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PUTTING THE TACTILE FEEDBACK TO QURANIC VERSES AND TAJWEED RULES

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ABSTRACT

Technology has enabled many physical books including Al-Quran to be presented in a software form. The digitized holy book comes with a complete colour-coded to assist readers read correctly without having to memorize each letter that forms the tajweed rules. Unfortunately, those with visual impairment are not able to enjoy fully such a feature because there are not many systems that could support the readers' different reading capabilities. Accessibility with regards to information visualization representing the colour-coded tajweed codes using sensory modalities other than vision is the issue in question. This paper investigates whether by providing tactile feedback to the Quranic verses together with the tajweed rules could add value to these readers. An interview and, observation on visually impaired readers learning Al-Quran were conducted to understand and capture the design requirements. The initial study findings revealed that those with low vision and very new to reading Al-Quran Braille are in favour of the prototype while the more experienced readers did not find the tactile tajweed rules necessary. These findings led to the development of a prototype using Braille-line 20. The prototype incorporates tactile feedback into the Al-Quranic Braille and the associated tajweed rules. A user testing was conducted with a group of visually impaired people to elicit their opinions on the prototype. The study findings signal for the prototype having potential as a promising learning tool.

Keywords: tactile feedback, accessibility, Al-Quran Braille, visually impaired.

INTRODUCTION

There are four levels of visual functions: the normal vision, moderate visual impairment, severe visual impairment, and blindness [1]. Both moderate visual impairment and severe visual impairment are grouped under the term "low vision". According to a fact sheet in 2010, 285 million (4.25%) people out of 6,697 million of the world population suffers from visual impairment [2]. From the 285 million visually impaired people, 246 million (86%) of the visually impaired has low vision and the remaining 39 million (14%) are blind. From this point onwards, the term "visually impaired" will be used to refer to those users having low vision and blindness.

In reading Al-Quran, it is important to use the correct tajweed i.e. rules to recite the holy book with proper pronunciation. Tajweed by definition is bettering, improving, and becoming excellent while functionally, it means articulating every letter in the Quran in its correct timing and from its proper point of articulation [3]. Al-Quran reciting is also necessary to be practiced in Islamic worshiping such as prayers. It is important to appropriately reciting the Quran as it is the proof of Allah words in the Quran. Reference [4] stated that there are differences in reading the Quran and a normal Arabic text due to the pronunciation rules that have to be respected during the recitation. These differences are due to the tajweed rules implied on the recitation of the Quran.

Technology has been used to make Al-Quran widely accessible though digitization and putting additional features that include colour-coded as a way to represent the associated tajweed rules. These features benefit the sighted readers but not to those with visual impairment. Accessibility in terms of enabling everyone to be able to read the represented information digitally may still be questioned. How could we present the Al-Quran and its tajweed rules digitally to those with visual impairement?

This paper attempts to address this problem by presenting a study that investigates the extent in which tactile feedback that represents the digitized Quranic verses and tajweed rules provide values to the readers. The focus of this study is mainly on representing the feedback in digital Al-Quran and to evaluate the tactile prototype in terms of how well it could aid users' learning. The idea is to support accessibility of information among the visually impaired people through visualization. This is motivated by earlier reported works such as in [5].

The organization of this paper is as follows: The subsequent sections involve presentation of related work; investigation on how the Arabic letters and tajweed rules in the Quran are represented in Braille and how the visually impaired read the Braille Quran with the tajweed; prototype development based on the investigation; evaluation study on the prototype.

RELATED WORK

There is plenty of Quran software that is available for download on the Internet or to be installed from CD [6]. The software varies in terms of its functionality and features. Al-Mudarris Quran Software is an example of Quran software that can be installed in the user's computer. It was developed by Dar-us-Salam Publications and could be purchased on the company's website [7]. There are also many other Quran software that could be downloaded and installed for free. Typically, Quran software has all the list of surah in the Quran, in each surah, the translation are usually included. Audio options are included for the users who would like to listen to the

recitation. Furthermore, most applications have the option to play the recitation of the same surah in loops or to repeatedly play one ayat of a surah for a number of times for learning purposes. Some Al-Quran software is even colour-coded to assist the readers in reciting the tajweed correctly [8].

The Quran is also available in Braille for the visually impaired to read. Braille is a series of raised dots that can be read with the fingers by people who are blind or whose eyesight is not sufficient for reading printed material [9]. Braille is not considered as a language as it is only a code for representing natural languages letters such as English or Arabic. However, according to reference [10], the vast amount of characters in a complete set of the paper embossed Quran caused it to be thick and need to be printed in several volumes.

