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1. INTRODUCTION

1.1. Background:

Braille is a system of reading and writing used by people who are blind or visually impaired. It was invented by Louis Braille, a Frenchman who lost his sight because of a childhood accident. Braille's system uses raised dots on a page to represent letters, numbers, and punctuation marks, allowing people with visual impairments to read and write independently. Braille is a form of tactile communication that can be read with the fingers. The dots are arranged in cells, with each cell containing up to six dots arranged in two columns of three dots each. Each dot in the cell is either raised or not raised, creating a total of 64 possible combinations of dots. The Braille system uses these combinations to represent letters, numbers, and other characters. Braille is used worldwide as a means of communication for people who are blind or visually impaired and can be written using a special stylus and slate, or it can be produced using a computer with a Braille display or printer.

E-learning, or electronic learning, refers to the use of electronic media and technology to deliver educational content and instruction. This can include online courses, video lectures, interactive simulations, and other forms of digital learning. E-learning has become increasingly popular in recent years due to the convenience and flexibility it offers. It allows students to access educational materials and complete coursework at their own pace and on their own schedule, making it a popular choice for adult learners and those with busy schedules. And was an opted option during COVID and post COVID times, it is necessary for every individual to have access to the devices they need to compete in the growing world.

Braille education provides individuals with a means of literacy and allows them to read and write independently. It opens a world of knowledge, literature, and information that would otherwise be inaccessible. Braille education provides individuals with the tools they need to navigate the world independently. They can read menus, labels, and signs, write notes and letters, and communicate with others without relying on others. Braille education can increase employment opportunities for individuals who are blind or visually impaired. Many jobs require reading and writing skills, and braille literacy can give individuals the skills they need to succeed in the workplace. Braille education can help individuals who are blind or visually impaired to socialize with others. By being able to read and write, they can participate more fully in social and community activities and feel more connected to others.

Overall, braille education can improve the quality of life for individuals who are blind or visually impaired by giving them the skills and tools they need to succeed and thrive. Achieving braille education is important for individuals who are blind because it provides them with a means of literacy and opens a world of knowledge, literature, and information that would otherwise be inaccessible. Braille literacy allows individuals who are blind to read books, newspapers, and magazines, as well as to write notes and letters independently. This enables them to participate more fully in society and to communicate with others on an equal basis. For instance, Helen Keller a remarkable woman who became deaf and blind at a young age but went on to become a renowned writer, activist, and advocate for people with disabilities. Throughout her life, she was motivated by a desire to show that people with disabilities could lead fulfilling and meaningful lives, and that they should be treated with the same respect and dignity as anyone else. Keller's own experiences of overcoming her disabilities inspired many others to believe that they too could achieve great things.

Of the world’s 37 million blind people, an estimated 90% live in developing countries. About 15 million of them live in India, a number that has doubled since 2007 to make it the highest number in any country. However, the braille literacy rate there is only 1%, far lower than the regular literacy rate of 77.7%. With this project we are trying to make basic learning for blind and visually impaired more accessible and cost-effective. As Charles Darwin said in *Origin of Species ‘It is not the strongest of the species that survives, nor the most intelligent. It is the one most adaptable to change’.*

Basic Braille Sheet:

A: ⠁	J: ⠚	S: ⠎
B: ⠃	K: ⠅	T: ⠞
C: ⠉	L: ⠇	U: ⠥
D: ⠙	M: ⠍	V: ⠧
E: ⠑	N: ⠝	W: ⠺
F: ⠋	O: ⠕	X: ⠭
G: ⠛	P: ⠏	Y: ⠽
H: ⠓	Q: ⠟	Z: ⠵
I: ⠊	R: ⠗	

1.2. Aim and Objective of the Project:

Braille is a system of raised dots that can be felt with the fingertips, allowing people who are blind or visually impaired to read and write. The Braille system consists of patterns of raised dots arranged in cells or groups of six dots, with each cell representing a letter, number, punctuation mark, or other symbol. There are two main types of braille:

- Grade 1 Braille: Also known as uncontracted braille, Grade 1 Braille represents each letter of the alphabet and each punctuation mark with a separate cell of dots. This makes it easy to learn, but it can also be time-consuming to read longer texts.
- Grade 2 Braille: Also known as contracted braille, Grade 2 Braille uses combinations of dots to represent common words and letter combinations, making it faster to read longer texts. For example, the word "and" is represented by the dot pattern for the letter "a" combined with the dot pattern for the letter's "n" and "d".

However, we will currently focus on generating Grade 1 alphabets.

According to fact sheet of WHO for the blind and visual impairment updated August 2014, 285 million people in the world are visually impaired with 90% living in developing countries and literacy rate for visually challenged people is as low as 3% to 5% in most developing countries. The conventional technique for learning Braille is bulky and requires assistance and the available e-braille machines cost around $2000 in the States.

