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Development of Electronic Braille Notetaker Algorithms

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ABSTRACT

In this era of high technology, most of the blind and visually impaired people are still used to Braille encoding in reading or writing. Currently, they are still using a manual mechanical typewriter called Perkin Brailler to take down notes during lectures or meetings. However, this typewriter is expensive and difficult to carry around, also heavy and can be broken down easily. Furthermore, Perkins Brailler can only type the characters on the paper physically. It cannot save the document as a softcopy and also connect the link to a desktop or laptop. The objectives of this paper are to develop the algorithm of an electronic braille notetaker system that can perform the basic notetaker features as well as the translation between the braille code and text. The scope of this project limited the file type to text file format and only grade 1 (uncontracted) braille is used. The braille notetaker prototype is composed of Raspberry Pi 4, mechanical switches, DC to DC converter, and a speaker. The algorithm generated provides the braille notetaker several features which can be categorized into File Manager, Reading Mode, Editing Mode, Trash, Setting, and Searching Mode. The typing speed can reach 0.3233s per character or 3 characters per second and the accuracy can achieve 97.5%. Thus, this braille notetaker can help blind people perform similar tasks to other normal people without obstacles during their school life or working hours. Blind people can learn at school, work at any company, and have the same right and power in writing and reading as other normal people.

1. Introduction

In Malaysia, 1.2% of people are blind, 1.0% of people are suffering from severe visual impairment, and 5.9% of people are suffering from moderate visual impairment [1]. It was clearly shown that blind and visually impaired people are huge in Malaysia. To reduce the communication gap between blind or visually impaired people and society, the braille system was invented by Louis Braille in 1824 [2]. The braille system refers 6 dot braille cell and represents a reading and writing system that blind or visually impaired people can touch and read [3]. The braille cell is a rectangular block cell with a 3x2 matric of raised dots, which is 2 dots wide and 3 dots tall [4]. The dots can be either raised or flattened and thus result in 64 possible combinations [5]. Thus, braille is not a language but it be can used to represent any language according to the representative standard.

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A Braille notetaker is a small and portable device for storing information equipped with braille keyboards [6]. The function of the braille notetaker had been improved from time to time. In the early stage, the braille notetaker may only be able to store information such as the name, telephone numbers, appointments, simple notes, etc. However, notetaker nowadays is more powerful and versatile since it was equipped with the advanced feature of word processing, web browsing, etc. Generally, the braille notetaker will be equipped with the braille output to make sure the user can read from the braille cell. Some of the braille notetakers are available for speech output so that blind or visually impaired people can hear from the braille notetaker [6]. Several braille notetakers had been discussed in detail including their physical properties and their functions as shown in Table 1 such as Orbit Reader 20 [7], Braille Trail Reader LE [8], BrailleSense 6 [9], and BrailleNote Touch Plus 32 [10]. In the past few years, University Teknologi Malaysia had developed a braille device which is ebraille Quran [11-13]. The device enables the user to read the Al-Quran, textbooks, dictionaries, etc. The additional features of bookmarks and recitation allow users to have better access to knowledge. The development of a graphical user interface also enabled the ebraille Quran to be used in the teaching and learning process in the classroom [14]. However, ebraille Quran did not equip with the notetaker feature. Users cannot take down notes in lectures or meetings. The user of the ebraille Quran is unable to perform their daily task in school or work which are similar to the sighted people. Therefore, a braille notetaker system should be developed to further improve the current ebraille Quran and promote the accessibility of the ebraille Quran.

