IMPROVE DESIGN FOR AUTOMATED TAJWEED CHECKING RULES ENGINE OF QURANIC VERSES RECITATION: A REVIEW

Noor Jamaliah Ibrahim
M. Y. Zulkifli bin Haji Mohd Yusoff
Zaidi Razak

INTRODUCTION

In this new technological era, speech recognition is a topic that is very useful in many applications and environments in our daily life. This research stimulates speech recognition technology, which incorporates with the various components in artificial intelligent, natural sciences, speech processing technology and human computer interaction [1]. However, speech recognition is the most challenging fields faced by most of researchers from a long time ago. The complete solution is still far from reach. Then, the research is applied to the enormous applications, due to obtained good speech recognizer that are free from constraints of speakers, vocabularies and environments. This task is not an easy task, due to the interdisciplinary nature of the problem and requires speech perception to be implied in the recognizer. Moreover, speech language processing of speech recognition relies heavily on pattern recognition, which is one of the most challenging problems for machines.

Because of that, in this paper we review previous work done on recognizing the Tajweed rules in Quranic verse recitation. Reciting Al-Quran in the appropriate way is very important for all Muslims and indispensable in Islamic worship, such as prayers. For this reasons, Al-Quran learning process through talaqqi & musyafahah method has been carried out. Such method has been considered, since the revelation of the Holy Quran, as the only way to learn how to recite Al-Quran correctly until twentieth century, where Technology produced system recording, storage and electronic devices that are able to keep both text and sound of Al-Quran with tajweed rules (correct pronunciation rules of Holy Quran). However, the effort spent by the computer scientific technology through Information Technology approach are still limited and very challenging.

For the sake of the Noble Quran for Muslim community, new ideas and research need to explore due to expand the broader field of techniques, focused in improving the Quranic learning process, through Quranic reading skill of *talaqqi* and *musyafahah* method. This application of ICT invented

is extremely important and beneficial due to strengthen the learning and teaching process of Al-Quran, especially for j-QAF. In our earlier research of previous work, the results showed the promising results, although it was only tested against the small Quranic chapters (*Surah Al-Fatihah* and *Surah Al-Ikhlas*). The engine invented capable to detect any mispronunciation of the Quranic recitation based on rules of tajweed, which has been set earlier into database. However, the data used for training and testing sets for both surah are limited, since those surah are two short Sourah of Al-Quran, which do not cover all aspects of Tajweed rules and all Quranic sounds with their phonotactic rules. Different methods have been used by other researchers to improve their system in recognizing the tajweed rules, with high percent of recognition accuracy rate. The methods and approaches used by these researchers will be discussed in details in the next part.

RECOGNITION CHALLENGES OF TAJWEED CHECKING RULES IN QURANIC VERSE RECITATION

Linguistic properties of Arabic Language

Arabic is the language of the Quran. It is an ancient classical language, which influenced by a lot of dialects. It has been used as an official language in more than 22 countries. Arabic is one of the languages that are often described as morphologically complex and the problem of language for Arabic are multipart by the variation of dialectal [2][3][4][5]. However, only Modern Standard Arabic (MSA) has been used for written and formal communication, because MSA has universally agreed upon the writing standard, as well as for communication purposes [2][3][4][5][6].

According to [4][5] and [7], there are many difficulties arise when dealing with the specialties of Arabic language in Holy Quran, due to differences between written and recite Al-Quran. Those same combinations of letters may be pronounced differently, due to the use of harakattes [7]. Some cause of error will be discussed in details in part 3, which also related with dielects. Furthermore, Quranic phonemes of pronunciation are marked by diacritics, such as consonant doubling (phonemic in Arabic). It is indicated by "shadda" sign and "tanween" sign of word final adverbial markers. These signs can reflect the differences of pronunciation, which important in setting up the grammatical functions that lead to the acceptable text understanding and correct reading of Al-Quran [4]. The entire set of diacritics is listed in Table 1, shown below [3]:

Table 1:
Arabic diacritics (from Vergyri, D. & Kirchhoff, K., 2004)

