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Quran Vibrations in Braille Codes Using the Finite State Machine Technique

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1. Introduction

How will blind people participate in a literate culture? How will they continue their education? What will make them feel as normal people? What about the Muslim blind people? Do they have the ability to read the Quran? What is a Braille system and how it was created? From these questions, the idea of Braille system has evolved.

Braille is a system of writing that uses patterns of raised dots to inscribe characters on paper. Therefore, it allows visually-impaired people to read and write by touching instead of seeing. Also it is a way for blind people to participate in a literate culture. The idea of Braille was started by Louis Braille, who was a blind person himself as a consequence of an accident that occurred when he was three years old. He needed a new way to learn. Although he had stayed at his old school for more than two years, he couldn't learn everything by listening. In 1821, a soldier named Charles Barbier visited the school. He introduced his invention, called "night writing," which was a code of 12 raised dots that had enabled soldiers to share top-secret information on the battlefield without having to speak. Louis had trimmed Barbier's 12 dots into 6 and then published the first Braille book in 1869 (Kim, 2009).

Braille is the system of touch reading and writing, which utilizes raised dots to represent the print alphabet letters for persons, who are blind. This system includes symbols to represent punctuations, mathematic and scientific characters, music and computer notations, and foreign languages. The blind are able to review and study written words using the Braille language, which provides a vehicle for literacy, giving the blind the ability to become familiar with spelling, punctuation, paragraphing, footnotes, bibliographies and other formatting considerations. A Braille cell, which consists of 6 dots - 2 across and 3 down, is considered as the basic unit for all Braille symbols. For easier identification, these dots are numbered downward 1, 2, 3 on the left, and 4, 5, 6 on the right, as shown in Figure 1.

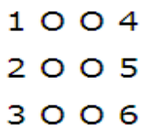

Fig. 1. Braille Code Cell

Sixty-four probabilities are possible from these six dots, including the space symbol. These sixty four patterns are represented by equation 1

$$P = 2^N \quad (1)$$

P : number of Braille symbols
N: number of Dots

With the huge growth of technology nowadays, Braille systems have become widely adopted in most natural languages such as English, Germany, French, and so on. The Arabic language has also been translated to the Braille system. The Arabic Braille symbols were created based on the English characters as the translation process from any language to Braille must match the English characters first. Table 1 shows the Arabic characters, the matched English characters and the Braille symbols.

This research deals with the Al-Quran, that has its own limitations and rules for Muslims or for those who need to read about Islam as GOD holy book. The Quran recitation is different from the Arabic language reading in that it has special vibrations that must be adhered to, as any change in the way of reading can give another meaning. `Allah said: "وَرَتِّلِ ٱلْقُرْآنَ تَرْتِيلًا" verses number (4), Surah (المزمل. (Al-Mozammel)', the meaning of which is `you should take care reading Quran verses, which Allah has ordered Muslims not to fall in the reading mistake'. The Arabic Holy Quran was translated to Braille code in Roy (2004). However this system is not complete as it does not include special vibrations required in reciting Al-Quran, which is different from reciting the Arabic language. In the study of Omar & Kishik (2008), they have concentrated on the Noon + Scoon vibrations only, whereas this study has included more vibrations left out by them.

These vibrations are: Noon + Scoon vibrations (اظهار (Edhare), ادغام (Edgham), اقلاب (Eklabe), قلقلة (Kalkala) and اخفاء (Ekhfa')), Meem vibrations (اظهار (Edhare), ادغام (Edgham), اخفاء (Ekhfa')); Lam vibrations (اظهار (Edhare), ادغام (Edgham)) and Mud vibrations. Therefore there is a need to develop a system for translating these special vibrations into Braille symbols for the Quran verses.

In this research, the Decision table controls the operation of the finite state machine and provides more flexibility for it. A new grade has been created for the Arabic Quran Braille, covering the vibrations, absent in existing systems. A suitable finite state machine has also been developed to handle (i) a new grade Braille for the same language, allowing a single set of rules to double in the translation to Braille and (ii) a simple list of character translation rules that can be edited directly by non-technical users.

