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Automated Voice based Braille Script Teaching Aid using Raspberry Pi

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Abstract:

Education is the key to success in life, normal children learn from teachers in schools seeing and communicating with each other. For Visually challenged students learning to read and write is much more difficult because of visual impairment. The teaching aids required to teach such blind pupil are special and require lot of teacher's attention. For a first time learning blind student, character set and numbers are taught with a help of marbles and slotted slate. Different arrangement patterns of marbles on slotted slate represent different characters. For each character representation, teacher has to reach each student and change the arrangement of marbles. This is harder and time-consuming exercise.

This paper describes a Raspberry Pi based Hardware Implementation of the Braille teaching device, where the above problem can be abridged. This project implements a Braille Script Teaching Aid in which the presence of marbles is detected using IR sensors and this information is given to Raspberry Pi which produces the audio output of the letter. This method provides an easy way of teaching Braille Script. Some self-learning programmes are developed to make students to learn without the help of a teacher. It is well suited for first time learners. We can teach different languages with the same setup by selecting the language based on the requirement.

Keywords **— Braille script, Braille cell, marble, Raspberry Pi, IR Sensor.**

I.INTRODUCTION

Visual impairment and Blindness are the significant problems affecting the common man worldwide. They lead to serious social & economic burden to the family and the society as well. India which is a world 2nd largest populated country is having world's largest number of blind people[6]. According to WHO statistics in 2006, 314 million people were visually impaired and among them 45 million were totally blind.

In 2010, 407 million people were visually impaired[3]. In order to make them self-dependent they should be made literate.so that they can work normally with a common man easily & share their ideas. For that a Language is required. It is the most basic path of communication to express our feelings & convey messages. Braille Script is used to reduce the gap between the blind and the normal people.

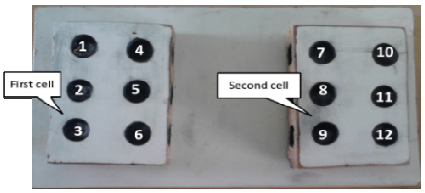


Fig.1 Dot format of Braille Letter

Braille is a tactile writing system used by people who are blind and low vision. It was invented by Louis Braille in 1824. It is traditionally written with embossed paper using slate and stylus or type it on a braille writer. Using this the blind people can read by placing their fingers on the dotted paper.Braille characters are represented as small rectangular blocks also called cells with 3 rows and 2 coloumns3. These are obtained by making holes on to the paper using a wooden stylus, such that 6 dots represent each braille character. Any dot may be raised at any of the six positions to form 2^6=64 unique combinations.

Braille script is generally represented using 12 dot format as shown in Fig.1. These dots are numbered vertically from top to bottom. The first cell is used to distinguish whether the letter is a capital, small or a number. Braille script has

separate conventions to distinguish letters. The second cell represents the actual letter.

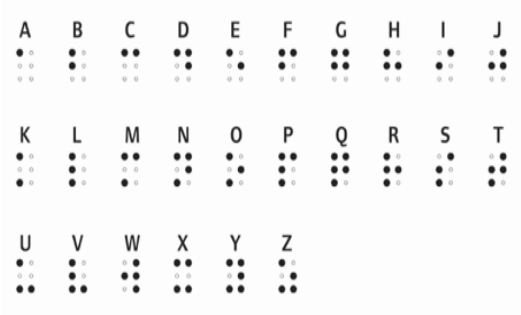


Fig. 2. Braille Alphabets

The Fig.2 shows the dot conventions for Braille alphabets. The capital alphabets of English can be represented by a dot at the 6th position. The first 6 dots form the constant representation for capital alphabets. The small alphabets can be represented by no dots in the first cell and the numbers are represented by dots at the 3,4,5,6 positions. The first cell format for capital numbers and numbers is shown in Fig.3.

