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Raspberry Pi based braille keyboard design with audio output for the visually challenged

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Abstract – Most blind and visually impaired students in third world countries still use mechanical braille for their education. With the advancement of technology and the spread of electronic communication, paper-based Braille is not effective and efficient enough. The Raspberry Pi-based Braille keyboard design with audio output is a low-cost electronic keyboard whose main features are to vocalize Braille characters written by a visually impaired student and display them on an LCD screen. Proposed to promote an interactive educational experience among students, teachers and parents, the Braille printer is affordable and cost-effective with advanced features. The design of the device is simple as it is based on Raspberry Pi technology. The user hears the output after a short buzzer beep when the character typing process is finished. gTTS (Google Text-to-Speech) is a Python package and Google Translates text-to-speech API is used to convert text to speech. The data is displayed on an LCD screen for the non-visually impaired (teacher/parent). The Braille keyboard study is designed through the Proteus simulation program. This work focuses on developing a Braille keyboard for later stages that allows users to use the Braille writing system to enter text and communicate with digital devices.

Keywords – Braille, Python, Keyboard, Raspberry Pi, Visually Challenged People, Voice Output

I. INTRODUCTION

One of the most important and necessary elements for us to recognize the individuals around us is our vision. Because our eyes provide 83% of our information about our surroundings [1]. Whether a person has full or partial visual impairment, they are considered visually impaired [2]. According to World Health Organization figures, there are 285 million visually impaired people worldwide, of which 39 million are blind and 246 million have limited vision [3].

The challenges that blind people face in their daily lives have necessitated the development of technologies to ease their burden. With the advancement of technology, academics have recently been trying to design methods to alleviate these challenges [4]. 90% of blind people live in underdeveloped countries. Despite the continuous advancement of technology, people with severe limitations are unable to benefit from it. Given the importance of this emerging technology in the education of blind youth, the creation of a low-cost device to translate Braille into Latin would allow schools to overcome this barrier not only educationally but also financially.

Braille is a code and a tactile writing tool that enables the visually impaired to write and read in any language. Since its introduction in 1821, Braille has been recognized as the leading method of written communication for visually impaired people around the world. It continues to be used today without fundamental change [5]. Braille is a tactile reading and writing method for the visually impaired that uses raised dots to represent letters in the alphabet. Punctuation marks, scientific letters, foreign languages and similar symbols are used to symbolize various representations. Each line is read by moving your hand from left to right. The Braille keypad cells are touched simultaneously according to the Braille combination of the letter or number the user needs to enter (see Figure 1).

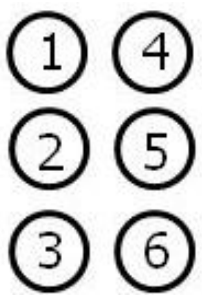

Fig. 1 The Braille cell.

Figure 2 shows the braille codes of the Latin alphabet. Nemeth [6] is another code used for math and science notation.

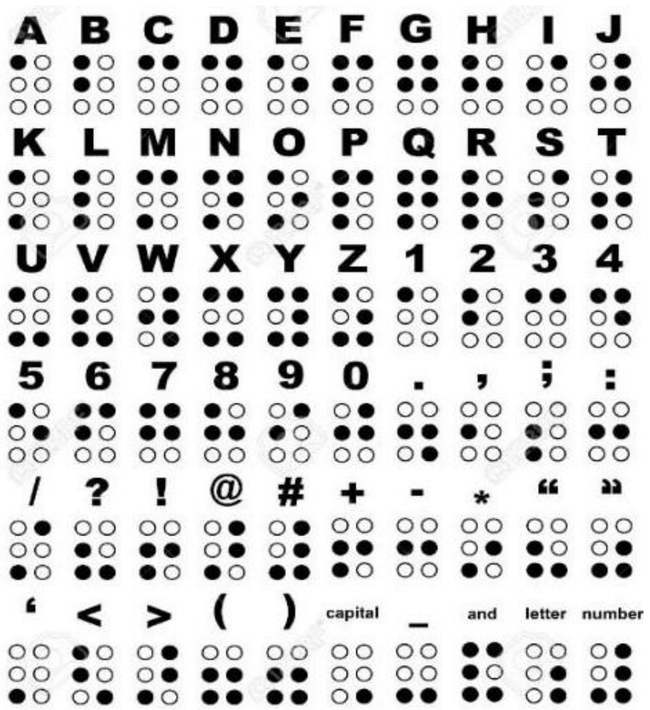

Fig. 2 The Braille system is used to represent English characters, symbols, and numbers.

Electronic Braillers are devices that convert electronic impulses into user input. Electronic equipment are typically faster and easier to use than mechanical ones. Table 1 compares some Brailles on the market based on their pricing and various functions.

