braille cell, Solenoids

I. INTRODUCTION

In the new era of vast technologies physically challenged people especially people with visual impairment find it troublesome to do their daily activities when no one remains around them. Existing text entry system for the mobile system is that either they need family person with them or they don't have affordable solution. But this becomes hectic for family members to stay always with them or it's not possible for middle class family to keep human assistance on payment basis. Therefore in order to overcome these several kind of problems a system should be developed for these visually impaired people such that system will ensure safety of them and will also provide assistance to live independently. To solve these issues, a system will be enabled for dealing with data text entry over mobile device using Braille 3x2 matrix design. As a part of confirmation, whether person has made right entry of data system, will have LCD display which will alert user for wrongly entered message. By configuring a system, thus entered message is made available to receiver through GSM module. A new mobile data entry system using microcontroller which will be helpful for communication purpose of them and to overcome the drawback of previous applications. Also focusing towards a low cost and robust system implementation within affordable reach. In this paper, section II includes the METHODOLOGY for the work section while section III includes IMPLEMENTATION with diagram representations. Section IV summarizes the evaluation results and ensures the validation of developed system.

II. METHODOLOGY

Task Analysis

a. Five subjects with visually impaired disability participated in the experiment. Subjects were interviewed to identify the user's needs and capabilities as well as their common use of mobile phones. Two female and three male subjects participated in the experiment with ages between 18 to 64. To identify convergence with mobile phone use, it was important to verify that all the users possess mobile phones and use it for calling once or more in a day. Only two of them reported having problems to dial the number due to small keypad size and lack of feedback. Generally dialling isn't problematic, thus it is not main concern of the work. Almost 60 percent stated that they text the SMS from which half of them said that they do it on daily basis. The users generally agreed that due to lack of feedback taking them to recurrently make mistakes as well as menu navigation is difficult and cumbersome. Palm sensitivity of all the subjects was also normal which was considered to be useful for the sensing stud pins at the Braille decoder.
b. At the initial level microcontroller based system was developed for the visually impaired persons. System enables the blind persons to enter the data using Braille matrix at the transmitter side and allows the user to sense the transmitted message using solenoids at the receiver side. Therefore few criteria were applied randomly and stepwise procedure was

repeated under the guidance. By collecting the data of these 5 subjects, performance was analysed. Comfort levels of users were took into considerations and analysis was carried out.

A. Material

The complete system consists of two parts: transmitter part consisting of 3x2 Braille matrix for the text data entry and receiver part consisting of Solenoid matrix to sense the received message. To develop such a standalone integrated embedded system;

1. Controller required

This system composed of an individual microcontroller at transmitter section and another separate microcontroller at receiver section. Microcontroller IC AT89S52 is used in both the sections.

2. Communication media required

This system used for the means of communication which requires faithful transmission and reception of text data entered so that target user can get desired benefit. For fulfilling the requirement GSM/GPRS modem from Sky microwave Corp. was used which operates on 1800 MHz

3. Mathematical model of system

In this Braille Matrix System there are two main sections:

I. Transmitter section

Let us assume the number of P push buttons be *m* denoted by eq.(1)

$$P = \{P_1, P_2, P_3, \ldots\ldots, P_m\} \qquad (1)$$

II. Receiver section

Let us assume the number of S solenoids be *n* denoted by eq.(2)

$$S = \{S_1, S_2, S_3, \ldots., S_n\} \qquad (2)$$

Push button is the physical device that is capable of accepting the text data form user according to force applied from finger of user randomly. By considering a discrete source generating the message, symbol by symbol. In that case let the push button P_1 be pressed a number of times for the alphabets A to Z, given by eq.(3)

$$P_1 = \{ P_1^a, P_1^b, P_1^c, \ldots\ldots, P_1^z\} \qquad (3)$$

Provided P_1^a = 1; push button P_1 pressed for code 'A'
= 0; push button P_1 not pressed for code 'A'

Similarly for P_i, be pressed *az* number of times given by eq.(4)

$$P_i = \{ P_i^a, P_i^{\,b}, P_i^c, \ldots\ldots, P^{az}\} \qquad (4)$$

Provided P_i^k = 1; push button P_i pressed for code 'k'
= 0; push button P_i not pressed for code 'k'