Arabic and the Quran Braille shares some similarities in terms of the symbols used. However, Braille contractions are also used in Arabic representation of Braille but not in the Quran version of Braille [11]. Both Arabic and Quran Braille are read from the left to right as opposed to the conventional way of reading Arabic which is from the right to left. It has been reported that AbdulMalik Al-Salman introduced the Braille in Arabic language research [12]. He proposed the ABE system (Arabic Braille Environment) which is a system translating the Arabic language to Braille symbols and vice versa. Unfortunately, the system is limited to the Arabic language without using abbreviation or vibrations.

The Arabic Braille symbols include the Arabic diacritics. These diacritics will determine how a letter is pronounced because in the Arabic language a letter can be pronounced in many ways depending on its diacritic. In this context, [13] claimed that the current system of the Quran Braille is not complete as it does not include special vibrations that are required in reciting Al-Quran as it is different than reciting the Arabic language. The vibrations reported are: Noon+Scoon vibrations Edhare (Izhar/Idhar), Edgham (Idgham), Eklabe (Ikhlab), Kalkala (Qalqalah), and Ekhfa' (Ikhfa'). To address this problem, they came out with the representation of these tajweed rules by using the finite state machine technique so that symbols would not duplicate the existing Arabic Braille symbols. From their experiments, they have produced a full translation prototype for the Quran verses that includes the associated vibrations that they have introduced to be tested by the mass.

The work reported in [13] share a similar approach with that in [14] in the way text information is being presented to the visually impaired. While the former involved presenting Quran verses in Braille codes, and tajweed rules using vibration, the latter focused and presented text and its attributes haptically using a Braille device. Reference [14] argue that the limitations of current assistive technology lie in the way non-textual information is being represented. They claimed that these limitations deter the visually impaired from having a comprehensive understanding of a webpage because non-textual content is often the key to fully understand a webpage. Thus, leads to proposing a few new Braille codes for text attributes to allow the visually impaired to have comprehensive understanding of a webpage they are reading in term of its text attributes (Table-1).

Table-1. Braille Codes for Text Attributes.

Elements	Braille code
Bold	(456,46)
Italic	(46)
Underline	(456,36)
Header	(TT)
Sub Header	(HR)

Apart from Table-1, the Braille code was also adapted into various languages to suit the needs of the visually impaired around the world that speaks and reads in various languages. According to [12], there are a few researches that have involved Braille code in their works. References [15] and [16] are among the earlier people who have translated English into Braille codes using Finite state machine and Decision table techniques to cover the gap between Grade 1 and Grade 2 Braille codes in English. Beside English, the research for Braille code transliteration system for in Indian text to Braille and vice versa was also presented [17].

THE STUDY

A study consisting of four main parts of work was conducted. The first part involves requirement gathering through a semi-structured interview whose findings will be used to develop a tactile Quran verses and tajweed rules prototype. This is followed by the second part that determines the metaphor to be used to represent the tactile information. The third part is on the prototype development while the fourth includes the evaluation of the prototype.

Interview

The objective of the interview was to investigate how the visually impaired teach and learn the holy Al-Quran, and the types of assistive technology they are using to help the process. The interview was also conducted to determine whether the proposed prototype to be developed is suitable and needed by the visually impaired. Findings from the interview will form a basis to develop a prototype in the third part of this study.

The respondents who took part in the interview were a teacher who teaches Al-Quran classes and, a group of students from the Malaysia Association for the Blind (MAB) Ipoh. One teacher and a total of six Muslims

students were interviewed. The age of the students ranges from 20 to 60 years old.

There are two sets of interview questions prepared. The first set is for the teacher while the second is for the Muslim students from the centre. The first set was made up of eight questions which consisted of basic background information. Other questions are related to the teaching which includes the teaching experience at the centre, how the Quran class is conducted and, the aids used to help the teaching and learning process. The rest of the questions are about the types of assistive technology the students used to help their daily activities, frequency of using computer and, familiarity with any Quran software, websites or applications.

On the other hand, the second set consisted of ten questions. The questions asked were the respondents' name, age, when they started having vision problem and the cause of the impairment, whether the respondent is totally or partially blind when they first attended Al-Quran class at the centre, and whether they have attended any Al-Quran lessons and if any how they learn the holy book prior joining the centre.

All respondents were invited to describe their feelings on learning Al-Quran and which assistive technologies they think could help with the process. They were encouraged to give opinion on whether an assistive technology to indicate the tajweed would help them learn or apply the knowledge of tajweed that they had learnt and reason for it.

