EGTactile “Braille display device”

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***Abstract*— Braille display is a device from which the visually challenged people can read the text output from the computer in the form of Braille character. The commercially available Braille display price is so expensive so it can’t be easily available for poor visually challenged people. So, this paper discusses the making of new type of Braille display, by rotating multi octagonal segments for braille display, with low cost, It’s also notetaker. Here the text is converted into Braille character by rotating each octagonal segment, which contains all possible combination of raised dots of one column of Braille cell on its faces, to a particular degree. The required Braille character appears on the top face of the octagonal segments. This paper further discusses the mechanical design of a new Braille display, converting text into corresponding degree of rotation to achieve the correct output (Braille characters).**

Keywords—CD-ROM stepper motors, mechanical design, low braille display and notetaker device.

I. INTRODUCTION

This paper presents the design and development of a low-cost Braille display and notetaker device with the objective of improving the accessibility of digital information for blind and visually impaired individuals. The device is portable, lightweight, and easy to use, with features such as haptic and auditory feedback, reading from USB, and the ability to take notes with Braille and save as a text file. The device utilizes readily available components and materials, and thorough testing ensure the final product meets the needs of the target audience. This low-cost solution aims to improve the quality of life and independence of visually impaired individuals, with the potential to be manufactured in future generations. Braille symbols are formed within units of space known as Braille cell, which consists of six raised dots arranged in two parallel rows each having three dots. A single cell can be used to represent an alphabet, number, special characters, or even a whole word by raising different combination of dots. English alphabets are represented in Braille code as shown in **Figure1** The dot positions are identified by numbers from one to six.

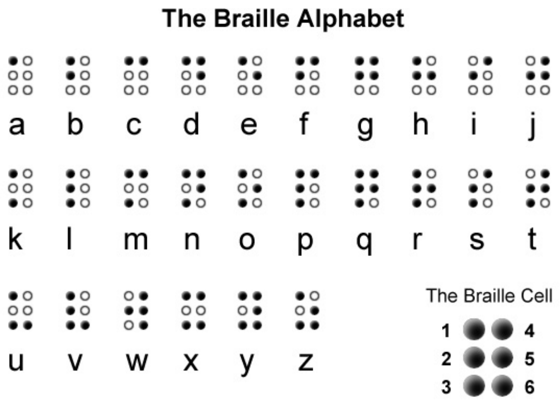

Figure 1_Braille Alphabets [1]

II. EXISTING BRAILLE DISPLAY

Braille display is a device used to tactually read information directly from the computer by the visually challenged people. There are many Braille technologies proposed, only piezoelectric Braille display[2] is commercially available in the market. That also too much expensive; it can’t be easily avail for everyone. Many researches are being conducted to develop a new type of Braille display in low cost. Some uses electromagnetic mechanisms[3], push-pull solenoids[4], gear mechanisms[5], brushless DC motors[6], Geneva wheel mechanisms and shape memory alloys[7] for developing Braille display. Some others proposed using piezoelectric linear motors[8].

III. SYSTEM ARCHITECTURE

The system architecture diagram for the low-cost Braille display and notetaker device consists of several components that work together to provide a seamless user experience.

The user interface component includes user-friendly controls and navigation buttons that are easy to locate and use, even for visually impaired individuals to control the device, to navigate between menus, choose what he wand and also to write in text files. The device also features audio feedback which provide users with real-time feedback on their interactions with the device, enhancing their overall user experience.

The data transfer component includes a USB port that enables users to read digital content from a USB drive, providing a cost-effective way for users to access and transfer digital content to the device to be able to read digital content in braille after conversion. The device also allows users to take notes using Braille, which can then be saved as a text file for future reference or sharing after converting braille to English characters.

The Braille display component is a critical element of the device, featuring Braille cells that can be mechanically moved to form tactile dots, allowing visually impaired users to read Braille characters in a cost-effective manner. The Braille display component is connected to the device's microcontroller, which translates digital content into Braille characters, and sends signals to the Braille cells to form the corresponding tactile dots.

The microcontroller acts as the central processing unit of the device, receiving input from the user interface and USB port, and processing the data to generate the corresponding Braille characters and signals to the Braille display component. The microcontroller also manages the device's power management, ensuring optimal power consumption and efficiency.