At the receiver section let the solenoid be used for the execution of task *i.e.* used to sense the uplifted pin denoted by S_i. For the reception of discrete message, symbol by symbol the solenoid S_1 be sensed *k* number of times denoted by eq.(5)

$$S_1 = \{ S_1^l, S_1^2, S_1^3, \ldots\ldots, S_1^a\} \qquad (5)$$

Provided S_1^a = 1; solenoid S_1 sensed for code 'A'
= 0; solenoid S_1 not sensed for code 'A'

Hence for the S_i be sensed az number of times given by eq.(6)

$$S_i = \{ S_i^l\, S_i^{\,2}, S_i^3, \ldots\ldots, S_i^{az} \} \qquad (6)$$

Provided S_i^k = 1; solenoid S_i sensed for code 'k'
= 0; solenoid S_i not sensed for code 'k'

III. IMPLEMENTATION

The block diagram of the transmitter system is a shown in Figure 1. It consists of Braille keypad, LCD display, microcontroller, power supply, GSM modem, *etc.* The Braille matrix of 3x2 allocates the user to enter the desired text data by pressing the respective push buttons. Symbols used for the braille code is fixed, by ensuring the corresponding key pressing, a message is generated. To detect any mistyped message LCD display is used in the system, so that whenever visual person is present with the target user he would understand the English version of texted Braille message. This is provided for the demo purpose at the initial level. Once the message is typed it is transferred to recipient through GSM modem with the help of microcontroller.

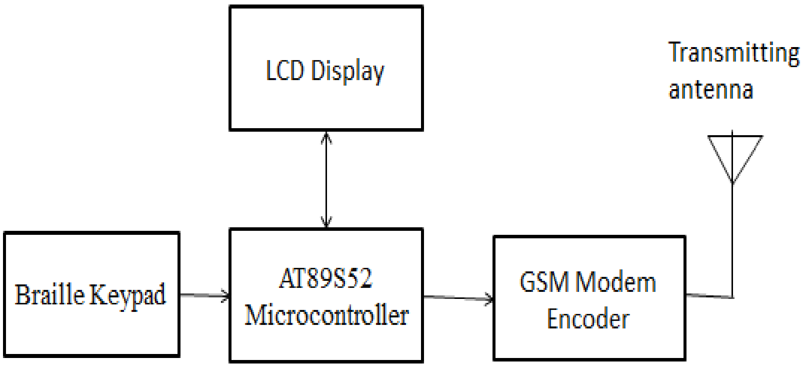

Figure 1: Braille Text Message Encoder

The block diagram of the encoder system is a shown in Figure 2. At the receiver side when a message is received with the help of GSM modem it is first transferred to microcontroller for the further processing. To provide constant supply to GSM a SMPS is used. Incoming message is converted into two languages: English and Braille. Braille is sensed through the solenoids, whereas solenoids are operated through relays. Each corresponding solenoid comes up symbol by symbol. Palm of visually impaired person is to be kept over total matrix of solenoid to read the text data.