Example	Symbol Name	Meaning
اَ	Fatha	/a/
اِ	Kasra	/i/
اُ	Damma	/u/
رّ	Shadda	Consonant doubling
درْس	Sukuwn	Absence of vowel after consonant
اً	Tanwyn al-fath	/an/
اٍ	Tanwyn al-Kasr	/in/
اٌ	Tanwyn ad-Damm	/un/
ى	'Alif Maqsuwra	/a:/ sound historical
هذه	Dagger 'Alif	/a:/ sound historical
آ	Madda	Double alif
في ألبيت	Wasla	On 'alif in *al*
لا	Laam 'Alif	Combination of laam and 'alif
ة	Taa Marbuwta	Morphophonemic marker

Tajweed rules in Quranic verse Recitation and its Acoustic Model

"Tajweed" or "Tajwid" is an Arabic word for elocution, meaning proper pronunciation during recitation of Al-Quran, as well as recitation at a moderate speed. It is a set of rules, which considered as an 'art', that govern on how the Quran should be read [7][8]. As we already know, each human's voice is different. Thus, the Quranic recitations which had been recited by most of recitors were totally differed from one recitor to another. Although those Quranic ayates were particularly taken from the same verse, but the way of the ayates been delivered or recited may be different [2][7]. It may produce the different sounds for the different recitors. Here, 'Art of Tajweed' indicates some of flexible well-defines rules in reciting Al-Quran. These rules create a big difference between normal Arabic speech and Quranic recitation, which may produce interesting results based on 'art' analysis towards acoustic model. Moreover, the 'art of tajweed' is still handled in manual method that needs a lot of work and proved to be unable to adapt with new recitors. However, it is still believe that, the special way to recite Al-Quran is by looking forward the art of tajweed [8].

Types of Recitation Errors

According to Salah, E. H. and Mohsen, R. (2006) [9], recitation errors can be classified under 2 major, which are (1) Cause of Error, which determine the suitable feedback; and (2) Effect of Error, which determines method of detection.

1. Cause of Error by Colloquial Pronunciation

   In this type of error, the equivalent formal Arabic pronunciation does not exist in mother colloquial dialect. Example:

   ❑ Egyptian colloquial Arabic does not contain the phoneme T (ث) and D (ذ), S (س) and Z (ز) is pronounced instead.

2. Cause of Error by Inaccurate Articulation

   In this error, it is usually happen due to insufficient practice and/ or knowledge of correct articulation of phonemes. Adjacency of phonemes with distant place of articulation that results in difficulty in correct pronunciation of phoneme, with weaker characteristics usually occurred. Examples for these errors:

   ❑ (النَّار) (?anna:r') becomes (?anna':r') (where a' is emphatic a)

   ❑ (تصِير) (tas'i:r) becomes (t'a's'i:r)

   Correction of these types of errors is much harder than first type because:

   i. Practice needed to get acquainted to the correct pronunciation (which is difficult).

   ii. It is difficult for learners to diagnose this type of mispronunciation by themselves.

   iii. The style of speaking of some words changes than Arabic colloquial dialect.

   iv. This type of mispronunciation happens frequently.

3. Cause of Error by Ignorance of Recitation Rules.

   Holy Quran recitation is totally differed than formal Arabic recitation, even a well trained formal Arabic speaker also shall make recitation errors. Examples of these errors are:

   ❑ Pronouncing non-vowelled noon (Manifestation), when it should be concealed: (مَن زَكَّها) (man:zakka:ha:) become (manzakka:ha:)

❑ Pronouncing a vowel followed by glottal stop, without extra lengthening, as it is compulsory lengthening as in (السماء) (?assama::?) become (?assama:?) (Where a:: stands for a double length a:).

4. Effect of Error by Phonetic Transcription.

That includes phone insertions, deletions and substitutions, such as:

❑ Insertion of glottal stop "همزة وؤصل" in (عن النباء) (?'aninnaba?), so it become (?'an?annaba?).

❑ Deletion of phoneme r "ر" at end of utterance as in (خبير) (xabi:r), so it becomes (xabi:).

❑ Substitution of phoneme T "ث" by phoneme s "س", seen as in (ثواب) (Tawa:b), so it becomes (sawa:b).

HMMs well-trained on the acoustic features of each phoneme will be sufficient detection tool for these error types.

5. Effect of Error by Phoneme Duration.

That includes lengthening of short phonemes or vice versa such as:

❑ Lengthening vowel (i) in (مالك يوم الدين) (ma:likijawmiddi:n), so it becomes (ma:liki:yawmiddi:n).