Overall, the system architecture of EGTactile is designed to be intuitive, user-friendly, and efficient, enabling visually impaired individuals to access digital content and take notes with ease. The system architecture diagram provides a visual representation of the various components and their interactions, contributing to the overall understanding and evaluation of the device's design and functionality. EGTactile device system architecture shown in **Figure 2.**

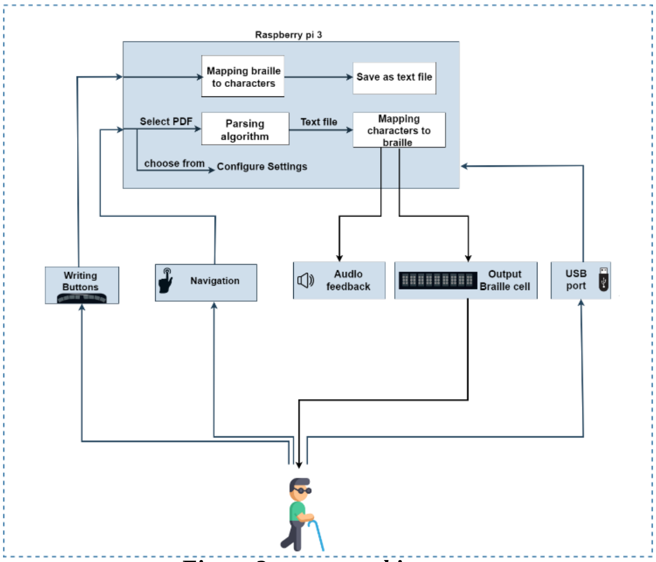

Figure 2_system architecture

IV. MECHANICAL DESIGN

Despite the drawbacks of motors, the most significant of which is size, we wish to reduce their constraints, which leads to the selection of "**CD-ROM stepper motors**" from laptops as shown in **Figure 3**, In this implementation, each character will only require two motors, 3D design for the mechanism used in this paper shown in **Figure4**.

Single octagonal contains of 10 faces represents a single column of Braille cell as shown in **Figure4.** Two octagonal disks combined together represent a Braille cell (Braille character).

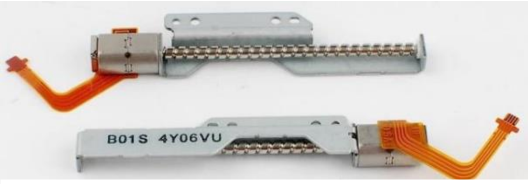

Figure 3_CD-ROM steppper motor

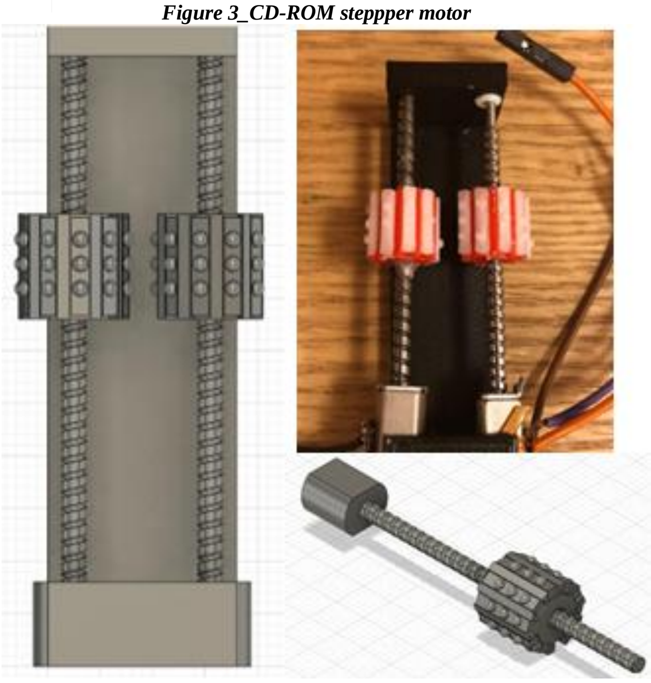

Figure 4_3D model and actual view for the mechanism

V. SOFTWARE

A. *Notetaking software system*

Software part:

1. Dictionary that contains all characters

2. Key = weight of the character, value = the character

3. Every button has weight, when the user presses buttons that he wants, the algorithm adds all weights and maps it to its character using this weight.

The weights are calculated as shown in **figure 5.**

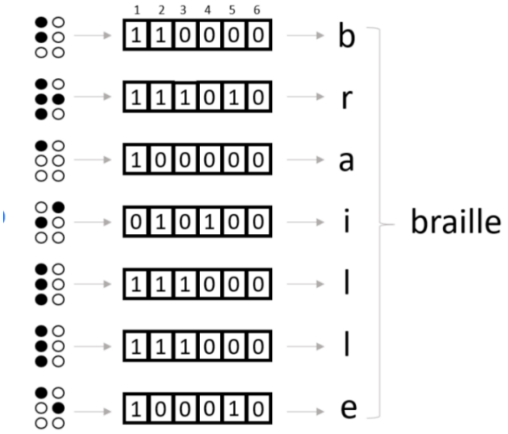

Figure 5_Braille to text conversion

B. *Braille display software system*

Software part:

1. Parsing PDF to txt files using pypdf2 library. PDF may be from
2. USB or from memory of the device.
3. Read txt files and convert each character to corresponding character in braille.
4. Map for all characters: 2 value pair, key is the character we Need to map, value is a tuple, 1st number of characters in 10 faces octagonal of braille cell, 2nd index of this face.
5. Map every character with characters in this map, if it exists Return the tuple, if NOT return 0,0.
6. Determine how many steps the motors should move after Conversion using the tuple created before. One character is shaped by two motors.