Realizing the social responsibility towards visually impaired and blind peers, we decided to develop cost-effective and self-learning e-braille, which will help blind and visually impaired people to learn braille alphabets without any assistance. This project is small scale and cost effective considering the requirements across the world, but it is a promising start for the goal of providing the blind and visually impaired people, the braille education that they need to succeed and compete in a dog-eat-dog world and will enable the students who are blind or visually impaired to access the same electronic learning materials as their sighted peers. This can level the playing field and provide equal access to educational opportunities, and this can make braille more accessible to a wider audience, including those in remote or underserved areas. Braille education can also increase an individual's confidence and self-esteem. It allows them to feel empowered and capable and can help them overcome the challenges and barriers associated with blindness.

1.3. Problem Definition:

To develop a self and e-learning program for tactile Braille that helps the visually impaired or blind peers to learn to read and type in braille grade 1, on their own, through audio-guided gamified content. The interactive Quiz mode is designed to keep the user engaged with a fun interactive quiz that will also help the learner to test their abilities; like Duolingo but for the blind and visually impaired.

1.4. Scope:

This project is low cost, small scale and cost effective considering the total need in the country, but they are a promising start to the goal of giving blind or visually impaired people the braille education that they need to succeed and compete. To gain the interest of students with two mode learning system and keeping track of their evaluation and learning with our Quiz mode. Quiz mode also helps with the competitive and cognitive development of the student. The conventional technique for learning Braille is bulky and requires assistance and the available e-braille machines cost around $2000 in the States. To make a cost effective that can be reached and accessible in the rural areas. There are many benefits to braille education for individuals who are blind or visually impaired, including:

Literacy: Braille education provides individuals with a means of literacy and allows them to read and write independently. It opens a world of knowledge, literature, and information that would otherwise be inaccessible.

Independence: Braille education provides individuals with the tools they need to navigate the world independently. They can read menus, labels, and signs, write notes and letters, and communicate with others without relying on others.

Employment: Braille education can increase employment opportunities for individuals who are blind or visually impaired. Many jobs require reading and writing skills, and braille literacy can give individuals the skills they need to succeed in the workplace.

Overall, braille education can improve the quality-of-life, inset confidence and help in socialization for individuals who are blind or visually impaired by giving them the skills and tools they need to succeed and thrive

2. REVIEW OF LITERATURE

Research has also been done on the relative solutions and alternative solutions present.

Available e-braille machines costs around 70K to 1 lakh Rupees in India and $2000 in the States. e-Braille displays can be expensive, making them difficult to afford for many individuals and organizations. This can limit the adoption of e-Braille technology, particularly in low-income areas. While the cost of e-Braille devices can be a barrier for some individuals and organizations, our initiative project aims towards making e-Braille more affordable and accessible. Some organizations offer e-Braille displays at a reduced cost or provide funding and grants to cover the cost of the devices, but there is a way around it to bypass this altogether.

E-Braille a self-learning braille device is an old project performed by alumnus of TERNA college. Helped in understanding the traditional problems with the device, for instance, the BeagleBone board; it is a traditional alternative which requires complex coding and limited future scope. And with our interactive quiz mode, we have added a zing not just to the project but to the user themself.

[1] The article presents the design and development of a refreshable Braille display that can be customized to suit the tactile sensitivity of individual users. The authors note that learners with different levels of tactile sensitivity require different sizes of Braille cells to achieve optimal reading speeds and comprehension. Overall, the article presents a promising solution for learners with different levels of tactile sensitivity, providing a more personalized approach to Braille reading that can help improve their learning outcomes.

[2] The article describes the development of a low-cost electronic Braille display for visually impaired individuals. The proposed Braille display is designed to be affordable and accessible to users in developing countries, where the cost of existing Braille displays is often prohibitively high. The authors describe the technical details of the proposed Braille display, which consists of a matrix of tactile pins that can be raised or lowered to form Braille characters. The article presents a promising solution for providing affordable and accessible Braille displays to visually impaired individuals in developing countries. The proposed Braille display has the potential to improve the quality of life for visually impaired individuals by enabling them to access information more easily and at a lower cost.

[4] The article discusses the design and development of a self-learning Braille device called E-Braille. The device is designed to help visually impaired individuals learn Braille more easily and efficiently. The authors note that traditional Braille learning devices can be expensive and difficult to use, which can make it challenging for visually impaired individuals to acquire this essential skill. The E-Braille device is designed to be affordable and easy to use, with a user-friendly interface and a variety of features to support Braille learning. The device includes a tactile matrix of pins that can be raised or lowered to form Braille characters, as well as a speech synthesis module that can be used to provide audio feedback and instructions. Overall, the article presents a promising solution for improving Braille literacy among visually impaired individuals. The E-Braille device has the potential to make Braille learning more accessible and affordable, which could have a significant impact on the quality of life for visually impaired individuals.

[5] The article presents a promising solution for improving the reliability and efficiency of protective relays in the petroleum and chemical industry. The use of digital protective relays has the potential to reduce downtime and maintenance costs, while improving the safety and performance of electrical systems in these industries.

3. PROPOSED SYSTEM and METHORDOLOGY

3.1. Proposed System:

3.1.1. Overview:

As the problem statement states the projects advancement focus at developing a self and e-learning program for Grade 1 tactile Braille that helps the visually impaired or blind peers to learn to read and type in braille, through audio-guided gamified content and without any external aid. The interactive Quiz mode is designed to keep the user engaged with a fun interactive quiz like Duolingo but for the blind and visually impaired that aims towards making learning more fun and creative. We have also proposed a sleep timer system where if the user is not using the proposed system for an hour, then the system will go to sleep; like the system Netflix uses where the program put the auto-play on hold if there is no interaction between the user and device for a certain period.