❑ Shortening of compulsory lengthening in (السماَء) (?assama::?), so it become (?assama:?).

Ordinary acoustic of HMM is not sensitive discrimination tool between models with similar acoustic features, but differs only in duration. Thus, HMMs will deploy only on phonetic segmentation of the utterance, then speaking rate normalization and a duration classification algorithms. The approaches used by these researchers will be discussed in details in the next part.

EXISTING APPROACHES

In early year of twentieth century, the research towards speech recognition technology using Quranic Arabic has been started to begin. Computer Aided Pronunciation Learning (CAPL) has been introduced, where it received a considerable attention in recent years. Many research efforts have been done for improvement of such systems, especially in the field of second language teaching [10][11]. In these recent years, researchers took serious actions, after experiencing some challenging problems and difficulties in recognizing Quranic letters, especially in checking the Tajweed rules. Moreover, CAPL also facing a same problem, in order to be automatic training for correct

recitation of the Holy Quran for Arabic speakers. Different strategies and approaches have been carried out by them, where the details are discussed after this.

Open Source Sphinx Framework

In this approach, Automatic Speech Recognizer (ASR) has been developed using the open source of Sphinx Framework as the basis of research. SpinxTrain is a tool based on HMM (Hidden Markov Model), for the development of Acoustic Model. Group of research lead by H.Tabbal, et al. (2006) [12] have go through the Quranic verse recitation recognition, which covered the Quranic verse delimitation system in audio files using this speech recognition techniques. The scope of this project more focus into the automated delimiter, which can extract the verse from the audio files. Research techniques for each phase were discussed and evaluated using implementation of various techniques for different recitors, which recite sourat "Al-Ikhlas". The most important tajweed rules and tarteel were also discussed, which can influence the recognition of a specific recitation in surah Al-Ikhlas.

Maximum Likelihood Linear Regression (MLLR)

A group of research from Jordan, lead by Ehab, M. et al. (2007) [13] have developed an automatic speech recognizer for Quranic based-speaker independent, based on the tri-phone Hidden Markov Model (HMM) and Maximum Likelihood Linear Regression (MLLR). Here, the MLLR will compute a set of transformations which reduces the mismatch between an initial model set and the adaptation data. Regression class tree were used, due to estimate a set of linear transformation for the mean and variance parameters of a Gaussian mixture HMM system. In this research, data used for training and testing data is Juz 30th of Al-Quran, with 5 famous readers of the Quran, which are Ahmad Al-Ajamy, Mohamed Brak, Saa'd Al-Ghamidy, Manshary Al-Ghafary and Abd. Alrahman Al-Sudees.

In developing a HAFSS© system, MLLR has been used in Speaker Adaptation block diagram, which mainly for adapting acoustic models to each user acoustic properties, in order to boost system performance. Originally, Sherif M. A. et al. (2006) [11][14] developed the HAFSS© system for teaching Arabic pronunciation to non-native speakers. However, this application has been applied into challenging task in teaching the correct recitation of the Holy Quran. Here, the pronunciation error hypothesis in HAFSS© represented in the form of a linear lattice that is flexible enough to support error hypothesis addition, deletion and overlapping of probable

mispronunciation. Most Quranic learners are not familiar with the phonemes, and thus in HAFSS© system, it will generate user helpful feedback that use lattice unit similar with the one used in traditional methods of the Holy Quran recitation teaching.

Figure 1(a):
Exercise screen

Figure 1(b):
Pronunciation learning flash [14]

Hidden Markov Model (HMM)

Omar, M.K. [16] proposed to use Hidden Markov Model (HMM) based speech verification system, in verifying the acoustic model of Arabic phonemes. Here, the Arabic phoneme set was clustered to a group of clusters and the pronunciation assessment was accomplished in 2 steps, which are detection step of substitution, insertion and deletion errors, as well as, tested by discriminatively trained HMM models against the units. Same approach also recommended by N. Jamaliah, I. [15], but the implementation was directly focus towards Quranic verse recitation. In this research, the Tajweed rules of Quranic verse recitation is verified by using HMM and confidence score values. The implementation of confidence score values is based on the Log-Likelihood Ratio Values, known as LLR. The acoustic model likelihoods are scaled by the likelihood of the first alternative path model of decode model, using Viterbi decoder for recognition part. Meanwhile, Baum-Welch algorithm is based on combination of forward and backward algorithm, mainly for HMM training model. Besides, Hidden Markov Model (HMM) based speech recognizer also has been used by Salah, E. H. and Mohsen, R. (2006) [9]. Here, the most probable pronunciation error hypotheses is generated from CAPL system, that are fed to this HMM speech recognizer, in order to test them against the spoken utterance. It also generates mapping information to determine the appropriate location for the feedback of each candidate hypothesis.