VI. RESULTS

The Braille display component, which was designed to be cost-effective and reliable, uses mechanically moved Braille cells to form tactile dots, providing visually impaired users with an efficient and accurate way to read Braille characters. The device's ability to read digital content from a USB drive and take notes with Braille and save them as text files also provides a cost-effective and efficient solution for managing digital content.

A. *Motor driver PCB*

Double layer PCB for motor driver to two motors together.

Figure 6_3D view for motor driver PCB (Top)

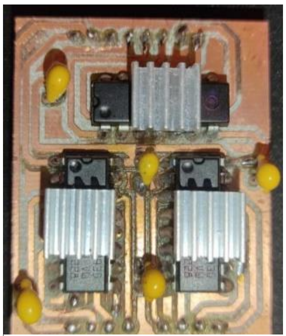
Figure 7_Actual view for motor driver PCB (Top)

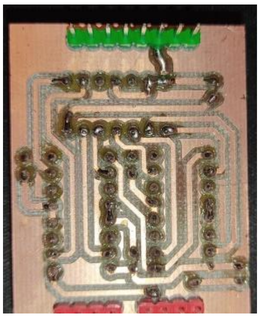
Figure 8_Actual view for motor driver PCB (Bottom)

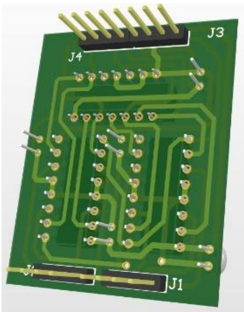

Figure 9_3D view for motor driver PCB (Bottom)

B. *Buttons PCB*

Single layer PCB.

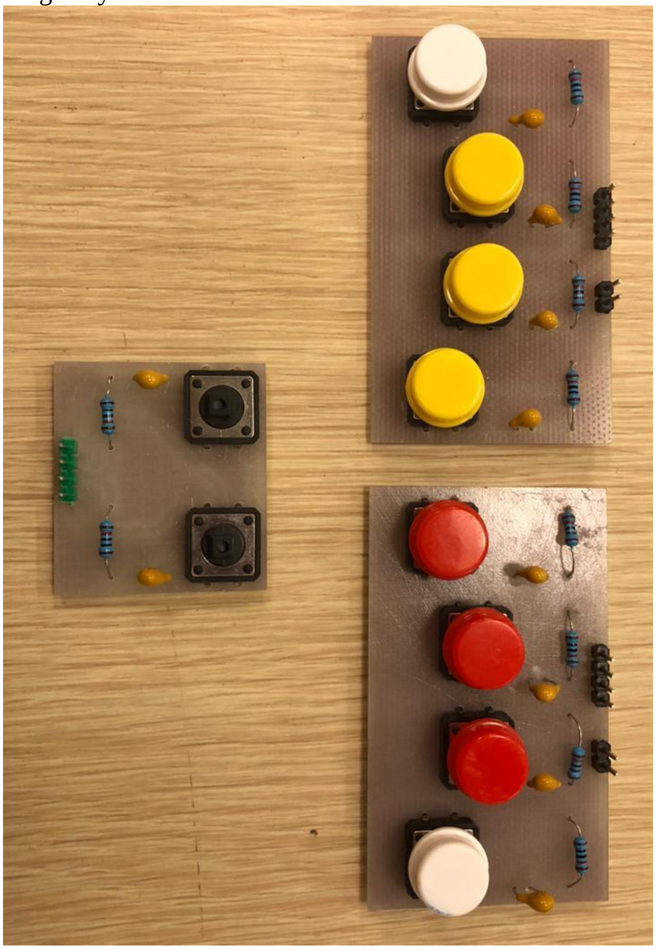
Figure 10_Buttons PCB

Overall, the results of our evaluation indicate that the low-cost Braille display and notetaker device has the potential to significantly improve the quality of life and independence of visually impaired individuals, providing a cost-effective and accessible solution for accessing digital content and taking notes. The device's ease of use, affordability, and reliability make it a promising addition to the field of assistive technology, with the potential for future advancements and improvements.