Table 1
The parameters of braille notetakers

Parameters	Orbit Reader 20	Braille Trail Reader LE	BrailleSense 6	BrailleNote Touch Plus 32
Dimensions (W x H x D)	168 x 35.56 x 112 mm	166 x 23 x 100 mm	245 x 22 x 144 mm	244 x 20.6 x 162 mm
Weight	450g	285g	717g	900g
Braille Cell	20	14	32	32
File supported	TXT, BRL, BRF	DOC, DOCX, TXT, BRF	DOC, DOCX, TXT, BRF	DOCX, PDF, HTML
Storage	32GB	8GB	128GB	64GB
Buttons	Dot 1,2,3,4,5,6,7,8 Up Down Left Right Select Space Panning keys	Dot 1,2,3,4,5,6,7,8 Up Down Left Right Action Spacebar Previous Left Right Next	Dot 1,2,3,4,5,6,7,8 F1, F2, F3, F4 Ctrl Space Alt Capsule keys Play Stop Next Forward	Previous Left Back Home Recent Right Next
Function	• File manager • Reader • Editor	• Clock • Stopwatch • Editing • Synchronize with iPhone, iCloud, Outlook, Gmail	• Password protection • File manager • Word processor • Notepad • Email • Media player	• Text-to-speech • Webview • Email • Contacts • Chrome • Keyword

2. Methodology

The project started with a literature review in order to identify the problem definition. Not only the problem definition, but the features of the braille notetaker will also be identified from the literature review which included the buttons used, editing functions, and UEB code [14,15]. After identifying the feature, the PCB of the braille cell and main circuit is developed by identifying the components used and the Perkin keys design. The algorithm of the braille notetaker system is developed also. After fabricating the PCB, all the components are assembled and integrated with the coding. The performance testing will be carried out in terms of the functionality of the braille cell and also the algorithm. The redesign of the algorithm will be carried out if any unexpected result occurred during the testing. The discussion and conclusion will be done only if the result is accepted.

2.1 Overall System Description

The block diagram of the braille notetaker is shown in Figure 1. The Raspberry Pi 4 Model B 4 GB SDRAM [16] is used as the main controller to control the whole notetaker system. It will receive the signal from the Perkin Keys, perform the required operation and send the signal to the braille cell module and speaker. In this project, the Perkin keys used are Dot 1 to 6, Enter, Backspace, Space, Esc, Shift, Left, Right, Up, and Down. The coding installed in the Raspberry Pi 4 will convert the signal from these Perkin keys into text or certain operations. The DC-to-DC converter is used to convert the 5V voltage output from the Raspberry Pi 4 into 200V for the use of a Braille cell module [17]. The braille cell module will be operated based on the signal from Raspberry Pi 4, which is the text-to-braille converter operation. The speaker will be activated when the user performs certain operations such as saving the file to notify the blind people that the file is saved.