2. Related Research

There were many researches done to translate natural languages to Braille symbols. In this section, there are two research examples using finite state machine - decision table and rule

base system to translate the English language to Braille symbols, and to apply some rules at the grade 1 of Braille symbols to become grade 2.

2.1 Text and Braille computer translation (King, 2000)

This was concerned with the translation of texts from and to Braille using the matching of left and right contexts of the translation windows with the finite state machine to handle grades of Braille within the same language and to allow a single set of rules to duple as translation from and to Braille. The decision table controls the operations of the finite state machine and simple list of character translation rules that can be edited directly by non-technical users.

2.2 A system for converting print into Braille (Blenkhorn, 1997)

In recent years, the UMIST translation system has been one of the few published works on text and Braille translation. The engine state is controlled by a finite state machine using the contents of the decision table, which regulates which subset of the language translation rules can be used. The translation engine can use any language rules table. So, any language can be translated to or from Braille code if the language rules table is constructed.

3. The Existing Braille Systems

3.1 Duxbury Braille Translation software

Duxbury Braille Translation (DBT) software is a window-based software system that automates the process of conversion from regular prints to Braille (Holladay, 2001) providing translation and formatting facilities. It also provides word-processing facilities directly in the Braille mode, where the user can treat the keyboard as Perkins machine to enter Braille text as well as using the software for ordinary word processing tasks. In addition, the software can translate Arabic text to Braille. With this supplementary function, one can create and edit natural Arabic texts using Microsoft Word (Arabic version), and then import and translate the file into Arabic Braille using the DBT. English texts can also be intermixed, and both languages may or may not be contracted, or in combination. Although DBT supports all the above features, there was still a small bug. The translation of Arabic characters in DBT was not 100% equivalent to the Arabic character set supported by Windows 95/98/NT/2000. Perhaps this was due to the difference in character code page used by DBT and Windows 95/98/NT/2000. Moreover, DBT does not support any type of sound, essential for the blind to interact with computers.

3.2 IBSAR

A Braille translate system (IBSAR) was developed by Al Alamiah, KSA (2004). The software was designed for the sighted users, having the ability to translate Arabic and English texts into Braille without contractions. It uses MS-Word as its platform.

3.3 Printing system with Braille software

The Kuwait institution for scientific research has developed software called printing system with Braille (Roy, 2000). It is a window-based application oriented for the sighted people to

convert Arabic texts to Braille (one way translation). The software supports multi-level contractions as well as the conversion of Holy Quran files into Braille, but it doesn't involve the vibrations of the Holy Quran.

3.4 Sensus Braille software

Sensus Braille was developed by Sensus ApS, a co-operative effort of Danish and International Braille authorities. It is window-based software that automates the translation of English and Danish texts into Braille and vice-versa. However it does not support the Arabic language (Sensus, 1999).

4. Theory Building

Theory Building is the construction of a conceptual framework that declares the truth, formulates a concept, designs a method and develops a theory that is used during the prototype development.

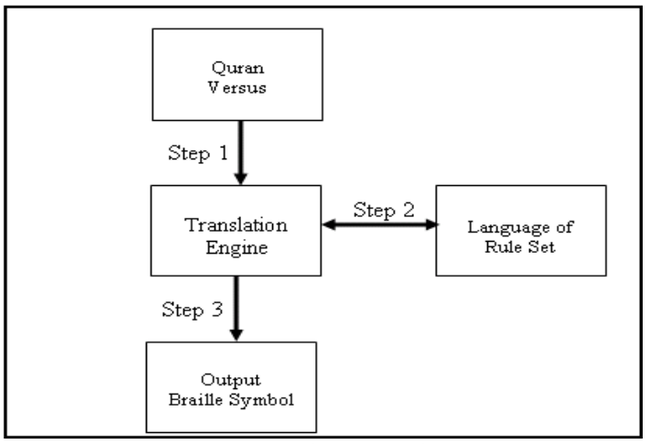

Fig. 2. Methodology approach for the translation algorithm

During the translation process the engine works along the input texts, character by character. It attempts to match a window of input text starting with the current character with one of the translation rules in the language rules table. Finite state machine involves the complications of state, control tables and many rules. An alternative approach using only the matching of left and right contexts of the translation window was developed. The former contains the translation algorithms and functions, while the latter has all of the translation information for translation of one language in one direction. The translation engine can use any language rules table, so any language can be translated to or from Braille code if the language rules table is constructed.