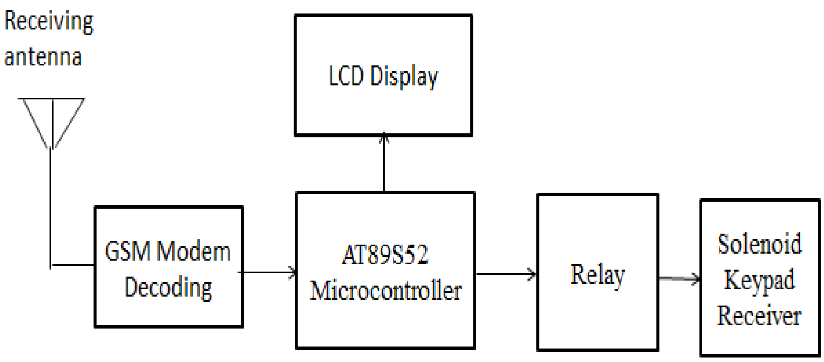

Figure 2: Braille Text Message Decoder

A. Experimental model

Braille keypad is consisting of 3x2 matrix by which we can display 64 different characters. Each character has symbolic pattern respective to its braille keypad. This keypad has “OK”, “Send” and “Space Button”. It consists of 9 keys arranged in 3x3 formats i.e. 3 rows and 3 columns. These keys are connected to accept I/O port of the controller. Keypad is used to take input from the user for further processing. In this paper interfacing is done by keypad with the MCU AT89S51 for sending message. A microcontroller is an economical computer-on-a-chip built for dealing with specific tasks, such as displaying or receiving information through LEDs or remote controlled devices. GSM module is used to send and receive short text messages. The subscriber identification module (SIM) is interfaced with the module which permits the use of mobile service. RS232 and TTL serial interface are used in this for connections with microcontroller. GSM Module was connected to the controller and transmits the incoming messages to the controller. It also receives the messages from controller. AT commands were executed on microcontroller to obtain the services of transmission and reception by various operations of AT commands.
Main experimental conditions implemented

Stimuli

1. The actual studs used were designed through mounting over plunger in such a way that stud can move out and in up to 1cm. This height of stud pins was specially designed for the experimental conditions to decide the perfect distance of palm from the receiver keypad.

2. Second experimental condition included critical distance between stud pins so that a target user can sense the code in according to palm sensitivity. Critical distance is the minimum separable distance between stud pins at which two separate pin points can be sensed. By default, critical distance between the stud pins is going to be decided by diameter of solenoid. The critical distance is not going to be less than diameter of solenoid and must be recognized in order to perfectly sense the Braille code through uplifted pins. The average size of solenoid 40 to 70mm was used for the experimental purpose.

Procedure

Subjects S_1 to S_5 with visually–partially impaired ones were considered under test. Twenty trials were carried out for each subject. In both cases the subject was seated with his/ her arm extended. The hand was positioned on keypad(Braille Matrix) at transmitter for the first case and was positioned on Stud pins(Braille Matrix) for the receiver side. The hand was positioned on keypad matrix with palm faced to it.

IV. RESULTS AND DISCUSSION

To analyze the performance of developed system subjects with visually–partially impaired disability were chosen. While considering the disability and number of iterative executions were carried out.

Results and discussion

The results are summarized into following tables:
Table 1 indicates the response for comfort level of subject while handling keypad matrix. Out of five subjects, four subjects found data text entry comfortable with Braille keypad. They voted for Braille keypad which depicts eighty percent user found it comfortable.

. Table 1: Experimental Results of System for Disabled Subjects for Comfort Level with Keypad and without Keypad

Sr. No	Subjects	Comfort Level Experienced	
		Without Keypad	With Keypad
1	S_1	No	Yes
2	S_2	No	Yes
3	S_3	No	Yes
4	S_4	No	Yes
5	S_5	Yes	No

Table 2: Experimental Results of System for Disabled Subject for Perfect Palm Distance for Single Trial

Sr. No.	Subjects	Score				
		Palm Distance(cm)from Keypad Surface				
		0.2	0.4	0.6	0.8	1
1	S_1	NR	NR	R	NR	NR
2	S_2	NR	NR	R	NR	NR
3	S_3	NR	R	NR	NR	NR
4	S_4	NR	NR	R	NR	NR
5	S_5	NR	NR	R	NR	NR

NR: No Response, R: Response

Table 2 indicates the experimental results of given Braille system, for the perfect distance should be maintained for palm to sense the Braille code exactly, to avoid any error. The term NR indicates "No Response". Table 2 is specially used to show single trial. As shown in Table 2, out of five subjects four subjects voted for the 0.6cm distance as perfect distance between palm and Braille keypad to sense the code correctly. Only one person found it at the 0.4cm as a perfect distance. Depicts 80 % voted for 0.6cm as a perfect distance. Then subsequent trials were carried out afterwards.

