An Open Source Refreshable Braille Display

Victor Rocha[1(✉)], Diogo Silva[2], Álvaro Maia Bisneto[2], Anna Carvalho[1], Thiago Bastos[2], and Fernando Souza[3]

[1] CESAR School, Recife, Pernambuco, Brazil
{vhr, agmc}@cesar.school
[2] CESAR, Recife, Pernambuco, Brazil
{dfsls, abvmb, tab}@cesar.org.br
[3] Federal University of Perbambuco, Recife, Pernambuco, Brazil
fdfd@cin.ufpe.br

Abstract. With the exponential growth in the technological era, the need arose to bring the users a way to use Braille as a communication interface with computers and smartphones. In order to achieve this, electro-mechanical devices were created, called Braille displays, allowing users to make use of Braille on their own devices. However, access to this kind of devices is difficult, because the embedded technology makes it expensive. In this context, this work aims to create an integrated solution of hardware and software, based on the concept of one Braille cell using only open source components. The proposed system was evaluated by blind volunteers with different Braille knowledge and computer experience.

Keywords: Accessibility · Accessibility tools · Refreshable Braille display · Visual impairment

1 Introduction

According to World Health Organization (WHO), there is an estimated 285 million people worldwide who suffer from severe visual impairment. Of these, about 39 million persons are blind and, by definition, cannot walk about unaided. They are usually in need of vocational and/or social support. Many people who suffer from severe visual impairment face a lifetime of inequality, as they often have poorer health and face barriers to education and employment. These figures highlight the need to give greater attention to create solutions that enable their integration into society [1].

In order for an individual to enjoy intellectual freedom, personal security, independence and have equal opportunities to study and work, one must be literate. There is no substitute for the ability to read, therefore no digital alternative can completely replace Braille. At the same time, this can also provide visually impaired people with a unique opportunity to integrate into society and to develop their skills to their full potential. The reader of Braille is not only able to read written texts, but also to read

C. Stephanidis et al. (Eds.): HCII 2020, CCIS 1294, pp. 86–91, 2020.
https://doi.org/10.1007/978-3-030-60703-6_11

information in Braille while using different services (e.g., lifts, maps, signs) and to read information on products (food, medicines) [2].

The Braille system, also known as the white writing, was created 150 years ago and has become the reading and writing alphabet most used by blind people worldwide. The Braille system is based on a grid of six tactile dots presented in two parallel columns of three dots each. The combination of these six tactile dots signifies a specific letter. The points are in high relief, allowing, through touch, to read what is represented. The points are arranged in a rectangle, known as Braille cell [3].

There are three factors that currently work against the use of Braille as the primary reading modality for blind readers [4]: 1) The cost of refreshable Braille displays, which range from approximately $2,000 for a 18-character display to $50,000 for a half page of Braille, 2) the decline in support for teaching Braille to blind children and newly blind adults, which has resulted in a corresponding drop in levels of Braille literacy, and 3) the increasing cost of producing hard copy Braille books which has reduced the availability of recently published books in Braille format, which in turn impacts the interest in and practice of Braille reading, particularly for young readers. For all of these reasons, the pressure to develop a novel approach to the design of refreshable Braille displays is mounting [4, 5].

Refreshable Braille displays render Braille characters dynamically refreshed over time, standing to the Braille language as a computer screen or an e-reader stands to written information for sighted people. They offer the useful and unique advantage of a dynamic fruition of written information that needs to be available fast, i.e. during navigation and search of web contents, without the need of being stored on a physical sheet of paper [6]. Usually those kinds of display consist of 40 cells where the information is presented in Braille, and which is then updated on the subsequent (or previous) lines.

The fact that Braille display technology has not changed significantly for 35 years is astonishing when considered alongside the continually shifting interaction paradigms of personal computing in general. In the years since the introduction of the first piezoelectric Braille cell in 1979, we have witnessed the demise of the command line, the evolution of the Windows-Icons-Menus-Pointer (WIMP) interface and finally the birth of co-located input and output in the form of the touchscreen [4].

In particular, Braille displays most of the time uses piezoelectric or electromechanical array that moves pins arranged vertically to represent multiple Braille cells [6, 7]. This tends to be an expensive approach, especially because it increases the number of cells to represent all information on computer screen [4]. This paper proposes a creation of a portable and refreshable one cell Braille display, using only open source technologies.

2 Related Work

Several studies in the literature describe the importance of technological solutions for Braille reading. Most of these solutions use piezoelectric principles, which are expensive, and also there is a trend to increase the number of cells [8]. The search is on, therefore, for a low-cost refreshable display that would go beyond current technologies and deliver graphical content as well as text. Many solutions have been proposed, some of which reduce costs by restricting the number of characters that can be displayed, even down to a single Braille cell [4].