When the user turns on the system, it approximately takes fifteen to thirty seconds for Operating System to wake up and start executing the prompted program. Once the program is in an active state the user can toggle through the two fun and interactive learning modes: Type and Practice and the Quiz mode. It is mandatory for user to select a particular mode and press 'Enter' to continue forward. The algorithm flowchart of the designed system menu is given below:

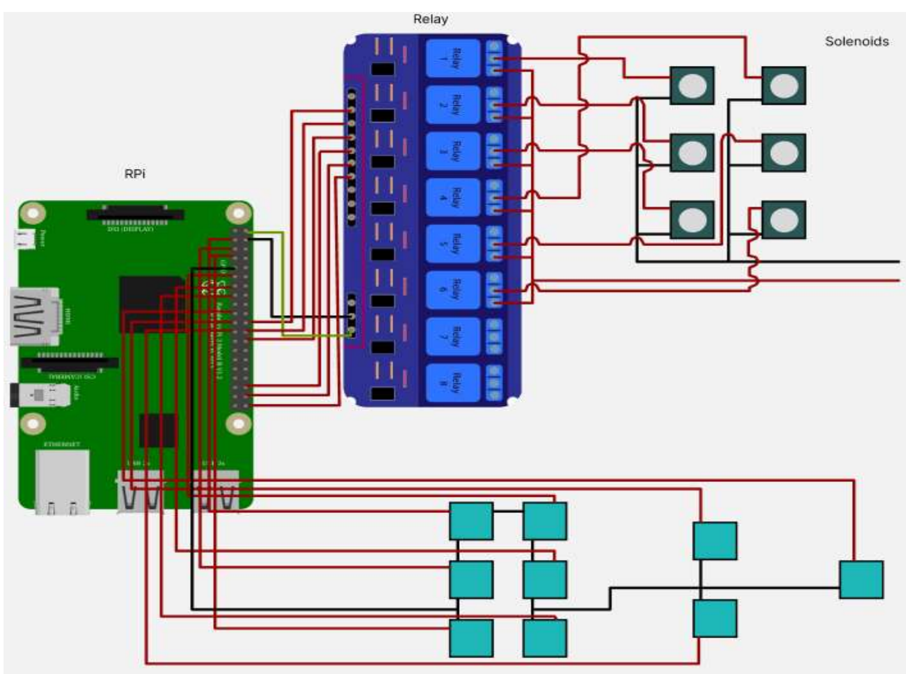

Figure 3.1 Circuit Diagram

3.1.2. Features:

Interactive Learning: The system will provide interactive and engaging learning that can be customized according to the student's learning preferences from the bi-optional menu.

Audio Support: The system will include audio support to assist students in learning pronunciation and guide them through the accessibility and features provided by the e-Braille Learning Device.

Progress Tracking: The system will track the student's progress and provide feedback to help the student identify areas that need improvement.

Gamification: The system will incorporate gamification elements to make learning more fun and enjoyable for the students. For instance, the Quiz Mode.

Accessibility: The system will be designed to meet accessibility standards, making it usable for students with different types of visual impairments.

Cost-Effective: While available solutions are expensive and not affordable to everyone. Our initiative project aims towards making e-Braille more affordable and accessible.

Other than the Learning and Supporting aspect of development in a student, it also helps in developing students' personality and grow emotionally by in setting them with; Confidence by increasing their self-esteem. It allows them to feel empowered and capable and can help them overcome the challenges and barriers associated with blindness. But also, socialization- Braille education can help individuals who are blind or visually impaired to socialize with others. By being able to read and write, they can participate more fully in social and community activities and feel more connected to others.

By achieving this basic braille education, the student who is blind or visually impaired will provide them with a means of literacy and opens a world of knowledge, literature, and information that would otherwise be inaccessible. Learners will gather basic intel on how to read books, newspapers, and magazines, as well as to write notes and letters, in braille, independently. This enables them to participate more fully in society and to communicate with others on an equal basis.

3.2. Methodology:

3.2.1. Sections of Architecture:

After the device is in run state. The user must select one of the following three modes and the operation will be carried further on.