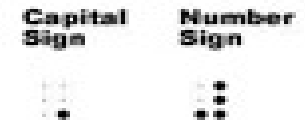


Fig.3 Format for Capital letters & Numbers

In the traditional method of teaching Braille, a wooden board (slate) as shown in Fig.4 with 12 holes was used and for each representation, the marbles are placed in the corresponding holes. Once the marbles are placed the blind student is made to touch each dot and feel the representation. Various methodologies have been implemented to ease teaching of Braille script in order to enhance the literacy rate among the blind. Another downside in those methods is the handling of these devices, since most of the devices are bulky.

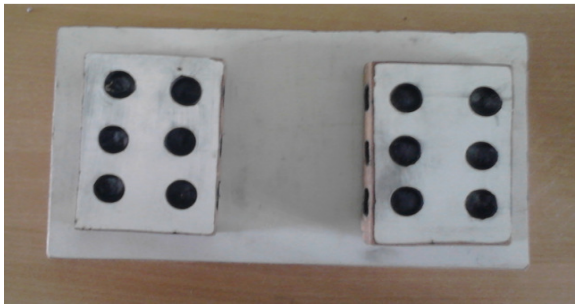


Fig.4 Braille Learning Kit

In the Braille display device by [7] consists of 6 switches at which the blind person gives the input. Those switches are interpreted through micro controller which gives the corresponding display of the letter.

Drishti- a cost effective printer by [9] replaces the vacuum suction principle in the older printers with electronic clutching principle. It also provides the audio output of the typed letter.

A prototype named Shape Memory Alloy based actuator for Refreshable display of Braille was proposed by [1] provides a blind person to access computers easily. It consists of a device in which all braille symbols can be represented on individual Braille cells with each dot having a separate actuator. The actuator raises the heights of each dot when it is being specified.Braille touch [4] provides an accessible keyboard on smart phones. It provides an easy way of text entry for the visually impaired on commodity smartphones. This printer is also provided with audio feedback for each character being entered.

Lambda based approach to teach mathematics to blind students was proposed [2] which provides access through braille, synthetic speech and a visual display. The Lambda Code has new symbols which represents maths in a linear form. The symbols can be rendered visually and in braille also. It is represented using 8 dot Braille cell. An important aspect of the braille notation is that it is based on 8-dot braille cells. The Lambda Editor resembles a text editor, but has been designed specifically to work on mathematics expressed in the code.The Adaptive Braille writing Tutor [10] consists of an electronic slate and stylus which monitors the writing of blind students and also sends the data in real time to the computer. The software runs on an external PC which translates the data from the E-slate to provide immediate audio sound to the user.

II.METHODOLOGY

This Project is implemented using a Braille slate with marbles in which the blind person places the marbles in the appropriate holes. The placing of the marbles is sensed by the IR Proximity sensor. If the combination of the marbles placed is

correct then the Raspberry Pi's Text to speak converter produces the audio sound output of the corresponding letter. The block diagram of the proposed method is shown in Fig.5.

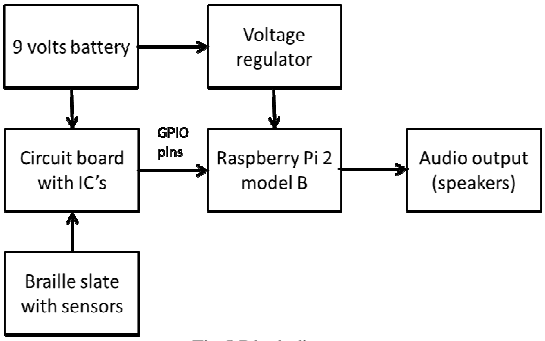


Fig.5 Block diagram

A) Braille Slate with sensors:

The Braille slate consists of a wooden block with 12 holes in it where marbles are placed in holes to indicate Braille alphabets. In this project the wooden board is embedded with IR proximity sensors at either sides of the holes. The positioning of IR Led and IR Sensor is shown in Fig.6. The IR sensors detect the presence of marbles based on obstacle detection principle.