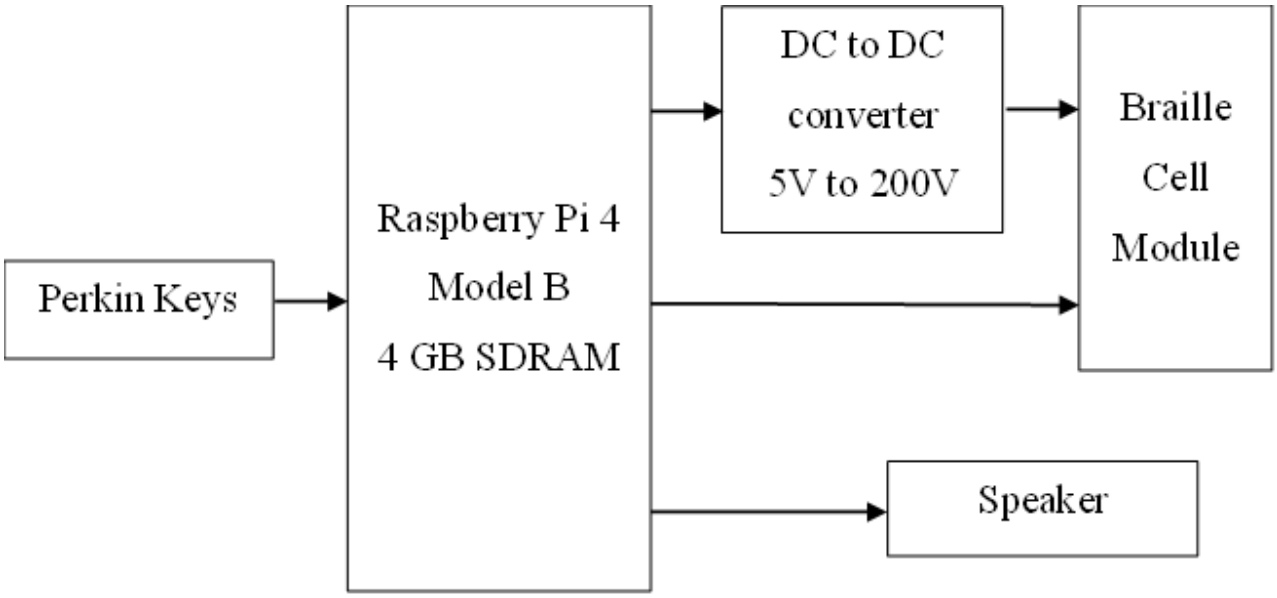


Fig. 1. The block diagram of the braille notetaker

2.2 Braille Cell PCB Development

A braille cell PCB is a PCB that will be used to connect the braille cell module to the main circuit board. Thus, the signal or data from the Raspberry Pi 4 will be able to send to the braille cell module to control the movement of pins. The braille cell PCB had been fabricated as shown in Figure 2.