The difference between eye reading, which captures whole words and many other information almost instantly, blind people read essentially one character at a time. Based on that, some researchers have proposed a system based on a single ‘bigger’ Braille cell and a specific software interface and driver communication. The display was constructed using six servo motors controlled by an Arduino Uno and a computer. To read the words, the person who suffer from severe visual impairment leaves his finger on the cell while points are triggered depending on the letter that is been displayed. To display words and phrases the characters are displayed sequentially. The problem with this approach is that the size and weight of the display, although having only one cell for reading, is almost the size of a Braille display of 10 to 20 cells. Another problem is that it is not possible for this to be used with tablets or smartphones since the display must be connected to a computer to receive the information that needs to be displayed.

Drishti is another solution that propose a different approach. The idea behind this solution is use a dot matrix to represent Braille dots using Solenoids. Although the design was quite good, it faced some problems such as high power consumption and noise, caused by the use of solenoids [9].

3 Proposed Solution

This work presents a refreshable Braille display of a single cell, to be used with computers, smartphones and tablets. The Braille display proposed is inspired on the operation of a tally counter. Tally counters are digital counters built using mechanical components. They typically consist of a series of disks mounted on an axle, with the digits from 0 to 9 marked on their edge, the counter moves incrementally from right to left depending upon the number of clicks made, the logic behind the increment, follows the natural numerical order.

Braille decodes each symbol in a cell composed of up to six dots. Dots of each cell are arranged in a matrix of two columns by three rows with fixed dimensions (see Fig. 1). Each Braille character is represented by a cell with different number and positions of the raised dots [6]. Instead of using movable pins to reproduce the relief of the points of a Braille cell, the idea is to replace these pins with a plastic disc (in the format of an extruded octagon) with eight sides and in each one on each side there is the relief of each of the eight possible configurations of 3 points.

Combining two of these discs is possible to reproduce all 64 symbols of the traditional Braille system. For each of the blocks were mapped all possible combinations of the 3 points (both in relief and without), which gave a total of 8 possibilities for each block (see Fig. 1). So, each face of the extruded octagon contains one of the eight possible combinations (see Fig. 1). The mechanism is based on the principle that there isn’t any difference between the combination of the dots 1, 2, 3 and the 4, 5, 6 as shown on. The pieces were printed using the 3D printer Ultimaker 2.

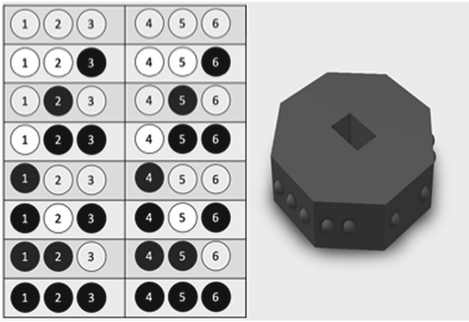

Fig. 1. Possible combinations for each column of Braille cell and extruded octagon [10]

Cell dimensions have to be optimal in order to allow the finger pad to cover the whole area of the cell and, at the same time, discriminate the different dots. During the years, Blind Unions and Authorities of different countries converged to a standardization of the Braille cell and dot dimensions [6]. According to the above recommendations, specifications of the Braille cells that are considered in the presented paper are summarized in Table 1.

Table 1. Braille dimensions considered in the presented work according to the European Blind Union recommendations [6]

Feature	Dimensions [mm]
Dot height	0.5
Dot diameter	1.5
Intra-cell horizontal distance	2.5
Intra-cell vertical distance	2.5
Inter-cell horizontal distance	6

Once printed, each octagon was attached to a stepper motor (model 28BYJ-48), as can be seen in Fig. 2. Each of the motors has been connected to a ULN2003 driver, that is controlled by an Arduino Nano board, with an ATmega328 microcontroller. The communication with the user device (smartphone, tablet or PC) is via bluetooth, for that a HC-06 bluetooth module was connected to the Arduino (the complete circuit diagram could be seen on Fig. 3). So, the "letters" that must be displayed on the display are sent by the device using the bluetooth protocol. Finally, the step motors were attached to a stand and placed inside a box to prevent direct contact between users and the electronics (see Fig. 2).