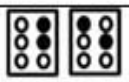
The interview utilized the qualitative research strategies to obtain richer information and deeper understanding from the respondents. In this study, conducting interview would be more ideal than questionnaires because the respondents would not need to answer the questions themselves. Each interview sessions were done in personal, face-to-face manner with every respondent. All the answers by the respondents were noted in the interview sheets. The interview sessions were also recorded using a voice recorder for reference purpose.

The Tactile Metaphor

Providing an appropriate tactile feedback to the surah chosen and its associated tajweed is very important. This study replicates the approach used in [14] whereby text and its attributes are being represented by the Braille symbols that are familiar to the target group.

The method involved in designing the new symbols in this study is by eliminating all the available signs in the Quran Braille, the diacritics symbols, and the five tajweed symbols by [13]. This is followed by an identification of the prolongation rules that involves the six harakat, four/five harakat, two/four/six harakat, and two harakat prolongations. After identifying the prolongation rules, each of the rules is given the respective symbol by matching the number of harakat to the pin number in the Braille symbol. The symbols to represent the prolongation tajweed rules are designed to be easy to remember by having the raised dots resembling the number of harakat for each rule as shown in Table-2.

Table-2. Prolongation Tajweed Rules Braille Symbols Used.

Rule	Braille Dots	Braille	French Braille
6 harakat	[4,5] [1,5]		€
4/5 harakat	3,6		–
2/4/6 harakat	2,4,6		æ
2 harakat	1,4		c

Prototype Development

The development tools used are Braille Line 20 Cell and a computer running on Microsoft Windows XP X86 for hardware, and, Visual C# 2010 and Metec Driver for software.

The prototype developed consists of the software and hardware parts (Figure-1). The software includes the Graphical User's Interface (GUI) that enables the users to click "start" button in order to run the Braille Line 20. This device is the hardware that displays the output of the surah which is the first verse of surah Al-Fatihah. The first two cells from the left side of the device are reserved for the tajweed rules indicator while the rest are meant for the Quran verses.

An example of the first verse of surah Al-Fatihah with the Braille symbols representation is shown in Table-3. Both Line 3's from the table present the Braille symbols and its associated tajweed rules. It should be highlighted that such a mapping between the Arabic word and its Braille symbols as shown in Table-3 and the rest of the verses in the surah has been verified by the Al-Quran teacher from MAB.

Since the Braille Line 20 device (Figure-1) is short and it was divided into sections, it was hard to display all the words in one line as it should be. Hence, the words were separated into three lines. Each time a line was completely displayed, the new line would start again at cell three. As depicted in Table-3, line three has both Quran verses and also the tajweed indicator as the words in the line contains a tajweed rule. The tajweed indicator was raised simultaneously with the words that have the tajweed rules and sunken when the next words are displayed on the Braille Line 20.

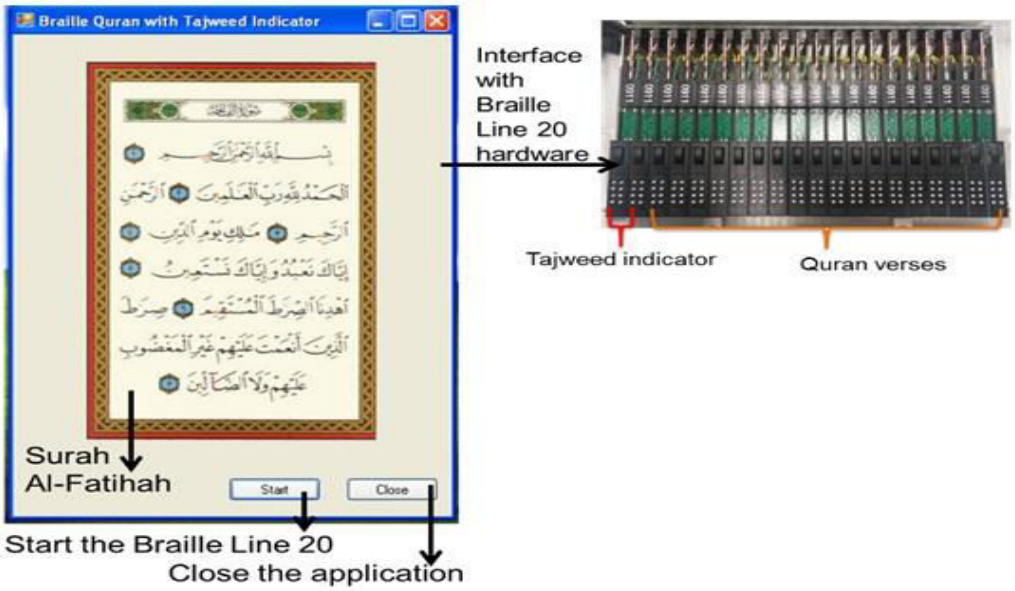


Figure-1. The Interface Design.