The language rules table consists of a set of translation rules and a decision table. A successful match with a translation rule must match a segment of text, the context - the text to the left and right of the window and the state of the engine. The engine state is controlled by the finite state machine, using the contents of the decision table, and regulates which subset of the language translation rules can be used. The translation rule provides the

translation for that window of input text, which is appended to the growing output text, and the engine moves along the input text to the next unmatched character.

The standard world Braille is represented by the English character, so that the developers of the Arabic Braille systems are able to use the English characters to represent the Arabic Braille symbols. Therefore, the process to create the new vibrations to be used in Quran Braille (اظهار (Edhare), ادغام (Edgham), اقلاب (Eklabe), اخفاء (Ekhfa')) for the Noon, Meem and lam characters; and قلقلة (Kalkala) for the Scoon, entails finding all the possible probability symbols, that do not duplicate with existing Arabic symbols, thus constituting the 5 new vibrations.

4.1 Develop the Rule set

1) Create New Vibration

The recitation for the Quran verses is not similar to the Arabic language reading, as the Quran verses have special vibrations that help the Quran reader to get the right meaning for the verses. This research is concerned with the creation 8 new vibrations that did not exist in previous systems.

As shown in Table 1, the Noon Sakenah, Meem Sakenah, and Lam Sakenah have similar tow vibrations (Edhare and Edgham); the Ekhfa' vibration occurs with the Noon Sakenah and Meem Sakenah; the Eklabe occurs with the Noon Sakenah, and the Kalkala occurs with the Scoon. The Noon Sakenah, Meem Sakenah, Lam Sakenah and Scoon have different rules for each vibration detected.

Noon and Scoon	Meem and Scoon	Lam and Scoon	Scoon	English Characters	Braille Symbols	Number Of Dots
Edhare	Edhare	Edhare		0	⠶	356
Edgham	Edgham	Edgham		8	⠦	236
Ekhfa'	Ekhfa'			7	⠷	2356
Eklabe				6	⠧	235
			Kalkala	p	⠿	1234

Table 1. New Quran Vibration Symbols

The Mud vibrations have many types - Mud for two characters (the reader should recite the character that have the Mud as two characters), Mud for four characters and Mud for six characters.

Mud Type	English Characters	Braille Symbols	Number Of Dots
Mud 2 Char	_B	⠸⠸	456 + 12
Mud 4 Char	_D	⠸⠸	456 + 145
Mud 6 Char	_F	⠸⠸	456 +124

Table 2. Mud Braille symbols

2) Character Rules

a) Arabic characters that need to translate.
b) Identifying all the Arabic characters to be translated.
c) Identifying all the new vibrations to be translated.
d) Identifying the English characters that meet the Arabic characters.
e) Identifying the new created symbols.
f) Identifying the world standard Braille symbols for the English characters

3) Vibration Rules

There are around 20 reciting styles for the Holy Quran verses, but the most widespread reciting in the Islamic World is the Huffs reciting style, as mentioned in Al-kari' (1998), followed by Ali bin Abi-Talib "Allah blesses him". The rules set for the Quran vibrations applied are consistent with the Huffs style reciting, and this is explained comprehensively in this section.

The system will check the verses, word by word and if it finds any vibration, it will put its symbol under the vibration in a separate line to maintain the reader's attention to the vibration for the word that he/she reads it before he/she falls in default.

a) Noon Sakenah Vibrations

This vibration occur, if the characters in each vibration comes after Tanween or Noon Sakenah as presented in Tables 3, 4, 5 and 6.