Table 3: Experimental Results of System for Disabled Subjects for Perfect Palm Distance

Sr. No.	Subjects	Score					Identification Score for 0.6cm
		Palm Distance(cm)from Keypad Surface					
		0.2	0.4	0.6	0.8	1	
1	S_1	0	0	20	0	0	97
2	S_2	0	0	20	0	0	
3	S_3	0	01	19	0	0	
4	S_4	0	01	18	01	0	
5	S_5	0	0	20	0	0	
	Avg	0	0.4	19.4	0.2	0	
	SD	0	0.48	0.8	0.4	0	

Avg: Average, SD: Standard Deviation

Table 3 indicates the results of system for disabled subjects for perfect palm distance(cm) from keypad surface. Total 20 trials were carried out for each subject, according to results obtained, out of 100 trials almost 97 trials resulted into vote for 0.6cm. From the results identification score of 0.6cm is maximum. Basically 0.6 cm was considered to be null hypothesis and from the results it is acceptable at any significance level. However 0.4 and 0.8cm distance was not encouraging with almost null for 0.2 and 1 cm.

Table 4: Experimental Results of System for Perfect Critical Distance of Stud Pins with 5 Trials for each Distance Resulting into 20 Trials per User

Sr. No.	Subjects	Score				Identification Score for 40 mm
		Critical Distance between Stud Pins (mm) Varied by 10mm for each Subject				
		40	50	60	70	
1	S_1	5	2	0	0	96
2	S_2	5	3	0	0	
3	S_3	2	3	0	0	
4	S_4	5	3	0	0	
5	S_5	4	2	0	0	
	Avg	4.2	2.6	0	0	
	SD	1.16	0.48	0	0	

Table 4 provides the critical distance to be maintained for the mounting of studs according to palm size and sensitivity. General size of palm from minimum to maximum is considered and the distance between stud pins is varied by 10mm. The minimum distance between two stud pins can't be less than 40mm because diameter of solenoid is taken into consideration. According to solenoid used in system implementation doesn't provide diameter less than 40mm; So the stud pins were placed at the distance of 40mm onwards in 3x2 matrix form and 5 trials were carried out for each critical distance. By varying distance ranging from 40 to 70mm total 20 trials were carried out for each subjects with equally distributed trials(5) for each distance range(placed at 10mm).

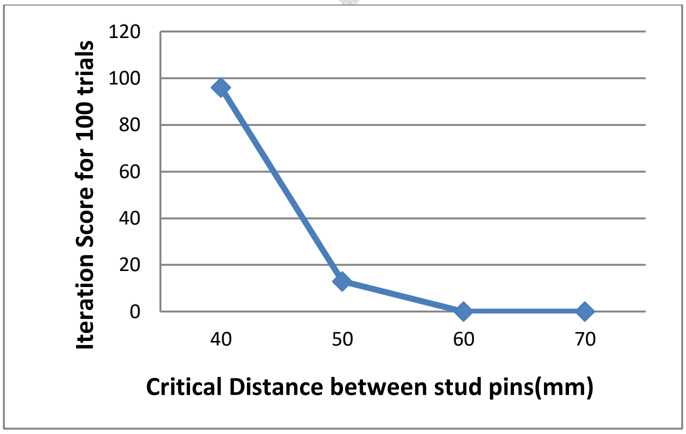

Figure 3: Graph of Efficiency in % on the Y- axis versus Critical Distances (varied by 10mm) between Stud Pins on X-axis

Thus total data of visually–partially impaired subjects are summarized in above Tables. Graphical representation of critical distance is also provided in Figure 3. From the graph, identification score is Maximum 96 for the 40mm distance indicating the preferable distance of studs.

V. CONCLUSION

Microcontroller based Braille Matrix system for text entry is developed as sort of assistance system for visually–partially impaired people has met its goal based on the simulations, test results and analysis. The proposed system not only makes visually impaired people self-reliant but also provides a means of text data entry in this vast communication world of mobile. The system provides the Braille keypad for text entry at encoder as well as to sense the Braille text at the decoder by means of push buttons and solenoids respectively. Results obtained from the series of tests indicate that Iteration score is 97% for perfect palm distance (0.6cm) and 96% for critical distance between studs(40mm). Better results could be obtained by sufficient training and literacy rate of Braille code.

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