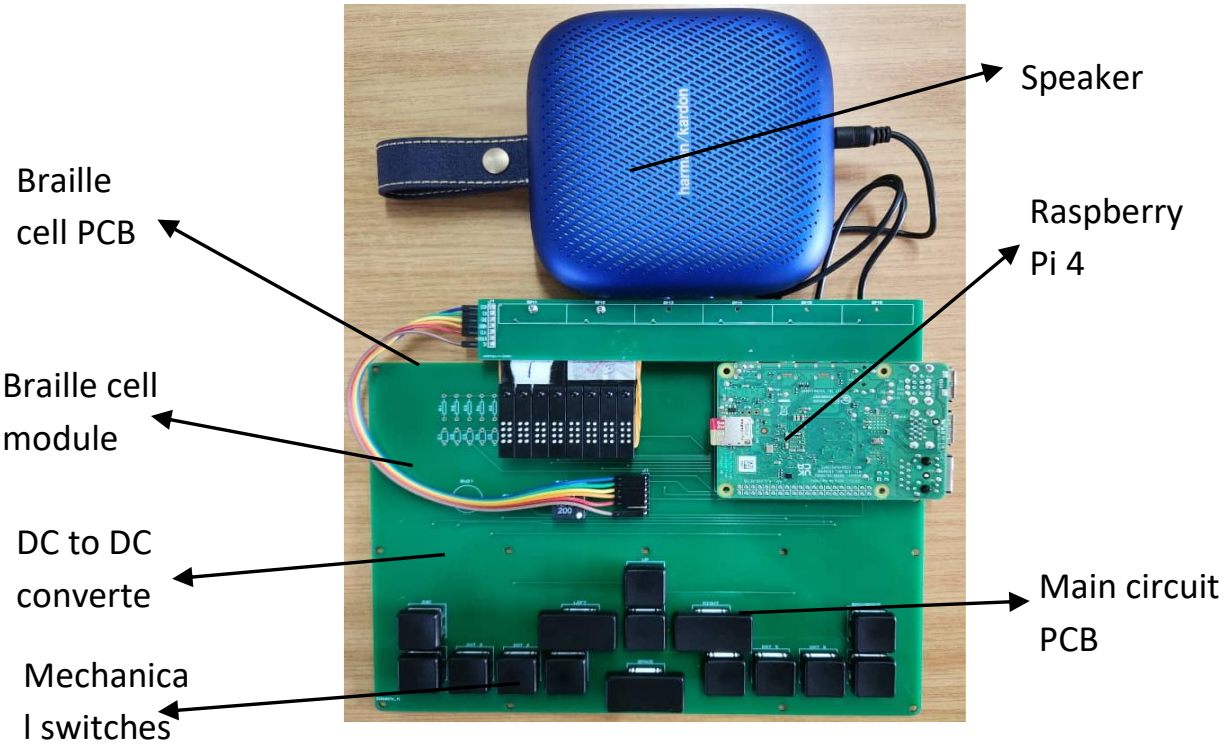


Fig. 2. The braille notetaker prototype

After soldering the angled male pin header, the braille cell modules were secured with the braille cell PCB using bolts and nuts. The main circuit PCB is used as the circuit distributor for the components used in this project which included the Raspberry Pi 4, DC to DC converter, speaker, Perkin keys, and braille cell module. The use of the main circuit PCB can connect all the components in order to make all the Raspberry Pi 4 able to receive the signal from Perkin keys and send the signal to the braille cell module and speaker. The main circuit PCB had been fabricated and soldered with other components. The notetaker prototype is assembled as shown in Figure 2. The braille cell PCB is connected to the main circuit PCB by using the jumper wire, while the Raspberry Pi 4 was inserted into the female pin header on the main circuit PCB. The speaker is connected externally through the audio jack of Raspberry Pi 4 [18].

2.3 Algorithm Development

The algorithm is developed by using Python 3 and several libraries had been used such as gpiozero, RPi.GPIO, time, os, shutil, pygame, and datetime [19]. The main structure of the notetaker system is a big while loop in order to make sure the program can run continuously without interruption. Within the big while loop, there are seven conditions that were required to compare which are “mainpage”, “notetaker”, “readmode”, “editmode”, “trash”, “setting” and “searchmode”. Once the if else condition is changed, the function to be run will be changed and able to perform different operations of the braille notetaker.

3. Result and Discussion

The developed algorithm provided a lot of features for the braille notetaker which can be categorized into File Manager, Reading Mode, Editing Mode, Trash, Setting, and Searching Mode. The functionality test will be used to prove that the feature had been achieved.

3.1 Features of Braille Notetaker

The file manager consists of the features of managing folders and files. All the folders and files are stored in the SD card of Raspberry Pi 4. The user can select the folder or file through the list of directories and also view their properties by pressing the left and right buttons. The properties of the folder and file include the last modification time, last access time, type, and size. Other features of file manager include renaming folder/file, creating new folder/file, copy folder/file, cutting folder/file, pasting folder/file, deleting folder/file, exit folder/file, and searching folder/file. The reading mode is activated when a file is selected and opened. In the reading mode, the content of the file stored in the SD card will be displayed line by line. The line of the content can be changed by pressing up, down, left, or right. The user can also edit the content with a certain shortcut key. The editing mode allows the user to write and edit the text file. In the editing mode, the user can perform normal typing operations such as capitalization, number, character, backspace, space, next line, copy, cut, and paste. Not only that, the user can also move the cursor left or right by one character or one word. The reminder will be activated if the user forgets to save the file before exiting the editing mode. The trash will keep all the deleted folders or files by the user. When the user deletes the folder or file, it will move to the trash. If two similar names are detected, the program will automatically rename them. The trash provides the feature of permanently deleting and also restoring the folder or file. Users can select the folder or file to be deleted or restored by using the up and down button. Users also can view the properties of a folder or file which include the last modification time, last access time, type, size, and also the original location. When restoring the folder or file, the program will rename it to its original name before moving to the original location. The setting of the braille notetaker provides customization to the user which includes the sound and the sorting of folder/file. Users can select to turn on or turn off the sound. Users can also select the order of sorting either ascending order or descending order. Not only that, the folder or file can be sorted by name, last modification time, last access time, or size. In the file manager, there is a feature searching that provides users to search the folder or file with custom keywords. After entering the searching mode, the user can type any name of the folder/file to be searched and press enter. A list of matching folders and files will be shown and the user can open the folder and file. Users can also perform features similar to the file manager's features.