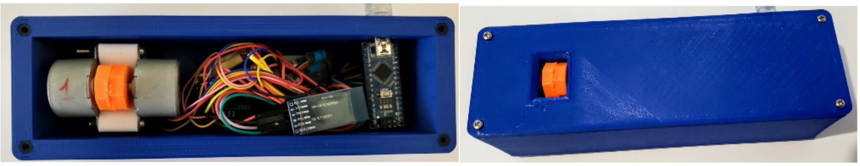

Fig. 2. Step motor with extruded octagon [10]

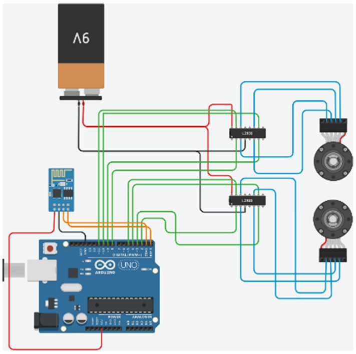

Fig. 3. Circuit diagram

4 Proof of Concept

The tests were done by five volunteers from the Instituto de Cegos Antônio Pessoa de Queiroz, from Recife, Brazil. All volunteers work in the institute and are familiar with reading in Braille. To evaluate the prototype an android application was created, where you choose a letter to be displayed on the Braille display. This letter is sent via bluetooth to the device.

The volunteers received an explanation about the Braille Display, its function and its relationship with smartphones, tablets and computers, as well as the goal of the all system. After the introduction the prototype was given to the user, the researcher chooses a character and sends it to be displayed on the display. The volunteer tries to recognize the characters represented at Braille cell, speaking aloud what character believes it is.

During the tests the volunteers were encouraged to give feedback on the use of the prototype and talk about the readability of the display. Regarding the prototype, users commented that they found it interesting and were excited about the cost of the solution, since commercial Braille displays cost more than 2000 dollars.

Some divergences between one cell solution and traditional Braille reading were detected. For example, cell points distances should be adjusted to reduce the distance between the two columns, because they were getting the impression that each column was a separate letter from the other.

On the other hand, some of the advantages of one cell Braille solution are: static reading reduces fatigue, also the price of one cell equipment is lower, simplicity, lack of line-breaking problems because the hand remained static over the device and simpler maintenance.

5 Conclusions

This work aims to contribute to the digital access of Braille by developing an integrated hardware and software solution. To this end, a single Braille cell was designed formed by two step motors controlled by an Arduino Nano. This study aimed to access the amount of effort required for reading Braille on a display formed by a single cell. It was designed to meet the demand of domestic and institutions appliances at low cost.

Experiments were focused in user's behavior, recording their evolution using the system. The use of a single cell showed promising results relating to cost and effort. The proposed solution represents an alternative way for communication of blind users, especially, young people, constantly discouraged by the traditional method of learning Braille. As a future work a mobile application is being developed to be used in conjunction with the display to teach Braille to the disabled without the need for an instructor.

References

1. WHO: Visual impairment and blindness. In: Fact Sheet (2019). http://www.who.int/mediacentre/factsheets/fs282/en/index.html. Accessed 10 June 2020
2. Marcet, A., Jiménez, M., Perea, M.: Why Braille reading is important and how to study it. Cult. Educ. **28**, 811–825 (2016)
3. Schmidt, M.B., Gustavo, L., Ramirez, A.R.G.: Single Braille cell. In: ISSNIP Biosignals and Biorobotics Conference, BRC, pp. 1–5. IEEE (2014)
4. Russomanno, A., O'Modhrain, S., Gillespie, R.B., Rodger, M.W.M.: Refreshing refreshable Braille displays. IEEE Trans. Haptics **8**, 287–297 (2015)
5. Runyan, N.H., Blazie, D.B.: The continuing quest for the "Holy Braille" of tactile displays. In: Esteve, J., Terentjev, E.M., Campo, E.M. (eds.), p. 81070G (2011)
6. Leonardis, D., Claudio, L., Frisoli, A.: A survey on innovative refreshable Braille display technologies. In: Di Bucchianico, G., Kercher, P.F. (eds.) AHFE 2017. AISC, vol. 587, pp. 488–498. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-60597-5_46
7. Bisht, S., Goluguri, S.R., Maheshwari, R., et al.: Refreshable Braille display using raspberry pi and arduino. Int. J. Curr. Eng. Technol. **6**, 965–968 (2016)
8. Cook, A.M., Polgar, J.M.: Assistive Technologies, 4th edn. Mosby, St. Louis (2015)
9. Kartha, V., Nair, D.S., Sreekant, S., et al.: DRISHTI - a gesture controlled text to Braille converter. In: 2012 Annual IEEE India Conference (INDICON), pp. 335–339. IEEE (2012)
10. Hazin da Rocha, V., Silva, D., Bisneto, A.B.V.M., et al.: Ensinando a Identificação de Caracteres Braille utilizando Dispositivos Móveis e um Display Braille. RENOTE **17**, 82–91 (2019)