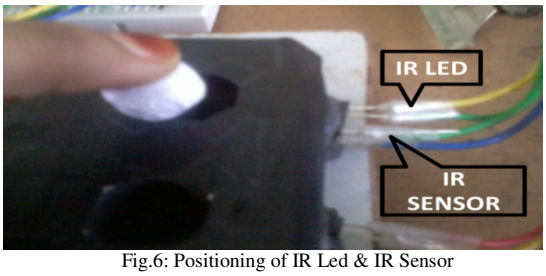


Fig.6: Positioning of IR Led & IR Sensor

B)Circuit Board with IC's:

The IR sensors are operated using LM324 IC which is having 4 inbuilt comparators in it, such that one IC is applicable for 4 holes of the wooden board. A big circuit is implemented on the bread board with 3 LM324 IC's such that it is applicable for 12 holes of the Braille slate.

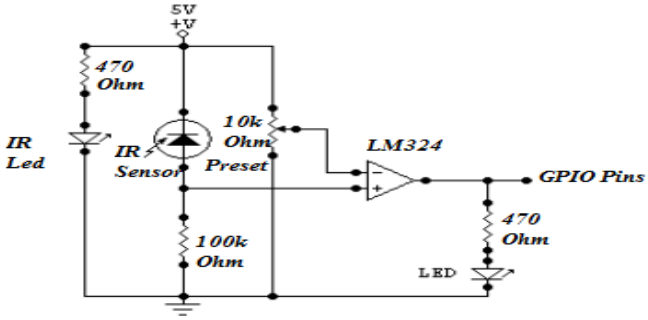


Fig.7.IR Obstacle Detection Circuit

The circuit diagram for the operation of IR Sensors to detect 1 marble position is shown in Fig.7. Similarly 12 such circuits are constructed. An IR Obstacle detection employs an IR LED and an IR Photodiode and combindly they are called as Photo Coupler. When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver through the obstacle (here marble). Based on the intensity of the radiation received by the IR photo diode, the output of the sensor is defined. Later the IR sensor output is compared with the 10 k ohm potentiometer whose value is adjusted at threshold 10. If the sensor output is more than threshold, it indicated the presence of an obstacle otherwise not.

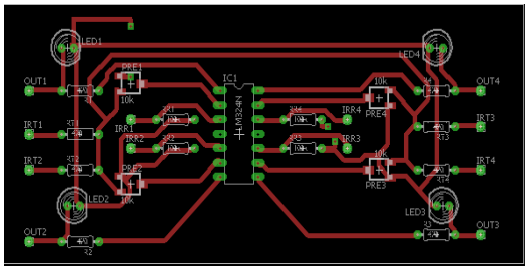


Fig.8 PCB Layout of LM324 IC performing Obstacle detection

The Fig.8 shows the PCB layout of LM324 IC, connected through IR sensors. The below PCB designed is implemented using Eagle CAD Software.

C)Raspberry Pi 2 Model B Board:

Raspberry Pi is a tiny computer board which is having processing speed of 6 times faster than its previous models.

Fig. 9: Raspberry Pi 2 Model B (Image courtesy of www.raspberrypi.org)

The model used in this project is shown in Fig.9. It is possible to install several versions of Linux Operating systems on to the board. It is having 900 MHz Quad core AR Cortex-A7 CPU and 1 GB Ram along with 4 USB Ports, Ethernet port, 40 GPIO pins, full HDMI port, 3.5mm audio jack, display interface(DSI), composite video, camera interface(CSI), micro SD Card slot and video core IV 3D Graphics core.

In this project the IR sensor output from the wooden board is received by the GPIO pins of the Raspberry Pi and according to that information the Simulink blocks are executed to recognize the correct letter[11].The connections of the IR sensor outputs from Braille Slate to the GPIO pins of of Raspberry Pi board is given in the Table I.