3.2 Functionality Test

After opening the file, the whole content of the file will be displayed on the terminal of Raspberry Pi 4 as shown in Figure 3(a). At the same time, the content of the file will also display on the braille cell module. There are two types of capitalization in the braille system First, letter capitalization will use one capital indicator in front of the text and thus only the first letter will be capitalized as shown in Figure 3(b). Second, word capitalization will use two capital indicators and the whole word will be capitalized as shown in Figure 3(c). To display numbers in braille code, the numeric indicator must be displayed in front of the text as shown in Figure 3(d). Without the numeric indicator, the text will be read as "a" to "j" in the English alphabet.

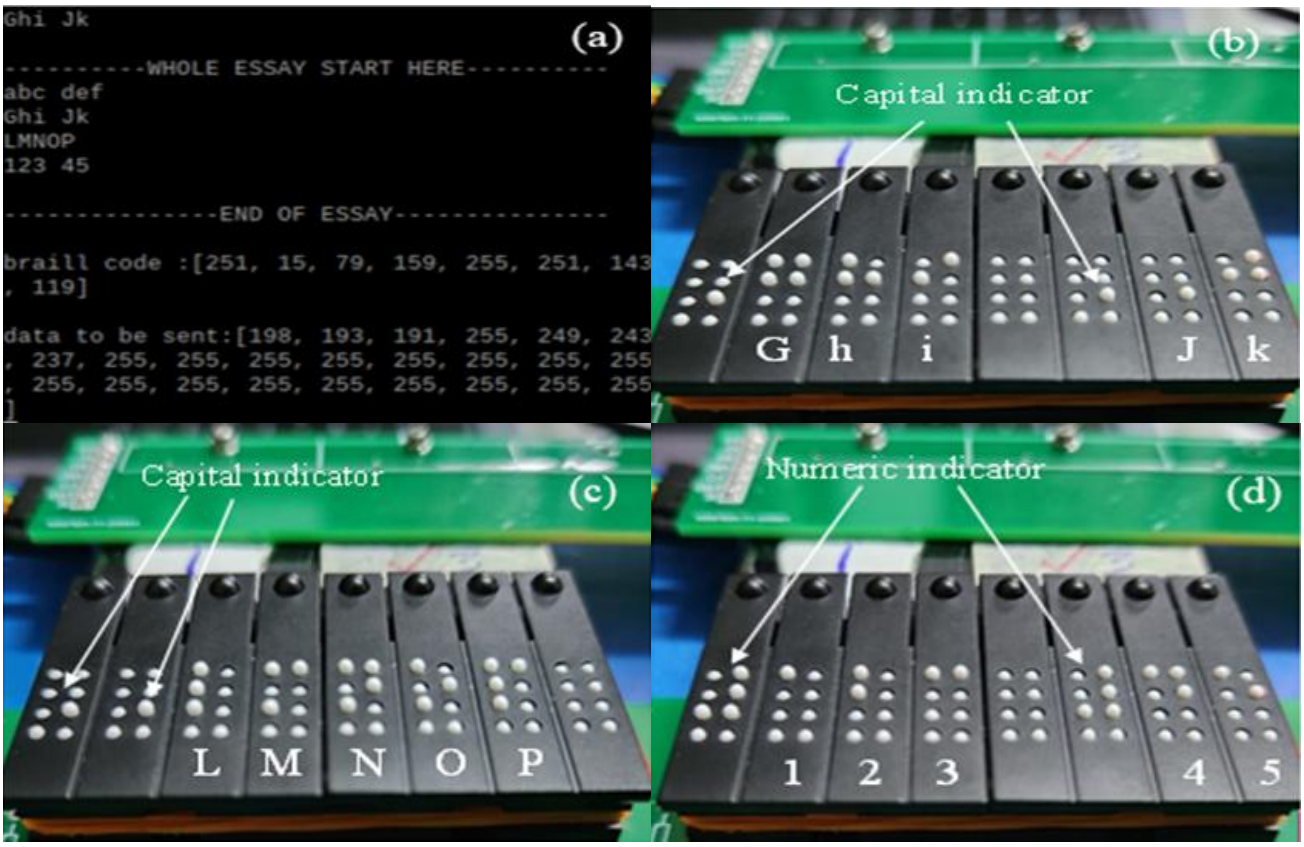


Fig. 3. (a) The terminal of Raspberry Pi 4 (b) The second line of the essay (c) The third line of the essay (d) The fourth line of the essay