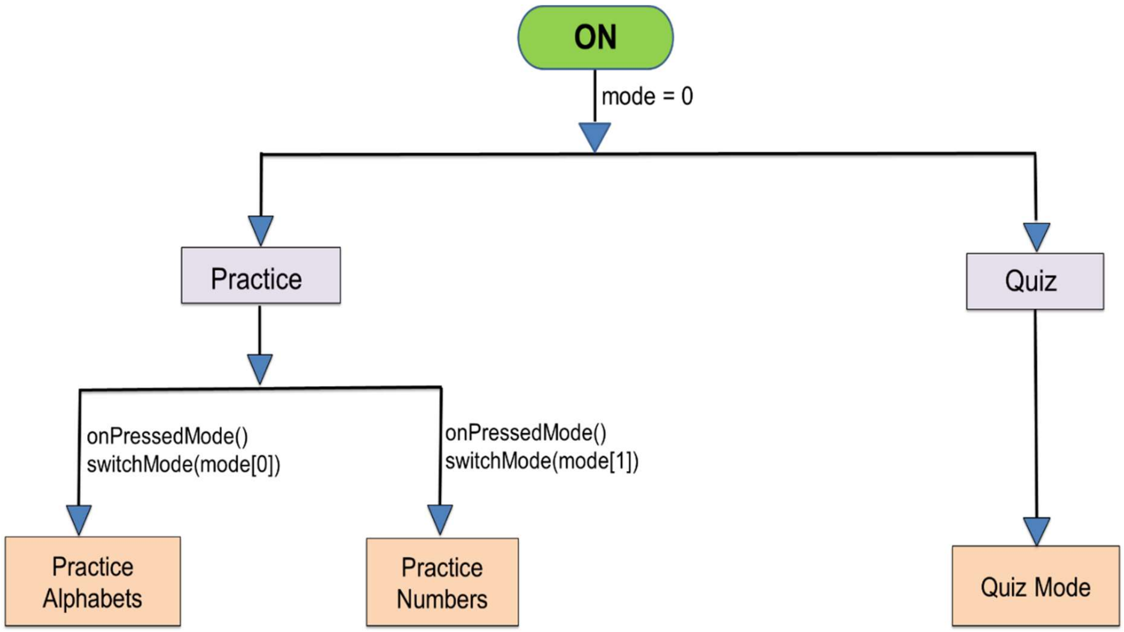

Figure 3.2. Types of mode flow chat.

Practice (Practice Alphabets)

In this mode, system will generate Braille pattern on Braille cell sequentially for all alphanumeric characters. First when the user presses mode button an audio will be prompted saying "Practice Alphabets, Press enter to continue", with that any solenoid which are set on will be deactivated. Initially variable i is set to 0, also the array of letters is defined which is a python list containing alphabets from A to Z. The variable i and letters list is defined globally which can be accessed by any function.

On pressing the enter button an audio is prompted saying "Type letter letters[i]", letters[i] is a particular letter from a list. After that braille display is activated. A particular combination for a particular letter is defined in the code which mentions that which solenoid should be activated for that pattern. Each solenoid works on either 6 V which draws about 1.2 A of current or 12 V which draws about 0.6 A of current. Solenoids are connected to the relays. Relays acts as a switch; the purpose of the relay is the solenoid draws much current which raspberry pi's GPIO pin cannot provide. For that purpose, solenoid is connected to relay for switching the solenoids of a particular braille pattern. A function activateBrailleSolenoids() is used which has a parameter as a letter.

As the pattern is displayed on the braille cell, the user has to feel the pattern and type that combination using a braille keypad. There is no time limit set, since the user is still practicing it will be beneficial to memorize the pattern rather than being in hurry. After the user has typed the combination, a function checkLetterTyped() is called to check whether the value inputted by the user and the combination of that letter is same. If the value gets matched an audio is prompted saying “Correct, Press next”.

Later when the user presses next button the value of i gets incremented by 1 again the same procedure happens for next letter.

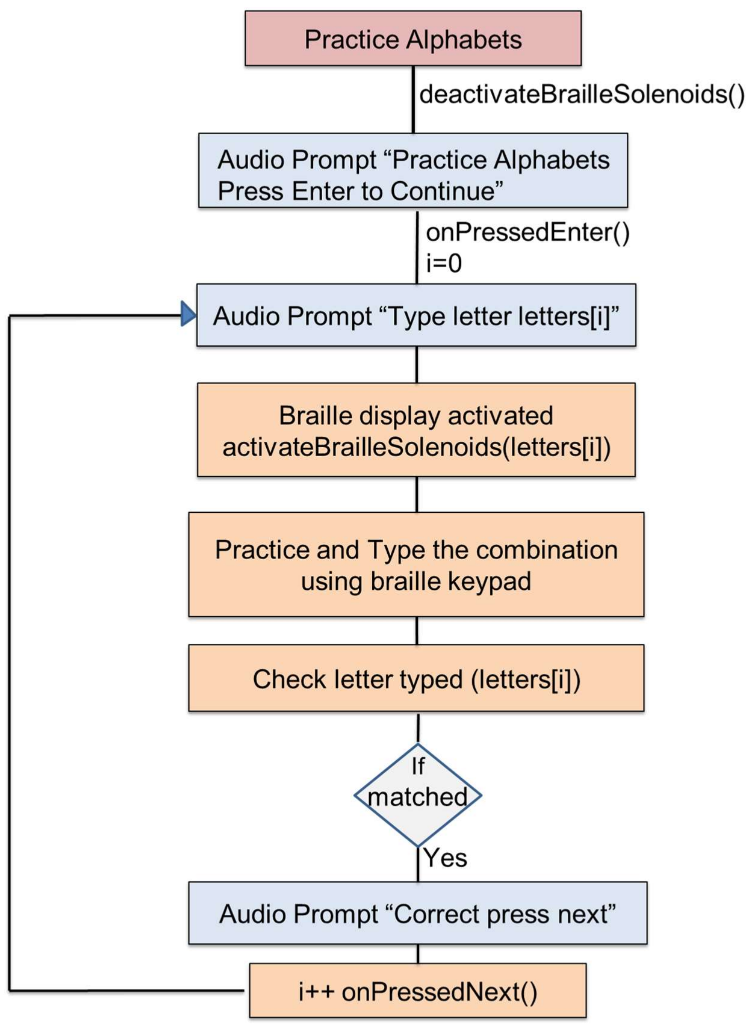

Figure 3.3. Practice alphabet mode flow chat.