TABLE I
GPIO PIN CONNECTIONS

GPIO Pin Connections	
Dot-1	GPIO-10
Dot-2	GPIO-9
Dot-3	GPIO-11
Dot-4	GPIO-5
Dot-5	GPIO-6
Dot-6	GPIO-13
Dot-7	GPIO-19
Dot-8	GPIO-26
Dot-9	GPIO-12
Dot-10	GPIO-16
Dot-11	GPIO-20
Dot-12	GPIO-21

D)Audio Output (Speakers):

The Raspberry Pi 2 model B is having a 4-pole socket which can carry both audio and video signals and it can be applicable to other multimedia devices like MP3 players, speakers, iPods, and smartphones. The Raspberry Pi is having two audio output modes HDMI port and 3.5 mm audio jack. It is possible to switch between these 2 modes by manually changing the settings in the terminal. If a HDMI monitor is having built-in speakers, in it then the audio can be played over the HDMI cable. Otherwise speakers can also be plugged in to the audio jack. In this project a set of external USB speakers have been used. When the corresponding configuration for the particular letter is met the speakers connected to the audio jack gives the audio output of that letter[5].

III.SOFTWARE IMPLEMENTATION

Software implementation of this system is done using Support packages for Raspberry pi in simulink and MATLAB (R2014a) software. Simulink provides an interactive and graphical environment with set of library blocks for not only image processing, signal processing but also for communication tool box and control system tool box. Raspberry Pi Simulink provides capability for video capture, audio capture, voice output etc. This proposed method is implemented by constructing a Matlab function with condition for execution of each letter. The below figure Fig.10 shows the Raspberry Pi Support packages for Simulink.

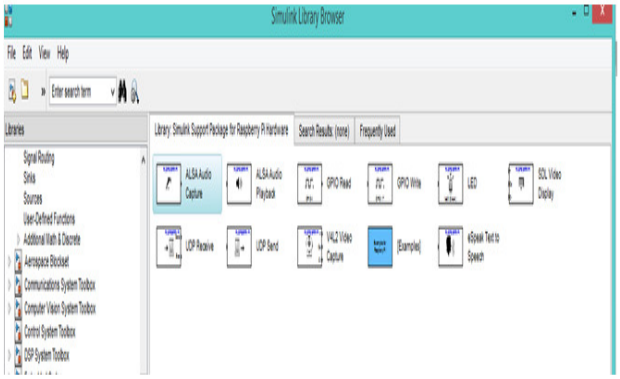


Fig. 10: Raspberry Pi Support packages for Simulink.

The Fig.11 shows the Simulink implementation in which 12 GPIO pins are taken which receive input from the comparator output of LM324 IC's which is on the Circuit board. It is having separate condition to find whether the letter is a capital or a small letter or a number.