When entering editing mode, the cursor can be identified by Dot 7 and Dot 8 in the braille cell as shown in Figure 4(a). Normally, the cursor will be moved up and down at the rate of 0.5 s. The cursor now is moved to the end of the third line and started to edit the file. The “Enter” is pressed to create a new line and “Tan” is typed on the notetaker as shown in Figure 4(b). Thus, the new word “Tan” is shown in the fourth line of the whole essay.

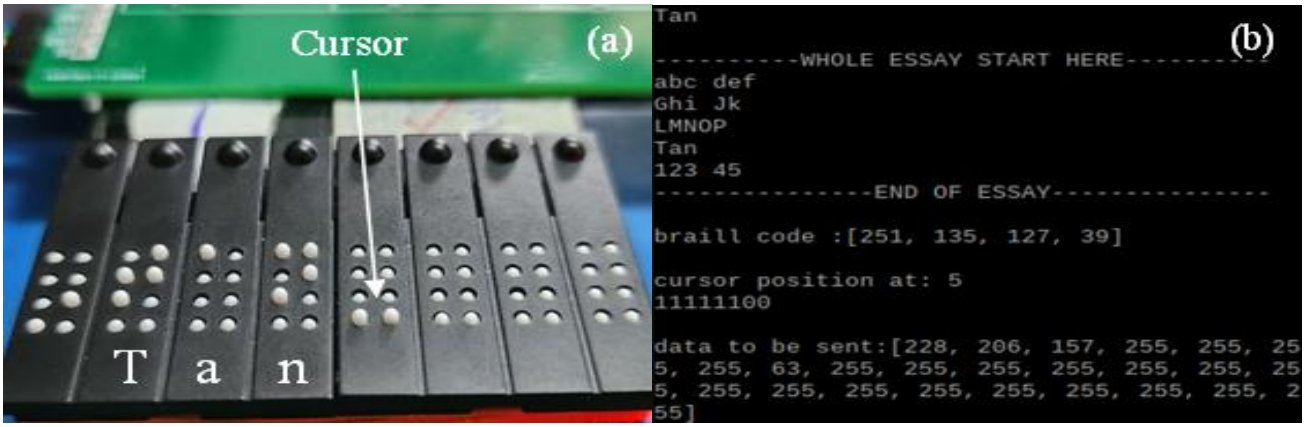


Fig. 4. (a) The cursor is shown on the 5th braille cell (b) The new word “Tan” is shown on the terminal of Raspberry Pi 4

Before exiting the file, if the program detects that the user did not save the file after making the save, the notetaker will remind the user by asking the user “Do you want to save the changes?”. However, only “Save or not?” will display on the braille cell module as shown in Figure 5 to save the space of the braille cell.