Commercial Braille devices [7] are characterized by large volumes and high costs, as indicated in the comparison table (see Table 1). As a result, third world countries cannot benefit from this emerging technology. Because of these disadvantages, various efforts are being made to teach low-cost Braille embossing.

Table 1. Comparison table of commercially available Braille devices.

Brailler	**Price ($)**	**Weight (kg)**	**Edit, saves convert to text**	**Audio Feedback**
Mechanical(Perkins)	750	4.7	No	No
Next Generation	710	3.6	No	No
Electric(Perkins)	995	5.08	No	No
Smart Brailler	2195	3.9	Yes	Yes
Jot-A-dot	425	0.35	No	No
Tatrapoint	1540	2.75	No	No
Mountbatten electrical brailler	3895	4.7	Yes	Yes
Cosmo Braille Writer	2330	-	Yes	Yes

Single-board computers, which basically consist of a processor, RAM and input-output modules, have emerged in recent years. Popular among users due to their low price, these computers are often project-based. The Mini2440 is the first example of this trend, which is proving to be extremely popular. This ARM-made computer has an ARM9-based 400MHz Samsung processor, 64MB RAM, 1GB FLASH memory and 34-pin GPIO [8]. Another board in this category is the BeagleBone produced by the BeagleBoard.org organization. The BeagleBone computer has a 720MHz ARM Cortex-A8 processor, 256MB RAM and two 46-pin GPIO connectors [9].

The Raspberry Pi organization launched the Raspberry Pi board in 2011 [10]. The original model, the Raspberry Pi Model B (see Figure 3), has sold more than 2 million units.

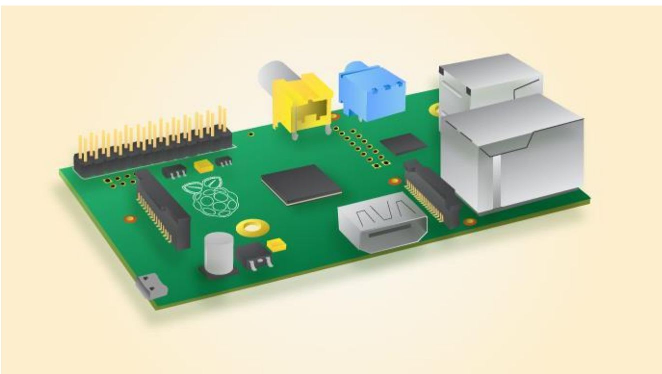

Fig. 3 Raspberry Pi Model B

The Raspberry Pi Model B computer is powered by a 700MHz ARM-based Broadcom processor, 512MB RAM, two USB2.0 ports and a 26-pin GPIO connector. The most important element in the sales graph of this computer is its price of $35. Many researchers have been working to take advantage of the Raspberry Pi computer. Dave Akerman and his colleagues attached a Raspberry Pi to a weather balloon and photographed the Earth from 40 kilometers away. Dr. Simon Cox and colleagues assembled 64 Raspberry Pi boards to create an experimental supercomputer. Although the Raspberry Pi is a powerful computer for its price, it has its limitations. Although it can be used as a desktop, its performance is comparable to a mobile device (such as a tablet). According to the Raspberry Pi organization, the overall performance of the Model B is comparable to a PC with a 300MHz Pentium 2 processor. Graphics performance is comparable to, if not superior to, the original Xbox gaming system. The Raspberry Pi runs Linux as the operating system. There are several Linux distributions for Raspberry Pi that can be downloaded from www.raspberrypi.org.

When connected to peripherals such as a display, keyboard and mouse, the Raspberry Pi can be used as a desktop PC; however, what distinguishes the Raspberry Pi from other desktop computers is that it has GPIO or general purpose input/output pins that can be controlled by software (see Figure 4). As a result, components such as buttons, LEDs and motors can be operated using the Raspberry Pi board in the same way as a microcontroller.

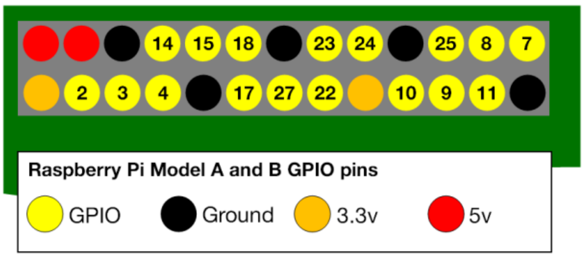

Fig. 4 Raspberry Pi GPIO pin outs

There are currently several microcomputers on the market for the creation of systems to assist people with disabilities. These devices include the UP2 Squared, Huawei HiKey 960, ODROID-XU4 and Arduino Uno. However, most of them are either very costly or have lower processing speeds and less functionality than Raspberry Pi. Many studies in the literature have indicated that using Raspberry Pi to design systems to assist the visually impaired guarantees the portability of the device and allows it to be used comfortably anywhere.