Practice (Practice numbers)

In this mode, system will generate Braille pattern on Braille cell sequentially for all alphanumeric characters. First when the user presses mode button an audio will be prompted saying “Practice Alphabets, Press enter to continue”, with that any solenoid which are set on will be deactivated. Initially variable i is set to 0, also the array of numbers is defined which is a python list containing alphabets from 0 to 9. The variable i and numbers list is defined globally which can be accessed by any function.

On pressing the enter button an audio is prompted saying “Type letter numbers[i]”, numbers[i] is a particular letter from a list. After that braille display is activated. A particular combination for a particular letter is defined in the code which mentions that which solenoid should be activated for that pattern. Solenoids are connected to the relays. Relays acts as a switch; the purpose of the relay is the solenoid draws much current which raspberry pi’s GPIO pin cannot provide. For that purpose, solenoid is connected to relay for switching the solenoids of a particular braille pattern. A function activateBrailleSolenoids() is used which has a parameter as a number.

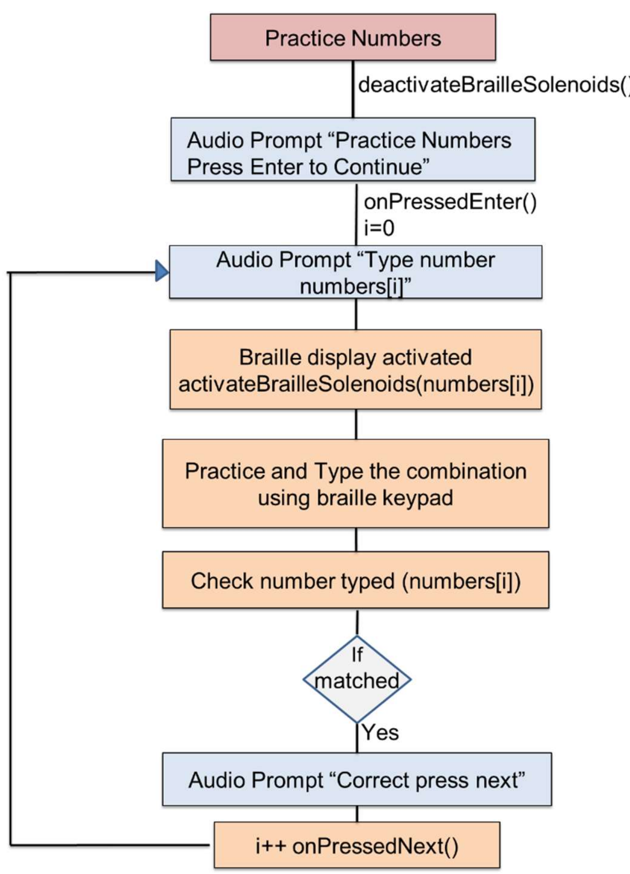

Figure 3.4. Practice numbers mode flow chat.

As the pattern is displayed on the braille cell, the user has to feel the pattern and type that combination using a braille keypad. There is no time limit set, since the user is still practicing it will be beneficial to memorize the pattern rather than being in hurry. After the user has typed the combination, a function checkNumberTyped() is called to check whether the value inputted by the user and the combination of that letter is same. If the value gets matched an audio is prompted saying “Correct, Press next”.

Later when the user presses next button the value of i gets incremented by 1 again the same procedure happens for next number.

Quiz mode

This mode is designed to test user's knowledge about Braille system. The system would ask 5 random questions to user related to braille pattern. In this mode, system will generate Braille pattern on Braille cell sequentially for all alphanumeric characters. First when the user presses mode button an audio will be prompted saying “Quiz mode, Press enter to continue”, with that any solenoid which are set on will be deactivated. Initially variable i is set to 0, also the array of numbers is defined which is a python list containing alphabets from 0 to 9 and letters A to Z. The variable i and alphabets and numbers list is defined globally which can be accessed by any function.

On pressing the enter button an audio is prompted saying “Type numbers[i]” or “Type letters[i]”, numbers[i] or letters[i] is a particular letter from a alphanumeric list. Initially testLetters is set to 5 so that the test is for about 5 alphabets or numbers. A random alphabet or number is generated from a alphanumeric list which is defined globally in the program. For generating random we are using python inbuilt random module. After the random is generated, an audio is prompted “Type random” here random is an alphanumeric character. For every random user has 3 attempts to test his/her knowledge. If it is correct next random is generated and same procedure is performed.

If the attempt is equal to 1, user has to learn and then type that character. As the pattern is displayed on the braille cell, the user has to feel the pattern and type that combination using a braille keypad. After the user has typed the combination, a function checkAlphanumberTyped() is called to check whether the value inputted by the user and the combination of that letter is same. If the value gets matched an audio is prompted saying

"Correct, Press next". Later the variable testLetters gets decremented by 1.