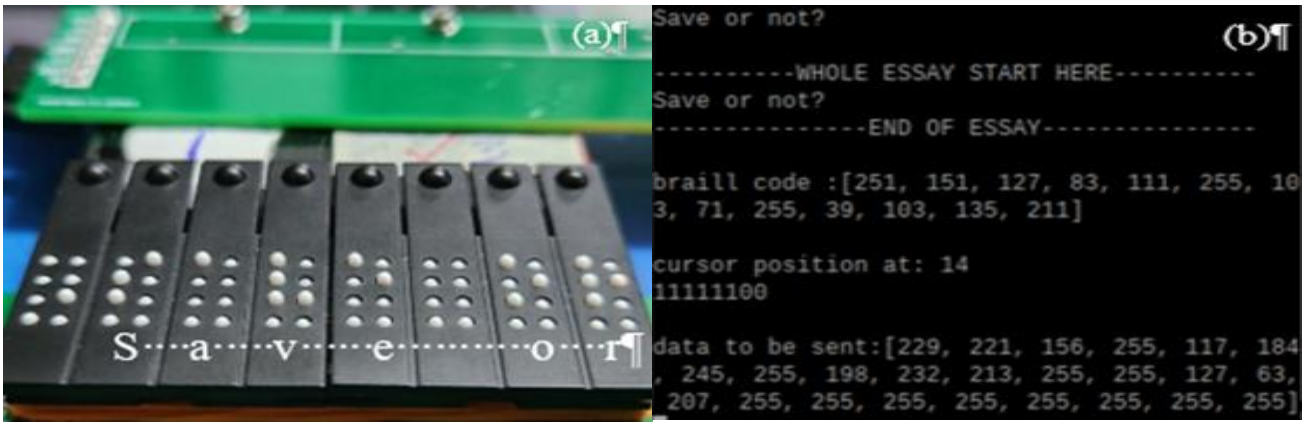
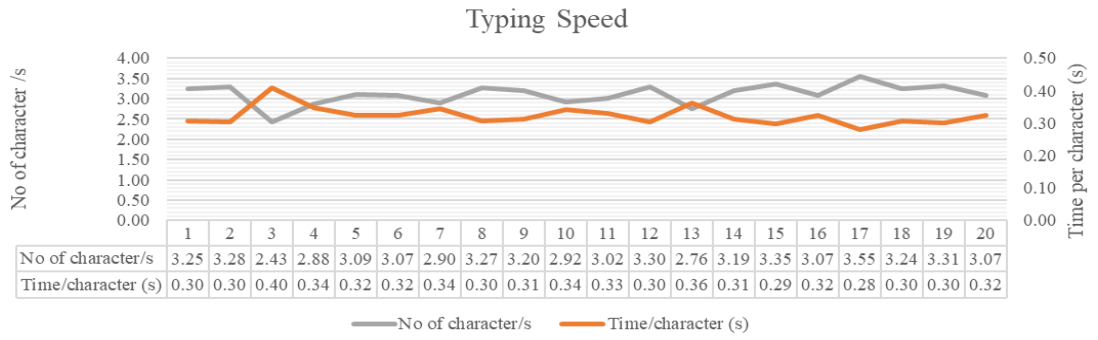


Fig. 5. The text “Save or not?” that shown on (a) the braille cell module and (b) the terminal of Raspberry Pi 4

The algorithm of the braille notetaker provides a high typing speed with high accuracy. An experiment had been carried on by typing “abcdefghij” 20 times using a braille notetaker. The time taken used to type 10 characters had been recorded as shown in Figure 6 and the average of the time taken had been calculated. As a result, the average time consumed for typing a single character is 0.3233s. In other words, the user can type average 3 characters in one second. The accuracy can achieve 97.5% and the error may be caused by the error in pressing the switches, the bouncing of switches, etc.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No of character/s	3.25	3.28	2.43	2.88	3.09	3.07	2.90	3.27	3.20	2.92	3.02	3.30	2.76	3.19	3.35	3.07	3.55	3.24	3.31	3.07
Time/character (s)	0.30	0.30	0.40	0.34	0.32	0.32	0.34	0.30	0.31	0.34	0.33	0.30	0.36	0.31	0.29	0.32	0.28	0.30	0.30	0.32

Fig. 6. The typing speed by using the braille notetaker

4. Conclusions

Based on the functionality test, a conclusion can be made that the objective of this project is achieved. A braille notetaker system has been developed successfully with completed hardware and software. This braille notetaker provides a lot of features that can be categorized into File Manager, Reading Mode, Editing Mode, Trash, Setting, and Searching Mode. Other than that, this braille notetaker had completed the conversion between braille and text and was also able to show the braille code on the braille cell module correctly. Not only that, the user is able to type 3 characters in a second with an accuracy of 97.5%. However, this braille notetaker can be still improved by handling other types of files, applying a smaller speaker, synchronizing the file with other online platforms, and also integrating the web tools.

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