PERFORMANCE EVALUATION AND COMPARISON

The proposed algorithm described in [11] was tested on 507 utterances representing the recitations of randomly selected users of the system, based on different gender, age and proficiency combinations. These utterances were tested and evaluated by language experts and labeled with actual pronounced phonemes that are used to evaluate the system. Here, the system responses will be compared with the human experts' transcriptions. This evaluation procedure was used to adjust system parameters by studying the changes occur of overall performance, due to change of each parameter. The HMM used in HAFSS© is triphone tied state model. Each state is modeled by mixture of Gaussians. In this experiment, Correct Judgment (CJ) ratio of HAFSS©, i.e accept correctly pronounced phones or report same pronunciation error as the human expert. From the results, the *system performance with confidence* able to reach to 96.87% of correct Quranic recitation, whereas *Message based system performance with Confidence* is 80.13% accuracy of correct Quranic recitation.

H. Tabbal, et al. (2006) [12] have carried out 2 different type of tests, regardless to the recitors, which are *Professional Recitors* and *Normal Arabic speaking people*. According to the first test result among 13 *Professional Recitors,* 90% of mean recognition ratio has been successfully achieved from them based on Tajweed. Meanwhile, another experiment under this test is based on Tarteel, which achieved 92% of mean recognition ratio. For the second test, speakers involved in the experiment were 40 recitors, that taken from *Normal Arabic speaking people.* Same evaluation were also been conducted, but the different is based on the gender, either *Male* or *Female*. Based on Male gender, the system developed able to recognize with 90% of mean recognition rate, while 85% mean of recognition rate were involved the female recitors.

Experimental results in [13] shows that, the data used in Juz 30th includes of 2000 distinct words. Using the software of "Sound Forge", these large sound data were divided into 2431 smaller files, within the length 1-20 words. Results shows that a good speaker-independent system can be applied to better fit the characteristics of any recitor. Here, the maximum accuracy of the recognizer is 83% which is Ahmad Al-Ajamy, and the lowest is 68%. The Al-Sudess reading style is differs from the other 4 readers in the reading of articulation sign [o] {المد}. Because of that, his recitation tends to be the lowest accuracy of percentage.

The algorithm used by [15] and [16] were totally the same, but the implementation is different. System developed by [15] is specifically towards the implementation in Quranic verse recitation and Tajweed rules. However,

the data used in her research is small, that only tested against small Quranic chapter, which is *Sourate Al-Fatihah*. The numbers of speech samples collected were 52 words (ayates) and 82 probable samples of phonemes for those ayates in different samples of the Quranic recitation in *Sourate Al-Fatihah*. Speech samples were recorded in a constraint environment, where 5 selected speakers (recitors) were choose and highly trained in Quranic recitation based on the 'Tajweed rules'. Here, the first chapter of Al-Quran (*Al-Fatihah*) were recited, with approximately recited 4 seconds (time length) each, in '.wav' of file format. For the 52 words (8 ayates of *Sourate Al-Fatihah*), the extracted features of this ayates is perfectly reached to 91.95%, with 8.05% of Word Error Rate (WER). Meanwhile, another 82 samples of phonemes were perfectly match the phoneme based template with the percent accuracy reached to 86.41%, with 14.34% of error rate only.

Based on the occurrences distribution result of judgment-response pairs, carried out by researchers in [9], the percentage of correct recitation of Holy Quran based on the errors' confidence score specified in part 2.3 has reached to 80.89%. This percent is based on judgments results between human and system judgment. This percent value was calculated using the system setting for novice users.

CONCLUSION

This paper has provided a comprehensive review of the methods for recognizing the tajweed rules in Quranic verse recitation, which previously proposed by researchers. After a brief description of the characteristics of Quranic recitation pronunciation in Holy Quran, we tried to configure the challenging parts in teaching the correct recitation of the Holy Quran and how it can access the quality of a user's recitation and produce feedback messages, due to help recitors locate their mispronounced letters and eventually overcome it. In other words, we tried to overcome any errors or problems which may affects the performance of Tajweed checking rules engine for Quran. After a while, method or approaches which logically and suitable to be applied has been decided, based on performance/accuracy gained by previous researchers.