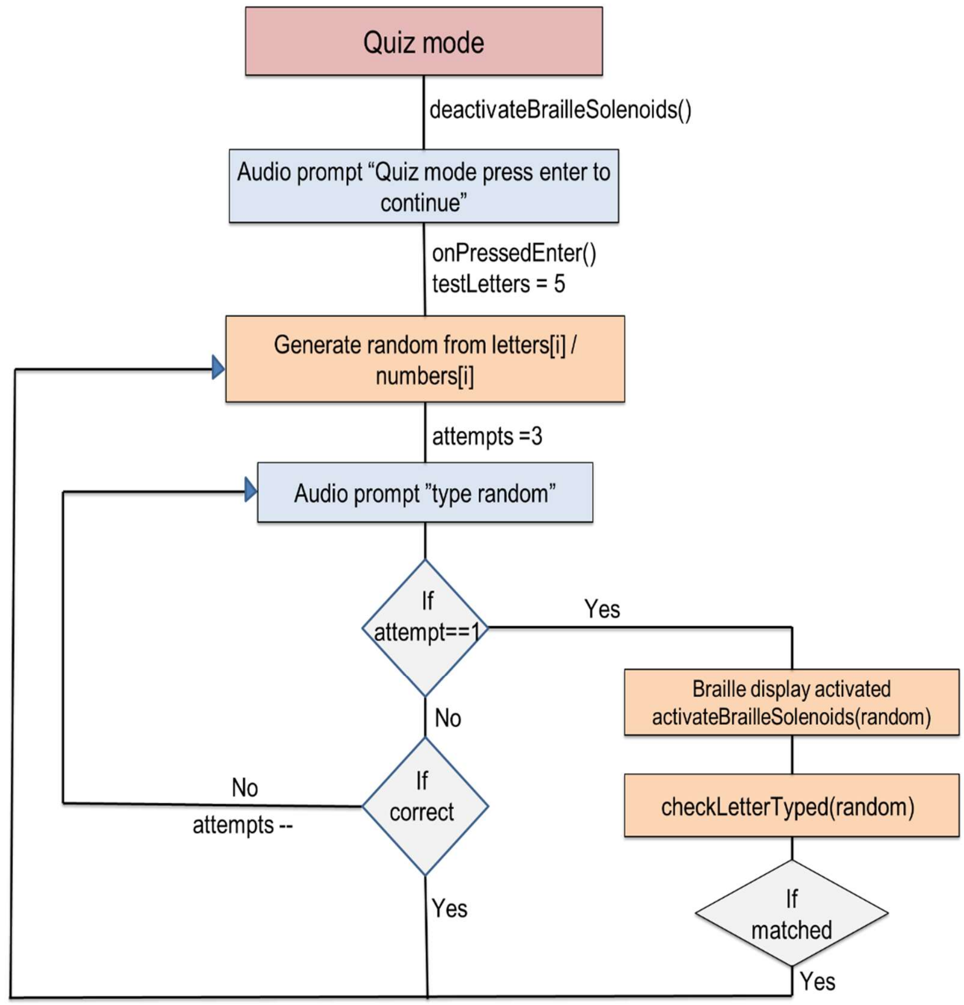

Figure 3.5. Quiz mode flow chat.

3.2.2. Implementation:

Hardware components used:

- Raspberry Pi 3B
- 6x Solenoid actuator, 6V
- 8 Channel relay, 5V
- 9x Push Buttons
- Jumper wires
- Prototype breadboard
- Power supply adapter, 12V 3A
- Speaker

Actuator:

In a e-braille system, an actuator is typically used to create tactile feedback for the user. When a button is pressed, the actuator provides a physical response in the form of a click or vibration, indicating to the user that the button has been successfully pressed.

The actuator is typically a small, electromechanical device that converts electrical energy into mechanical energy. When a button is pressed, an electrical signal is sent to the actuator, which then generates a physical response. In addition to providing tactile feedback, the actuator also helps to ensure that the button is pressed down completely, which is important for accurately registering the input. Overall, the actuator plays a critical role in the design and functionality of a braille keypad, helping to make it more accessible and user-friendly for individuals with visual impairments. A solenoid actuator can be used in a braille keypad to provide a tactile feedback response to the user. A solenoid is an electromechanical device that converts electrical energy into mechanical energy. When a user presses a button on a braille keypad that uses a solenoid actuator, an electrical signal is sent to the solenoid, which then moves a plunger or piston to create a physical response in the form of a click or vibration. The movement of the solenoid can be adjusted to provide different levels of tactile feedback, making it customizable to the user's preferences. Solenoid actuators are often used in high-traffic applications because they are durable and have a long lifespan. They are also capable of generating a strong physical response, making them an effective choice for users with varying levels of sensitivity.

Overall, a solenoid actuator can be an effective solution for providing tactile feedback in a braille keypad, enhancing the accessibility and usability of the device for visual impaired.