Venkateswarlu et al [11] investigated the efficiency and cost effectiveness of developing a Raspberry Pi based system for text-to-speech translation to assist visually impaired students in their studies. The system is simple to use as the Raspberry Pi is a credit card sized device with full computing capability. According to Sharath et al [12], one of the key advantages of adopting Raspberry Pi to create a system to assist the visually impaired is its low cost and security.

The Raspberry Pi can be connected to the cloud, which serves as the foundation for the Internet of Things and intelligent automation and control of devices and sensors. According to Baskaran and Balachander [13], the low cost of the Raspberry Pi makes it ideal for experimentation. According to Rajbongshi et al [14], most text-to-speech libraries on the Raspberry Pi are compatible and can be easily incorporated into Linux applications. Dunai et al [15] underlined that Raspberry Pi based solutions are cheaper. According to Akour et al [16], the Raspberry Pi acts as a server to which other components can be added in the creation of intelligent systems. According to Ismail et al [17] , Raspberry Pi-based systems are easily scalable. As a result, additional sensors and devices can be added to the system to increase functionality when needed.

In this study, the Braille keyboard circuit board was connected to the Raspberry Pi, allowing the visually impaired user to enter the alphabet. The Raspberry Pi is simple to use as it does not require extensive knowledge of programming. The Raspberry Pi acts as a controller that controls and monitors a wide range of system processes [4]. Thanks to logarithms and Python-based coding, Raspberry Pi produces precise results. If an electronic Brailler is properly developed, visually impaired people can use it to help them navigate computers in the same way as sighted people.

II. Materials and Method

This paper describes the design of a low-cost braille-to-text converter using the Proteus simulation environment. Braille keypads use braille cells as six keys that can be pressed simultaneously to type a specific letter, word or number based on actual braille combinations. This device can detect which of the six braille keys is pressed, convert the braille characters into alphabetic characters displayed on the corresponding screen and read them aloud. This type of braille is ideal for blind or visually impaired students who do not need to learn the standard "QWERTY" keyboard.

This design actively engages students in the learning process while at the same time providing a platform for their writing abilities. Teachers and parents can interact with their visually impaired peers who are not familiar with Braille. Voice assistance is also available in the system, enabling the visually impaired individual to hear and recognize the equivalent alphabetic character of the Braille character and be guided through their work. The main components of the Brailler system are shown in Figure 5.

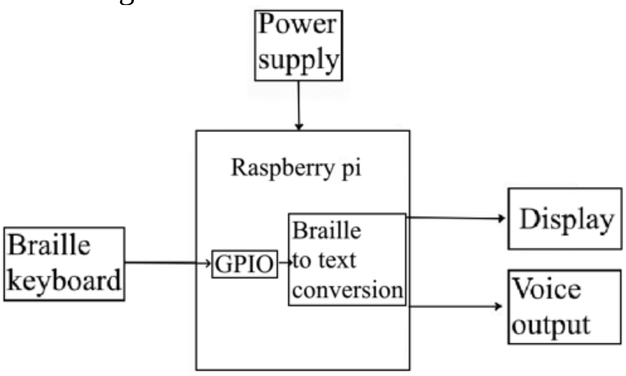

Fig. 5 Block diagram of the system.

The keyboard is connected to the Raspberry Pi using the system's GPIO inputs. A +5.1V micro USB power supply powers the Raspberry Pi 3. The Raspberry Pi detects the key pressed and is suitably designed to translate braille code into alphabetic letters. The LCD display is added so that non-disabled people who follow what is typed can see what data is being typed, rather than visually impaired users. The audio output is used to provide a vocalization of the entered character.

The Google text-to-speech API converts text to speech. gTTS (Google Text-to-Speech) is a Python library and command-line interface for interacting with Google Translates' text-to-speech API. This API takes text as input and outputs an audio file as output. After that, the audio file is saved in .mp3 or .m4a format or some other format. A music player is then used to play this .mp3 audio file.

The buzzer emits a short sound after pressing the keys or inserting the character in the Braille cell. This buzzer reminds the user of the sequence of actions. During the program phases, the user starts typing in braille code and the software checks the keys pressed. This mode continues until the user presses the letter indicator. If the general key is pressed after the braille code for the character is written, a buzzer sounds and the character is displayed on the screen.

The sound is transmitted to the player and the cycle repeats. Figure 6 shows an overview of the design created in the Proteus simulation environment and includes an LCD display, braille keyboard, Raspberry Pi, buzzer and power module.