C. PCB for holding motor drivers

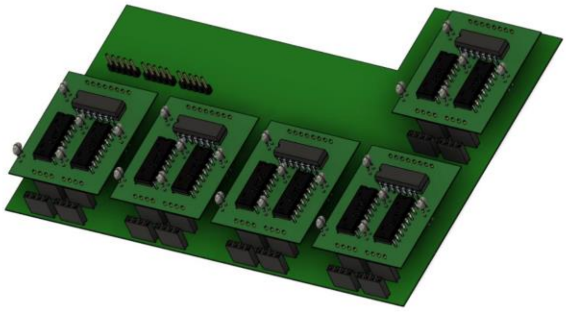

Figure 11_PCB for holding motor drivers.

D. Packaging 3D design

Figure 12_3D design for braille display device view1

Figure 13_3D design for braille display device view2

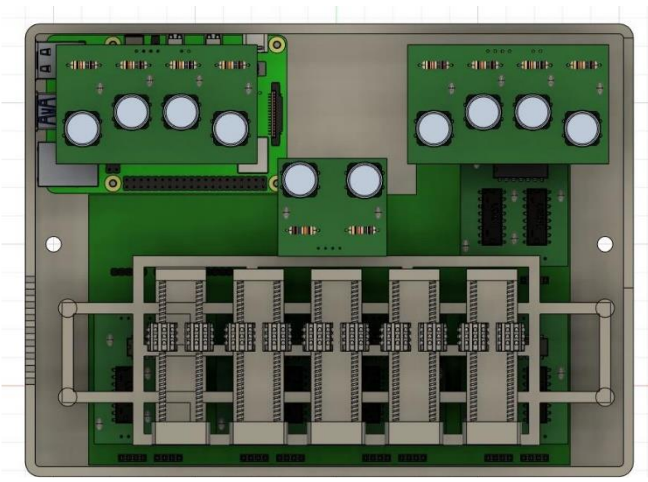

Figure 14_internal 3D design for braille display device

E. Metrices

H/W metrices for braille display device:

Number of braille cells	**5**
Refresh rate	**100ms** for every motor for refresh all braille cells
Connectivity	USB
Power consumption	Two power sources: 1. One for Raspberry pi =2 ampere & 5 Volt 2. One for motors (max 3 ampere & 3.3 Volt) Can be 1 ampere & 5 volt but it'll take more time to display characters. **Total (MAX when all motors run)** **=** **5 ampere & 5 Volt**
Size and weight	Lightweight ~ 650 gm
Noise level	No noise

Table 1_H/W metrices

The table below shows a summarized comparison between EGTactile and one of the popular braille display devices "Chameleon 20".

	Cost	Energy	Latency
EGTactile	~$90	Internal⟶5 Volt **LOW** External⟶5 Volt **LOW**	**LOW** **(~100 ms)**
Chameleon20	$1,715.00	Internal⟶3600 Volt **HIGH** External⟶**LOW**	**LOW**

Table 2_Comparison

Accuracy measures for EGTactile will refer to the ability of the device to correctly translate and display digital content into braille, as well as the accuracy of the device's note-taking features as shown in table 3:
These values are based on 20 trials of testing at various times.

	Notetaker	Braille display
Character accuracy	98%	97%
Word accuracy	98%	96%
Note-taking accuracy	98%	-
Translation accuracy	98%	97%

Table 3_Accuracy measures

I. Conclusion and future work

A. Conclusion

The low-cost braille display project has developed a simple and easy-to-use device that addresses the issue of accessibility for visually impaired individuals. The device is safe, comfortable, and appropriate for blind people to read, write, and edit text files in English. The project aims to make braille display devices more accessible by leveraging low-cost materials, which has the potential to significantly reduce the cost of such devices. Despite challenges and limitations, the project has the potential to make a meaningful difference in the lives of visually impaired individuals by improving their accessibility to information and communication.

B. Future work

The following tasks are suggested as future works:

1. Wireless connectivity: The braille display can be further developed to enable wireless connectivity, such as Bluetooth or Wi-Fi, to provide greater flexibility and convenience for users.
2. Integration with voice assistants: The braille display can be enhanced to integrate with voice assistants such as Siri or Alexa to provide a more comprehensive solution for visually impaired individuals.
3. Support for multiple languages: The braille display can be further developed to support multiple languages such as Arabic, enabling users to read and write in their native language.
4. Replace power supplies with removable batteries.
5. Advanced navigation features: The braille display can be further developed to incorporate advanced navigation features such as search, bookmarks, and annotations, enabling users to more easily navigate and interact with digital content.

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