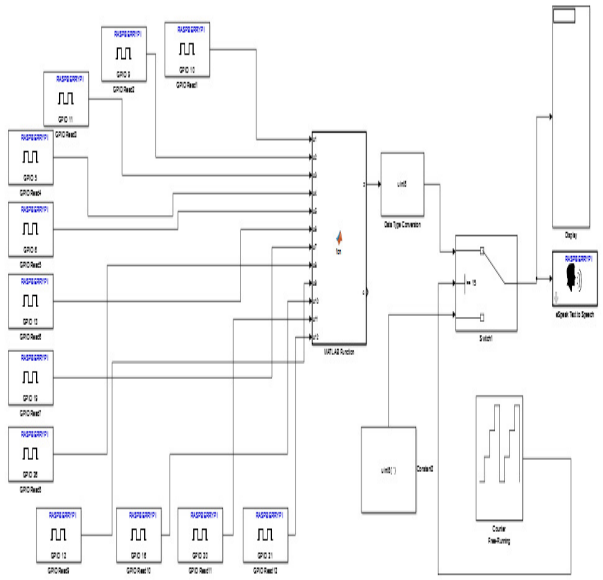


Fig. 11: Implementation in Simulink

IV.HARDWARE SETUP

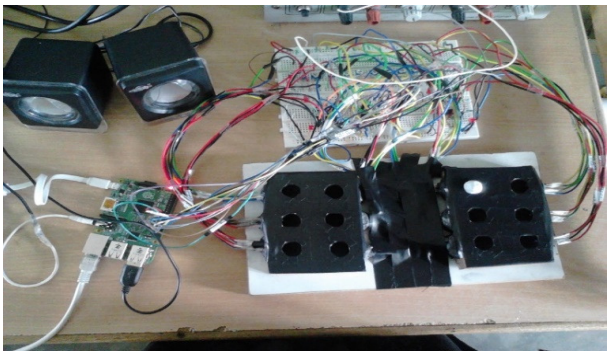


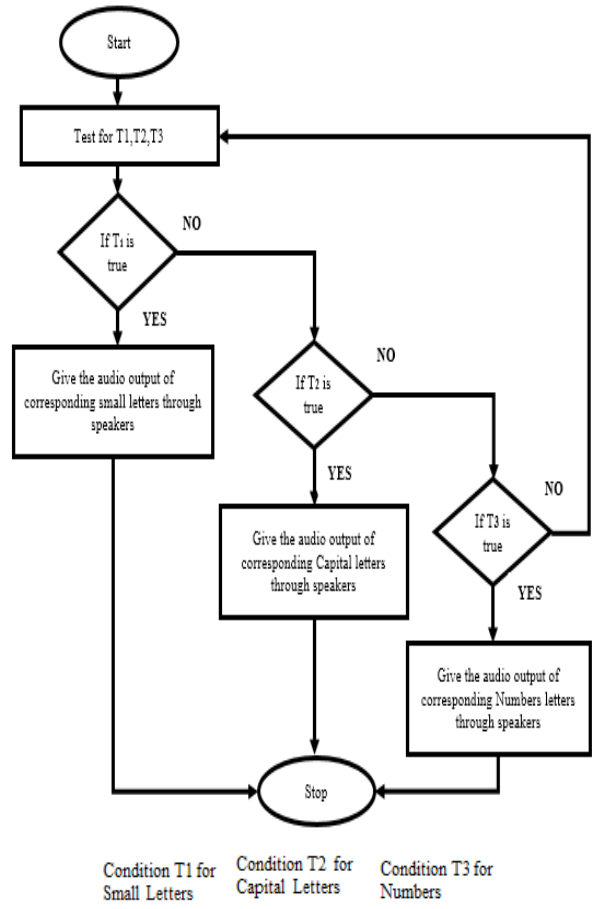
Fig.12.Hardware Setup of proposed System

In Fig.12 we can see that the Braille Slate is embedded with IR Sensors on either sides. The holes are covered with Black colour in order to avoid light illumination losses and the marbles are also coated with white colour so that there is a perfect obstacle (marble) detection. The power supply to the circuit board can be provided through a 5V battery and the power to the Raspberry Pi can be given through a power bank, since it is a standalone system.

The other aspect of this system is that it can be applicable to teach not only English alphabets but also other languages like Hindi, Telugu, Tamil etc[8]. The Hardware Setup will remain same and it is provided with provision to select the language based on the requirement. Hence it is very advantageous in a multi-lingual country like India.

V.FLOW CHART

T1, T2, T3 in the dialog box indicates the conditions for a letter for being a small letter, capital letter or a number. T1 Condition is satisfied if there is no marble in the first cell which indicates Small letters. T2 Condition is satisfied if there is a marble at the 6th position of the first cell which indicates capital letters. T3 condition is satisfied if there are marbles at the 3, 4, 5, 6 positions of the first cell which indicates Numbers



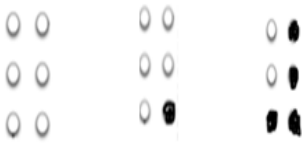


Fig.13: Status of First cell for Small letters, Capital letters, and Numbers

VI.RESULTS

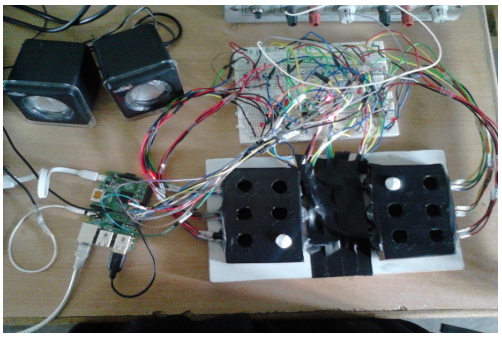


Fig.14: Placing of marble for a capital letter "A"