Table-3. Representing the Arabic Words.

Line	Braille symbols	Reading order	Arabic word	Romanisation
1	⠃⠎⠍⠊ ⠁⠇⠇⠁⠓	ب س م ا ل ل ه	بِسْمِ اللَّهِ	Bismi Allahi
2	⠁⠗⠗⠁⠓⠍⠁⠝	ا ل ر ح م ن	الرَّحْمَٰنِ	Al-Rahmani
3	⠁⠗⠗⠁⠓⠊⠍	ا ل ر ح ي م	الرَّحِيمِ	Al-Rahimi
3	⠠	Will be displayed to indicate 2 harakat in "ح ي م" at the same time "ح ي م" is displayed		

The Evaluations

The objective of the user evaluation is to determine how well the prototype is valued by the users in terms of its ability to support learning. This is a form of validating the tactile feedback integrated into the prototype. The test participants involved were chosen from a group of students from the Malaysian Association for the Blind (MAB) Kinta, Ipoh. The students are visually impaired (either suffering from low vision or total blindness) who have some basic to extensive knowledge on Arabic Braille letters. This is a different group of students from that who took part in the first stage of the study.

The user test started with a training session for the participants. Each participant is briefed about the system prototype and how it operates. This includes introduction to the tajweed rules being represented with tactile feedback and, how to read the pins on the Braille Line 20. The test participant was then invited to explain to the experimenter on the instructions given to check the level of understanding on the system before proceeding with the individual testing session. The time taken for each test participant to finish the whole first verse of the surah Al- Fatihah and how much letters that they managed to read out of the 34 letters was recorded. This common surah is purposely chosen for the test despite may raise

questions on the test participants' tendency to memorise the letters during the study instead of reading the Braille Line 20. One main reason for this choice is to make the verification process easier without compromising quality and validity of the test. Finally, a post-test interview session was conducted with test participants being asked a few questions based on their experience using the prototype.

RESULTS AND DISCUSSION

This section presents the study findings from the evaluation activities described in the earlier section. The first three sub-section reports the findings from the interview while the last is meant for the user testing results. Such a presentation is made as the former sub-sections consist of findings that form the basis to develop the tactile prototype. This will involve groupings that relate to understand users' learning especially on their previous experiences with Braille and reading Al-Quran, learning preferences, and technology environments. The latter sub-section involves study findings that examine the users' learning performances when interacting with the prototype.

Demographic Background

There are several reasons for choosing respondents from the Malaysia Association for the Blind (MAB) Kinta, Ipoh, Perak. Among them are:

- Accessibility to the adult visually impaired community is a challenge. It is not easy to find a large number of the visually impaired respondents that are attending the same Quran class.
- Most of the students are new to reading Quran in Braille. Thus, we want to see how these new learners are adapting to the new system. It is easier to get the comparison between using the old system and using the new system from new learners as they will as much as possible choose the method that is easier for them to learn and use.

From the interview, it is found that four out of six students learnt to read Al-Quran at school before they enrolled in MAB, Ipoh. Majority of the students are partially blind. They had become visually impaired due to health issues. One student said that she is blind from child but was trained at a special school for the blind from small. Two students receive private tutoring from religious teachers to learn Al-Quran before studying at MAB. One of the two students who are partially blind due to glaucoma said that he uses online sites such as YouTube and Quran.com to learn more on how to read the Quran.

Learning Preferences

The findings from the interview revealed that four out of six students prefer to use assistive technology in aiding them learning and reading the Quran (Figure-2).

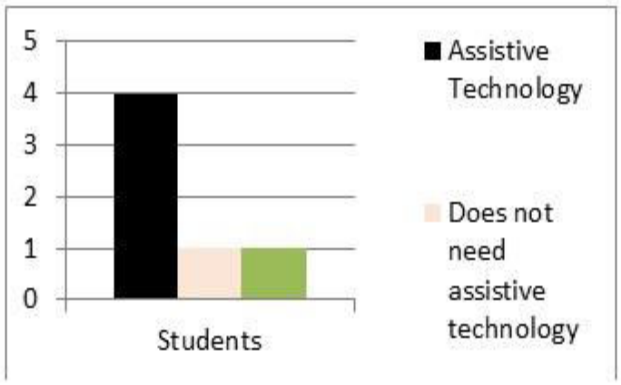


Figure-2. Students' Learning Preferences.