خ	غ	ح	ع	هـ	ء	أ	إ	ؤ	ئ
X	>	:	)	H	`	/	.	|	Y
⠭	⠜	⠱	⠣	⠓	⠈	⠌	⠄	⠳	⠽

Table 3. اظهار (Edhare Vibration)

ن	ل	م	ر	ي
N	L	M	R	I
⠝	⠇	⠍	⠗	⠊

Table 4. ادغام (Edgham Vibration)

ب
B
⠃

Table 5. اقلاب (Eklabe Vibration)

ظ	ض	ث	ف	ز	ط	د	س	ق	ش	ج	ك	ت	ذ	ص
=	$	T	F	Z	(	D	S	Q	%	J	K	?	!	&
⠿	⠎	⠞	⠋	⠵	⠣	⠙	⠎	⠟	⠩	⠚	⠅	⠹	⠮	⠯

Table 6. اخفاء (Ekhfa' Vibration)

b) Meem Sakenah Vibrations

The vibrations that will occur, if the characters come after Meem + Scoon, are shown in Tables 7, 8 and 9.

Arabic Characters	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ع	غ	ف	ق	ك	ل	ن	ه	و	ي
English Characters	a	t	?	j	:	x	d	!	r	z	s	%	&	$	(	=	)	>	f	q	k	l	n	h	w	i
Braille Symbols	⠁	⠃	⠞	⠹	⠱	⠓	⠭	⠙	⠮	⠗	⠵	⠎	⠩	⠯	⠫	⠣	⠾	⠜	⠷	⠋	⠟	⠅	⠇	⠝	⠓	⠺	⠊

Table 7. اظهار (Edhare Vibration)

Arabic Character	م
English Character	m
Braille Symbol	⠍

Table 8. ادغام (Edgham Vibration)

Arabic Character	ب
English Character	b
Braille Symbol	⠃

Table 9. اخفاء (Ekhfa' Vibration)

c) Lam Sakenah Vibrations

The vibrations that will occur, if the characters come after Lam + Scoon, are given in Tables 10 and 11.

Arabic Characters	أ	ب	غ	ح	ج	ك	و	خ	ف	ع	ق	ي	م	ه
English Characters	/	b	>	:	j	k	w	x	f	)	q	i	m	h
Braille Symbols	⠁	⠃	⠜	⠓	⠚	⠅	⠺	⠭	⠋	⠪	⠟	⠊	⠍	⠓

Table 10. اظهار (Edhare Vibration)

Arabic Characters	ط	ث	ص	ر	ت	ض	ذ	ن	د	س	ظ	ز	ش	ل
English Characters	(	?	&	r	t	$	!	n	d	s	=	z	%	l
Braille Symbols	⠦	⠹	⠯	⠗	⠞	⠳	⠮	⠝	⠙	⠎	⠿	⠵	⠩	⠇

Table 11. ادغام (Edgham Vibration)

d) Kalkala Vibrations

The vibrations that will occur, if the characters come after Scoon, are given in Table 12.

د	ج	ب	ط	ق
d	j	b	(	q
⠙	⠚	⠃	⠦	⠟

Table 12. قلقلة (Kalkala)

e) Mud Vibrations

The vibrations for Mud occur in three different conditions as presented in sub-sections below with the associated tables.

1. Mud for two characters

Arabic Character	ا	ـُـو	ـِـي	ا + ء	ـُـو + ء	ـِـي + ء
English Character	a	u + w + 3	e + i + 3	‘ + a	‘ + w + 3	‘ + i + 3
Braille Symbols	⠁	⠥ + ⠺ + ⠼	⠑ + ⠊ + ⠼	⠄ + ⠁	⠄ + ⠺ + ⠼	⠄ + ⠊ + ⠼

Table 13. Mud rules for two characters

2. Mud for four characters

Arabic Character	ء + ا	ء + وْ	ء + يْ
English Character	a + ‘	w + 3 + ‘	i + 3 + ‘
Braille Symbols	⠁ + ⠄	⠺ + ⠒ + ⠄	⠊ + ⠒ + ⠄