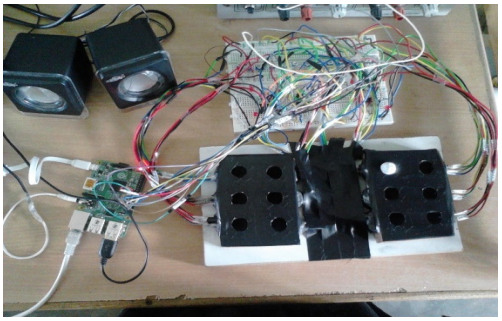


Fig.15 Placing of marble for a small letter "a"

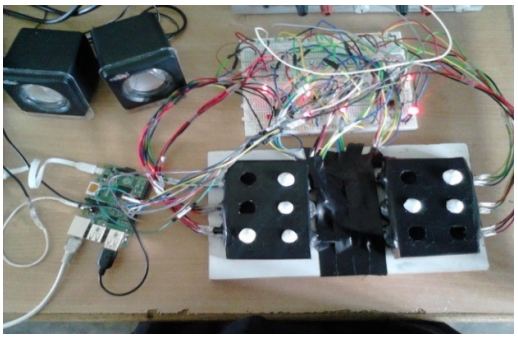


Fig.16 Placing of marble for a Number "0"

The accuracy of the proposed system is obtained by performing this procedure for all alphabets. In the Fig. 2 we have the marble configuration for alphabets. The marble representation for capital letters, small letters & Numbers under test is shown in Fig 13,14 and 15.. All those patterns has to be placed on the second cell keeping the first cell pattern same for one type of letters (small & capital) one by one to find accuracy of the system. Similarly, it
has to be repeated for all letters i.e., from A-Z, a-z, and 0-9.

TABLE –II

ACCURACY FOR NUMBERS

Input	Recognised output for 30 Trails										Success rate
	0	1	2	3	4	5	6	7	8	9	
0	30	0	0	0	0	0	0	0	0	0	100%
1	0	30	0	0	0	0	0	0	0	0	100%
2	0	0	30	0	0	0	0	0	0	0	100%
3	0	0	0	30	0	0	0	0	0	0	100%
4	0	0	0	0	30	0	0	0	0	0	100%
5	0	0	0	0	0	30	0	0	0	0	100%
6	0	0	0	0	0	0	30	0	0	0	100%
7	0	0	0	0	0	0	0	30	0	0	100%
8	0	0	0	0	0	0	0	0	30	0	100%
9	0	0	0	0	0	0	0	0	0	30	100%

TABLE 3
ACCURACY FOR CAPITAL LETTERS

i/p	Recognised Output for 30 Trails																									Success Rate
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
A	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
B	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
C	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
D	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
E	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
F	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
G	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
H	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
I	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
J	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
K	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
L	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
M	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
N	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	100%
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	100%
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	100%
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	100%
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	100%
S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	100%
T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	100%
U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	100%
V	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	100%
W	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	100%
X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	100%
Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	100%
Z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	100%

TABLE- 4
ACCURACY FOR SMALL LETTERS

The Tables 2,3& 4 shows the accuracy for Numbers, capital letters and small letters which are individually tested 30 times

i/p	Recognised Output for 30 Trails																									Success Rate
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	
a	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
b	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
c	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
d	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
e	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
f	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
g	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
h	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
i	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
j	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
k	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
l	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
m	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	100%
n	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	100%
o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	100%
p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	100%
q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	100%
r	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	100%
s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	100%
t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	100%
u	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	100%
v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	100%
w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	100%
x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	100%
y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	100%
z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	100%

VII CONCLUSION AND FUTURE SCOPE

The proposed method provides an easy way of teaching Braille Script to the first time learners since it gives the audio feedback of what is being written. It is based on simple method of obstacle detection using IR sensors. This system can be used to teach any language not only English alphabets and Numbers.

The proposed method uses IR Sensors & IR Leds and also magnitude comparators to detect the presence of marbles in the Braille Teaching Aid which makes the circuit bulky. These things can be replaced with Reed Relays and marbles can be replaced with spherical magnets.

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