The participants believed that assistive technology will aid them in learning to read the Quran Braille better. This is because they are just learning to get used to reading Al-Quran in Braille. However, one student feels that the conventional way of reading the Quran without any assistive technology such as tajweed indicator is good enough as she said that Braille Quran has its own way to read it. The remaining one did not express her opinion whether assistive technology would help her learn or read Quran better. Overall, this learning preferences suggest that most of the experienced visually impaired Braille users are in favour of learning Al-Quran with assistive technology to indicate the tajweed rules; thus, implying the feasibility of the proposed prototype.

Technology Environments

When asked about the assistive technology used, all six students said that they use the Braille technology everyday as they were taught to read it in classes (Figure-3). Some students depend on Braille to read. The students are also familiar with audio aids as four out of six students are using audio assistive technology. Three of them are also familiar with screen readers such as JAWS. This indicates that the students are also keeping in touch with the technology in their daily life. However, from the interview only one student has used text-to-speech device or software as while the rest of the students have not heard about the technology. This might be due to the cost of the device or software is quite expensive.

The students were also asked if they are familiar with computer and the frequency of using it. Four of the students said that they are frequent users while the other two did not use computer very often. The reason behind this could be because of the visual level that the students possess. Those with total blindness were found to be using computer lesser than the others having partial impairment. Familiarity with Al-Quran software was also asked from the students. Among all six students, only one answered yes while the rest answered that they did not use the software. Some are not even aware that this software exists.

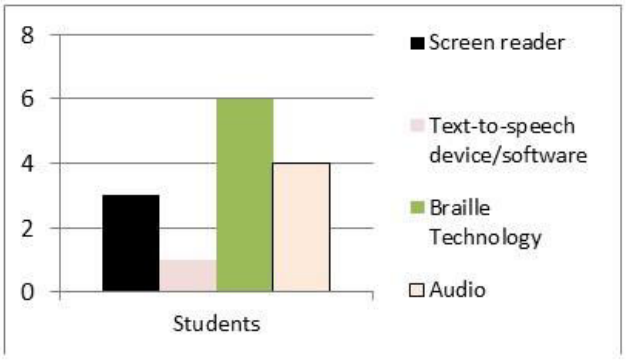


Figure-3. Assistive Technology Used Daily.

In general, the interview results indicate that the students have knowledge in Braille since they are using it in their daily life. However, some of them are not being exposed to other types of assistive technology since they did not use the computer often. The students who are well aware of the screen readers are among those who use the computer often. The results also suggest that these students are not totally excluded from using technology as people with vision impairment. Despite most students in the study were not aware of Al-Quran software, their exposure to Braille may result in positive experience should they use the software in the future. Similar to the findings reported in the previous sub-section, the responses received in the interview also signal the feasibility of having Al-Quran software together with its tajweed rules being represented in a tactile manner similar to that with the existing colour-coded Mushaf.

User Testing Results

Six test participants from MAB, Kinta, Perak, took part in the study. One of them suffers from total blindness while the rest are partially impaired. The time taken to complete the verse was recorded while the accuracy of reading the letters were noted and calculated in percentages. The means of both readings were calculated. The results of the user testing gathered were tabulated as shown in Table-4.

Table-4. Study Results With Target Audience.

Participant	Visual Function	Time Taken (sec)	Accuracy (%)	Recognize Tajweed Indicator?	Pace of Pins
1	Total Blindness	88	59	No	Too Fast
2	Low Vision	100	100	Yes	Too Slow
3	Low Vision	110	44	Yes	Nicely Paced
4	Low Vision	72	40	Yes	Nicely Paced
5	Low Vision	89	94	Yes	Too Fast
6	Low Vision	73	94	No	Nicely Paced
		Mean **88.67**	**Mean** **72**		

The test results from Table-4 show that the time taken for each test participant to finish reading the verse varies. This could be due to participants having different reading styles and Braille skills. Some test participants read the cells on the Braille Line 20 and re-read the whole line again while others read each of the cells only once very quickly. Braille skills were also a factor in why some of the test participants have shorter reading time but low accuracy. Since the test participants skipped some words that they did not know or unsure of, the accuracy in terms of recognizing the correct tajweed indicator became lower and the time they took became shorter. Some of the test participants have high accuracy and shorter reading time because of the Braille skills they have. However, test participants who took longer time did not necessarily mean that he is not skilled at Braille. The study findings indicate that time taken to read the Braille could be affected by the Braille skills and the way a test participant reads Braille. For example, Participant 5 who took 1 minute 29 seconds (89 seconds) scored 94% accuracy and Participant 6 scored 94% of accuracy but took only 1 minute 13 seconds (73 seconds) to read the verse.