Sensor:

In this e-braille system, a sensor is used to detect when a button is pressed. When a user presses a button, the sensor sends a signal to the device's controller, indicating which button has been pressed. There are several types of sensors that can be used in a braille keypad, including:

Mechanical switches: These are simple, reliable switches that are activated when the user presses the button down. They are typically made of metal or plastic and have a long lifespan.

Capacitive sensors: These sensors detect changes in capacitance when a user's finger comes into contact with the button. They are commonly used in touchscreens and can be more durable than mechanical switches.

Optical sensors: These sensors use light to detect when a button is pressed. When the button is pushed down, it blocks the light from a light source, which triggers the sensor.

The type of sensor used in a e-braille keypad will depend on the specific design requirements and the desired user experience. Regardless of the sensor type, it is important that it is accurate and reliable to ensure that the user's inputs are correctly registered. While Optical sensors are more accurate and provide with better feedback; Mechanical switches are cheap and performs the job smoothly. Hence, mechanical switches are used in the development and final implementation.

Processor:

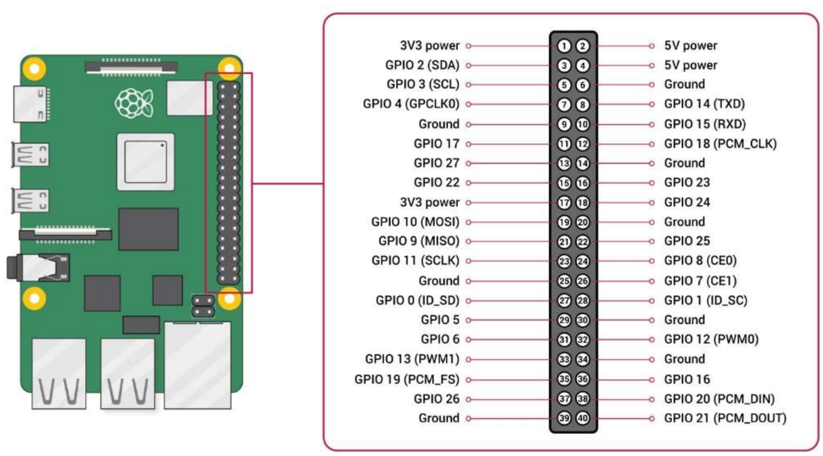

Figure 3.6 RPi 3B

Raspberry Pi 3B is chosen as the microcontroller board because it can be easily programmed and needs 5 Volt to operate. For this E-Braille system, Raspberry Pi receives character or number inputs from a computer and has 40 pins.

Pins 2, 5, 7, 11, 13, 15: Connected to Braille Keypad buttons.

Pin 19, 21, 23: For switching modes, Enter, Next.

Pin 9: Ground pin for buttons.

Pin 1, 2, 6: Vcc, JDVcc, Ground pins connected to relay.

Pin 22, 24, 26, 36, 38, 40: Connected to relay for activating solenoids.

Processor: Broadcom BCM2387 chipset. 1.2GHz Quad-Core ARM Cortex-A53 802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)

GPU: Dual Core VideoCore IV® Multimedia Co-Processor. Provides Open GL ES 2.0, hardware accelerated OpenVG, and 1080p30 H.264 high-profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure.

Memory 1GB LPDDR2

Operating System Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT. Dimensions 85 x 56 x 17mm Power Micro USB socket.

A microprocessor like Raspberry Pi (RPi) can be used in a e-braille keypad to control the input and output functions of the device. The RPi is a small, single-board computer that is capable of running a variety of software applications and programming languages. By using an RPi in a braille keypad, we have developed a more versatile and customizable device. The RPi can be programmed to interpret the input from the keypad's sensors and send signals to other components of the device, such as the solenoid actuator or display. Furthermore, for future development aspect the RPi can be connected to the internet or other devices, allowing for remote control and monitoring of the e-braille keypad. This feature can be particularly useful for individuals who may require assistance with using the device or for developers who need to troubleshoot or make updates to the software.

Overall, the use of a microprocessor like Raspberry Pi in a braille keypad can enhance the functionality and accessibility of the device, providing users with a more flexible and customizable experience.

4. DEVELOPED SYSTEM

4.1. Implemented System

4.1.1. Learning

A braille keypad is a device that allows individuals with visual impairments to input information into a computer or other electronic device using braille characters. Braille is a system of raised dots that can be felt by touch and is used by individuals who are blind or have low vision to read and write. To create a braille keypad, a microcontroller is typically used to control the input and output functions of the device. The microcontroller receives input from sensors that detect when a user has pressed a button on the keypad. The microcontroller then sends signals to a solenoid actuator to provide tactile feedback to the user in the form of a click or vibration. The microcontroller can also send signals to a display to provide visual feedback to the user. The software for a braille keypad project typically involves programming the microcontroller to interpret the input from the sensors and send signals to the solenoid actuator and display. The software can also incorporate features such as customizable tactile feedback and remote control options.

Overall, a braille keypad project involves combining hardware components and software programming to create a device that is accessible and user-friendly for individuals with visual impairments. By using a braille keypad, individuals with visual impairments can more easily input information into electronic devices, enhancing their independence and ability to participate in various activities.