Table 14. Mud rules for four characters

3. Mud for six characters

Arabic Character	ـٓ + (حرف) + ا	ـٓ + (حرف) + وْ	ـٓ + (حرف) + يْ
English Character	a + (char + 3)	(w + 3) + (char + 3)	(I + 3) + (char + 3)
Braille Symbols	(⠁ + ⠒) + (char + ⠒)	(⠺ + ⠒) + (char + ⠒)	(⠊ + ⠒) + (char + ⠒)

Table 15. Mud rules for six characters

Arabic Character	ـٔ + (حرف) + ا	ـٔ + (حرف) + وْ	ـٔ + (حرف) + يْ
English Character	a + (char + ,)	(w + 3) + (char + ,)	(I + 3) + (char + ,)
Braille Symbols	(⠁ + ⠒) + (char + ⠂)	(⠺ + ⠒) + (char + ⠂)	(⠊ + ⠒) + (char + ⠂)

Table 16. Mud rules for six characters

Table 17 shows that if the listed Arabic characters are found separately at the beginning of the surah (Quran Text), it will have Mud for six characters.

Arabic Character	ن	ق	ص	يس	طس	حم	الر	الم	المر	طسم	المص	كهيعص
English Character	n	q	&	i+s	)+s	:+m	a+L+r	a+L+m	a+L+m+r	)+s+m	a+L+m+&	k+h+i+(+&
Braille Symbols	⠝	⠟	⠯	⠊⠎	⠕⠎	⠒⠍	⠁⠇⠗	⠁⠇⠍	⠁⠇⠍⠗	⠕⠎⠍	⠁⠇⠍⠯	⠅⠓⠊⠣⠯

Table 17. Mud rules for six characters

4) Develop the Decision Table

Decision table is a powerful documentation tool for understanding and maintaining documents and is also useful in verifying the rules. Table 18 is regarded as the main table that will manage the process of applying the vibrations rule for the Holy Quran text.

IF Conditions	(Noon + Scoon) OR (Tanween) (Meem + Scoon) (Lam + Scoon) (Kalkala Char + Scoon) (Mud Char) (ELSE)	Y N N N N N	N Y N N N N	N N Y N N N	N N N Y N N	N N N N Y N	N N N N N Y
ACTION	GO To Noon Vibration D .Table 20 Go To Meem Vibration D .Table 21 Go To Lam Vibration D .Table 22 Put the symbol of Kalkala Go To Mud Vibration D .Table 23 RE - Check General D .Table 19	X	X	X	X	X	X

Table 18. General Table

Tables 19, 20, 21 and 22 represent the actions that occur after applying the conditions shown in Table 18.

IF Conditions	{((Noon + Scoon)OR (tanween)) + (Edhare Char) } {((Noon + Scoon)OR (tanween)) + (Edgham Char) } {((Noon + Scoon)OR (tanween)) + (Eqlabe Char) } {((Noon + Scoon)OR (tanween)) + (Ekhfa' Char) }	Y N N N	N Y N N	N N Y N	N N N Y
ACTION	Put the symbol of Edhare Put the symbol of Edgham Put the symbol of Eqlabe Put the symbol of Ekhfa'	X	X	X	X

Table 19. Noon vibrations

IF Conditions	{(Meem + Scoon) + (Edhare Char) } {(Meem + Scoon) + (Edgham Char) } {(Meem + Scoon) + (Ekhfa' Char) }	Y N N	N Y N	N N Y
ACTION	Put the symbol of Edhare Put the symbol of Edgham Put the symbol of Ekhfa'	X	X	X

Table 20. Meem vibrations

IF Conditions	(Lam + Scoon) + ((Edhare Char) + (Not Shudah)) (Lam + Scoon) + ((Edgham Char) + (Shudah))	Y N	N Y
ACTION	Put the symbol of Edhare Put the symbol of Edgham	X	X

Table 21. Lam vibrations

IF Conditions	(MUD 2) (MUD 4) (MUD 6)	Y N N	N Y N	N N Y
ACTION	Put the symbol of MUD 2 Put the symbol of MUD 4 Put the symbol of MUD 6	X	X	X

Table 22. Mud vibrations

5) Develop the Finite State Machine

Finite state machine (FSM) is a useful data structure to express actions with a given sequence of events. FSM concepts are used for pattern recognition, artificial intelligence studies, and language. The basic concepts are easy to understand and immensely powerful. The idea behind FSM is that a system such as a machine with electronic controls can only be operational in a limited (finite) number of states. Consider some simple systems that you encounter every day - a door may be open or closed; a light may be on or off; a light bulb may be on, off or broken; a cassette player may be playing, stopped, rewinding or fast forwarding, (Gibson, 2000).