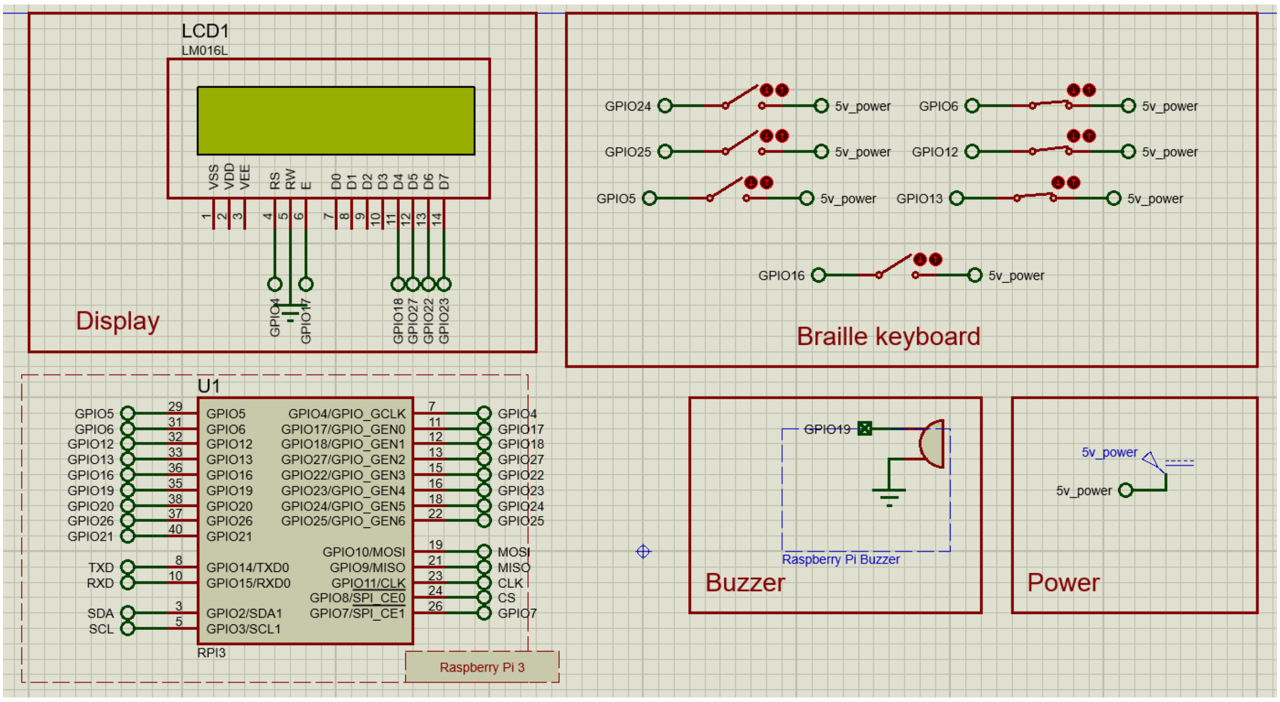

Fig. 6 Screenshot of Proteus simulation environment.

III. Results and Discussion

The accuracy and ease of typing on a Braille keyboard is extremely enjoyable for both students and teachers compared to a regular keyboard. This technology provides a variety of tools to connect with visually impaired students. Most of such projects are carried out more intensively in poor or third world countries. Consequently, there is a need for more research on the subject to increase academic experience, improve the current system and advance the current algorithms used.

The Braille keyboard design in this paper aims to provide a simple and effective data entry technique for the visually impaired. The aim of the work is to increase inclusion and accessibility by making it easier for visually impaired people to connect with digital tools. To speed up the development and testing process, the system with Raspberry Pi was tested in Proteus simulation environment. To ensure reliability and usability, the simulation environment tests and flexibly adjusts the performance of the Braille keyboard in real time.

IV. Conclusion

This Braille keyboard study aims to develop an innovative data input alternative for visually impaired people using Raspberry Pi and Proteus simulation. The aim of this work is to realize the first stages of a Braille keyboard that allows users to compose text and communicate with digital devices using the Braille writing system.

The user keys a series of Braille codes, each representing a different Braille character, and engages the data input switch. The Raspberry Pi interprets the Braille key input and converts it into text characters. The Proteus simulation program is used as a virtual environment that allows you to test the efficiency and accuracy of the Raspberry Pi and the Braille keyboard.

This research compares the basic functions of various Braillers and highlights the benefits of this design. With the proposed method, the Braille keyboard becomes an easier and more practical option compared to other systems. The less complex hardware architecture reduces the cost of the device and makes it easier to use.

Using Raspberry Pi and Proteus simulations, the Braille keyboard is an important step towards improving digital interactions for visually impaired people. By bridging the gap between traditional Braille writing methods and digital technology, the aim is to provide a more inclusive and accessible digital experience for visually impaired individuals.

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