4.1.2. Product

It a great way to enhance accessibility for individuals with visual impairments. Here is the output of the initially implemented design:

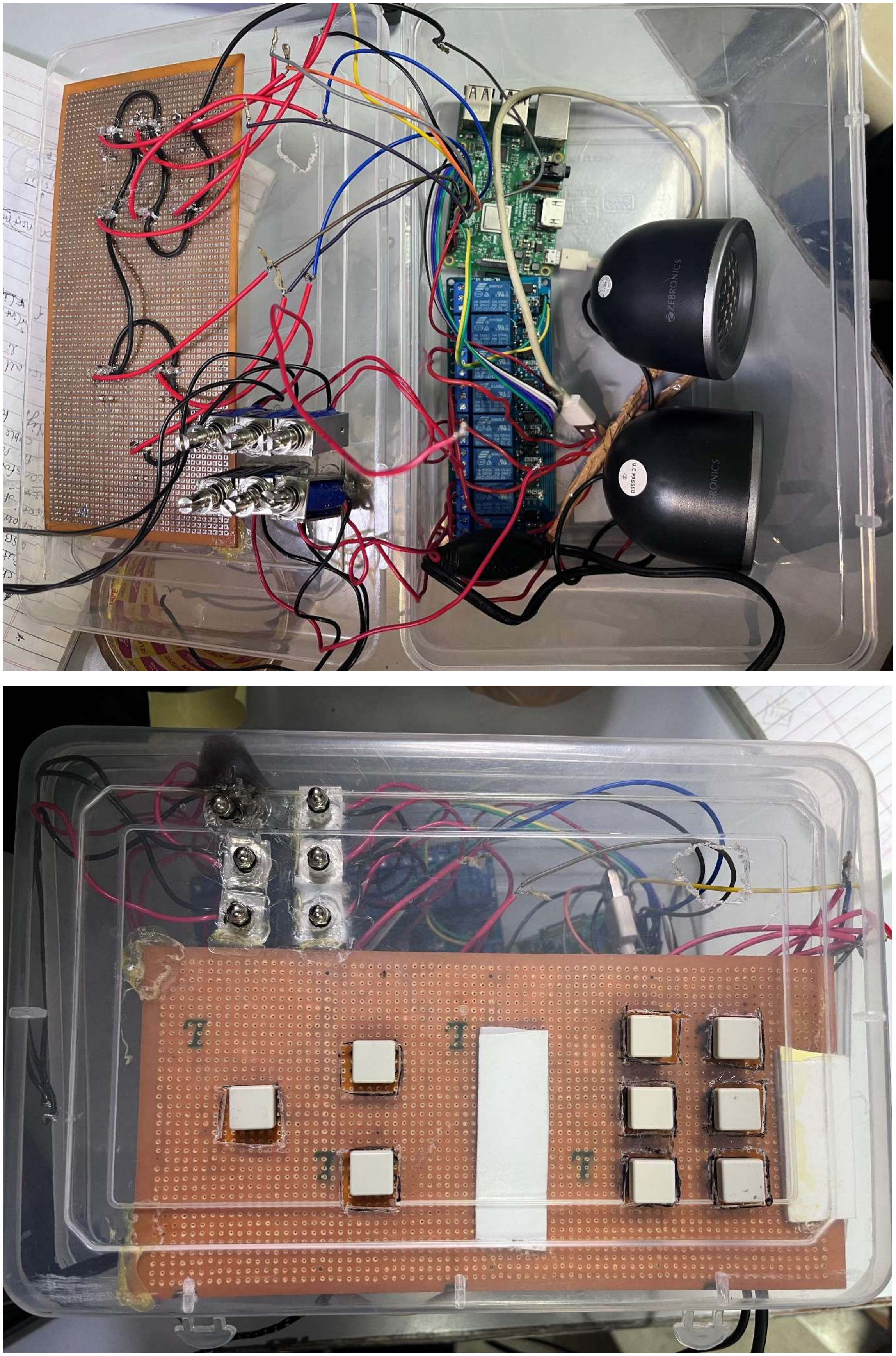

Figure 4.1. Designed Product

5. CONCLUSION

The problem of braille literacy is creating a major hurdle in enabling the visually disabled people in achieving a rightful place in the society. The braille system is an independent, user friendly, portable and cost-effective manner. It can enhance the learning ability of visually challenged people in a comfortable and interactive way. The estimated cost of the project is around Rs.10K, that is almost 8x cost efficient than available devices in the market.

Bi modal learning system and keeping track of their evaluation and learning with our Quiz mode. Quiz mode also helps with the competitive and cognitive development of the student, whereas Speak and Practice mode and Type and Practice mode help in language development of the end user.

The problem of Braille literacy is creating a major hurdle in enabling the visually disabled people in achieving a rightful place in the society. The use of Braille system is inevitable for such people. Our project emphasizes the use of Braille system in an independent, user friendly, portable and cost-effective manner. It can enhance the learning ability of visually challenged people in a comfortable and interactive way. The software processing that is performed in the project is developed independently and does not rely on internet connectivity. The different modes of operation ensure a user-friendly approach for the designed system. This device can be used effectively to make learning Braille easy. It can prove to be a breakthrough in enhancing the literacy rate for visually challenged people.

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