For each pair of state and input symbol there is one and only one transition to a next state, or each input symbol will then be transitioned to a state governed by a transition function. The first step to develop the FSM is determining the states needed to do the translation process (five main states in this study). Then determine the transition function needed to make the transition from state to state.

Figure 3 depicts the FSM method that was used in the system to monitor the translating processes.

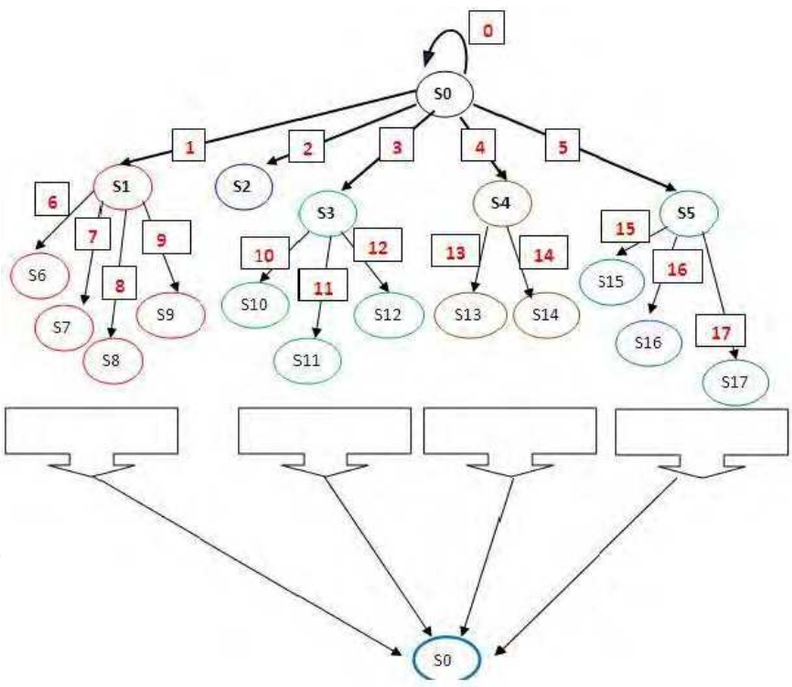

Fig. 3. Finite state Machine Diagram

For example, to demonstrate how the FSM works, the verses (فمن يعمل) were applied to the technique. At the initial state S1, the cursor reads the first character in the verses and because it does not have any vibrations, the transaction function is (0), translating the character to the corresponding Braille symbol, and the current state for the algorithm

becomes S0. The cursor then moves to the second character, and as it also does not have vibration, the transaction function is (0) as well, with the current state still at S0. Next, the cursor moves to the third character and finds - Noon followed by Scoon, and then applies the transaction function (1). Then it checks the character after the - Noon followed by Scoon to determine the special vibration for the character, and subsequently moves to S1. Finally, the cursor checks the next character to determine the type of vibration present, then translating it to an appropriate symbol of the special vibration at this vibration location. In the previous example, the character that followed the Noon Sakenah was (Ya), where it was then considered as one of the Edgham vibration, so the cursor moves to S6 after translating the Edgham vibration. After that, the current state was back at S0 to continue the translation and detecting process for the rest of the verses and so on.

Table 23 represents the truth table for the FSM status for each state and each possible input from the user.