The accuracy of the reading was counted by each of the letters that the test participants managed to read. There are 34 letters including the tajweed indicator displayed on the Braille Line 20 as output. When a test participant correctly read a letter from a cell, a score of one was awarded. The total score and percentage were calculated. Three out of six test participants scored high accuracy on the reading which exceeded 90%. The other three scored lower due to insufficient Braille skills.

Based on the findings, the mean of the time spent to complete the task and the accuracy of the reading was calculated. The average time taken to read the whole verse is 1 minute 28.67 seconds (88.67 seconds) which is better than the expected time limit projected that is 2 minutes. The average accuracy of the reading is 72% which is high considering that there are test participants who are not fluent in Braille at the time the study was conducted.

Out of six test participants, three were able to recognise the tajweed indicator on cell one. This shows that with proper training and understanding on how the system works, users could benefit from the system as an assistive technology to aid them reading Al-Quran using refreshable Braille display. When asked about the pace of the pins raising and sinking, three of the test participants said that the speed was nicely paced. However, two test participants complained that the speed was too fast especially for beginners while another test participant said that the speed was too slow.

From Table-4, one comparison that could be highlighted is between Participant 1 (with total blindness) and Participant 2 (low vision) who scored 100% in accuracy. Participant 1 reached 59% accuracy in 1 minute 28 seconds (88 seconds); this is because he is familiar with the verse. However, Participant 2 who had 100% accuracy took longer time because he is not familiar with the verse as he is apparently a non-Muslim student with no formal Arabic education but have extensive knowledge on Braille and basic Arabic braille knowledge, and very enthusiastic in learning. This result signals that the system could be utilized as a learning tool for the non-Muslim visually impaired learners who would like to learn the Quran. It is suitable for these learners as the tajweed indicator will guide them in reading the Quran correctly.

The ability of a person who does not understand the content of the reading materials but able to perform well in the task given also signals for the suitability of how the tactile feedback being mapped on to the tajweed rules to mimic the existing colour-coded Mushaf. The method as used by [14] could be replicated to represent non-Roman letters as well. This also extends the work in information visualization since the tactile feedback as well as vibration provided (reported in [13]) could be useful in presenting attributes associated to specific words or letters.

Other findings from the testing are test participants' performances were not affected by their visual function and the accuracy of their reading. Even though the interview findings indicate that blind users rely more on audio but from the testing, it was found that they can perform as well as their low vision counterpart when reading haptically.

Findings from a post-test interview revealed that all test participants agreed that a full version of the system would be useful if it is available as they realized that the system would be a great assistive technology that could help them read the Quran. One of the reasons as stated by the participants is that the system has the tajweed indicator which was not present in embossed printed Braille Quran. Furthermore, the embossed printed Braille Quran tends to exhaust over time due to wear and tear. They mentioned that the system using the Braille Line 20 would solve the problem of reading worn out embossed printed Quran and having to replace the Quran often. However, the participants complained about the device being too small and short to read i.e. display the whole ayat. They prefer longer refreshable Braille display as it is more comfortable to read because they were used to emboss printed books that are big. To make the system more usable, trainings should be provided to users so that they have better learnability on the tajweed rules as the rules were newly introduced to them.

CONCLUSIONS

This study has demonstrated how the Arabic letters and tajweed rules in the Quran are represented in Braille device and how the visually impaired read the Braille Quran with the tajweed. It investigates whether providing tactile feedback to the Quranic verses together with tajweed rules could benefit the readers in terms of their learning. The test results show that with proper training and understanding on how the system works, users could benefit from the system as an assistive technology to aid them reading Al-Quran using refreshable Braille display.

Further works should involve an exploratory study to find out how the visual impaired value the tactile prototype other than just on users' learnability. In other words how ease of use or ease of learning helps the prototype become more valuable for these target users.

Other future work can be done to the prototype system to include the options for users to adjust the speed of the pins so that they could read the Braille Line in the speed they prefer. Similar work should also be replicated using a bigger tactile display to provide natural interaction.

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