Status	Transition Function																	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
S0	S0	S1	S2	S3	S4	S5	-	-	-	-	-	-	-	-	-	-	-	-
S1	-	-	-	-	-	-	S6	S7	S8	S9		-	-	-	-	-	-	-
S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S3	-	-	-	-	-	-	-	-	-	-	S10	S11	S12		-	-	-	-
S4	-	-	-	-	-	-	-	-	-	-	-	-	-	S13	S14		-	-
S5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	S15	S16	S17

Table 23. Truth Table

Table 24 describes the transition for each state. The transition function is to determine the next state based on the current input and state.

Transition Function	Description
0	Normal character
1	(Noon + Scoon)OR(Tanween)
2	Kalkala
3	Meem + Scoon
4	Lam + Scoon
5	Mud

Table 24. Transition Function Description

6) Design and developing the translation engine

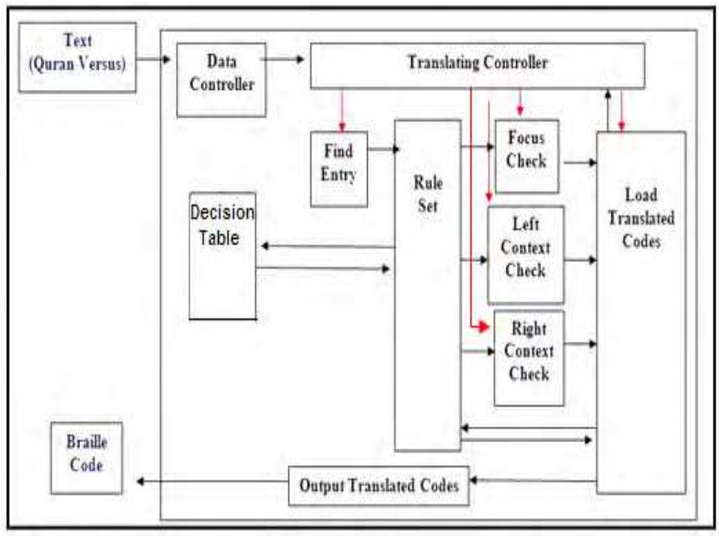

Fig. 4. Translation Block

Figure 4 depicts the translation block. The find-entry block receives one entry character from the translating-controller block and outputs a particular address to the rule-set block, where two operations are kept running. One reads rules from the Decision table block, while the other sends every single rule to focus-check, right-context-check, left context-check, and load-translated-codes blocks. The rule-set block receives signals from the find-entry block obtaining addresses, and signals from the load-translated-codes block, that indicates if the output rule can be used. The rule-set block sends an address to the Decision table to read one rule at a time and sends it separately to the focus-check, right context-check and left-context-check blocks. If the rule does not find a match, then a signal is generated and the rule-set block gets the next rule and sends it. This process continues until a match is found and the focus is successfully translated. The focus-check and right-context-check blocks receive not only the rules from rule-set block, but also the whole group of words to be translated from the translating controller because more than one letter of focus and right context may need to be checked. Each block generates signals for the load-translated-codes block indicating if the focus, the right context or the left context were successfully matched. If one of the three fails, then a signal is sent back to the rule-set block requesting the next rule. If the focus, right context and left context match one of the rules, then the load translated- codes block sends the translated codes to the output translated- codes block, and informs the translating-controller block how many characters were translated. After one group of characters has been translated, the output-translated-codes block transmits the corresponding Braille ASCII characters one by one. Then the translation of a new set of characters begins.

5. Conclusion

In this study, the Quran Braille System was developed. It provides blind Muslims an easy way to read and understand the Holy Quran as well as the chance for other blind people to learn about Islam.

The experiments have produced a full translation prototype for the Quran verses including associated vibrations. The result of the experiment will be printed out using a Braille printer to introduce the usefulness of this study particularly to researcher and society at large. This study will adhere to its objectives, which are:

- To reorganize appropriate Braille symbols for the Quran vibrations.
- To translate Quran verses to Braille symbols.
- To propose accurate Quran Braille prototype for the translating process and the vibrations that will be detected from the Quran verses.

In order for this study to achieve the quality of outstanding systems, contributions from many institutes and research centres nationwide are required. Also, there is a need to standardize the Braille symbols to the Quran vibrations, because they have individual contraction rules.

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