The implementation through HAFSS© system [14] is believed able to improve the user performance based on Hidden Markov Model (HMM) acoustic model and Maximum Likelihood Linear Regression (MLLR) speaker adaptation, specifically for correction of Quranic recitation. The previous research project will be modified and added with additional features as in HAFSS© system, due to create the self learning system in Quranic lesson. This self learning system, able to be improved and fully

implemented to j-QAF students as it is designated to its purposes. Thus, the efficiency and accurateness of tajweed checking able to be enhanced with small defeats (minimize errors). The targeted users (J-QAF students), could able to learn Al-Quran by themselves without the presence of teachers/ Mudarris to monitor them.

Table 2: Approaches used by previous researchers in recognizing the Quranic Verse Recitation

Author	Experiment Data	Experiments	Performance/ Accuracy
[H.Tabbal, et al. '06]	13 Professional recitors & 40 normal recitors	Implemented using MFCC feature extraction and Hidden Markov Model (HMM) for classification (Using Open Source Sphinx Framework) – tested against tajweed and tarteel.	85% - 92%
[Sherif M. A. et al. '06]	507 utterances	Developed a HAFSS© system, that used HMM acoustic model and MLLR speaker adaptation, due to correct and correct recitation of the Holy Quran.	Model Tuning result= 97.58% - 96.96% Sys. Performance with confidence=96.87% Message based sys. Performance with confidence = 80.13%
[Ehab, M. et al.'07]	2000 distinct words	Developed an automatic speech recognizer for Quranic based speaker-independent. This system is based on the	The level of accuracy from the tested range 68% - 85%

		triphone Hidden Markov Model and Maximum Likelihood Linear Regression (MLLR). The advantages of using the Quranic verse as the database – uniqueness of the words and high level of orderliness between verses.	

REFERENCES

Hewet, T.T., Baecker, R., Card, S., and et al., Report of the ACM Special Interest Group (SIG) on Computer-Human Interaction Curriculum Development Group: Curricula for Human Computer Interaction, 1996.

Zaidi, R., Noor Jamaliah, I., M. Yamani, I. I., Emran, M.T., Zulkifli, M.Y., and Noor Naemah, A. R., 2008. "Quranic Verse Recitation Recognition Module for Support in j-QAF Learning: A Review". IJCSNS International Journal of Computer Science and Network Security, Vol.8, No.8, August 2008, pp. 207-216.

Vergyri, D., K. Kirchhoff, 2004."Automatic Diacritization of Arabic for Acoustic Modeling in Speech Recognition." COLING Workshop on Arabic-script Based Languages,Geneva, 2004.

Maamouri, M., A. Bies, S. Kulick, 2006. "Diacritization to Arabic Treebank Annotation and Parsing." Proceedings of the Conference of the Machine Translation SIG, 2006.

Kirchhoff, K., D. Vergyri, J. Bilmes, K. Duh, A. Stolcke, 2004."Morphology-based language modeling for conversational Arabic speech recognition." Eighth International Conference on Spoken Language ISCA, 2004.

Kirchhoff, K., 2002."Novel Speech Recognition Models for Arabic." Johns-Hopkins University Summer Research Workshop 2002.

Tabbal, H., W. El-Falou, B. Monla, 2006. "Analysis and implementation of a "Quranic" verses delimitation system in audio files using speech recognition techniques".In: Proceeding of the IEEE Conference of

2nd Information and Communication Technologies, 2006. ICTTA '06. Volume 2, pp. 2979 – 2984.

Bashir, M.S., S.F. Rasheed, M.M.Awais, S. Masud, S.Shamail,2003. "Simulation of Arabic Phoneme Identification through Spectrographic Analysis." Department of Computer Science LUMS, Lahore Pakistan.

Salah, E.H. and Mohsen, R. (2006), "Automatic Generation of Hypotheses for Automatic Diagnosis of Pronunciation Errors", Department of Electrical Engineering, Higher Tech. Institute & The Engineering Company for the Development of Computer System, RDI.

Franco, H., Neumeyer, L., Ramos, M. and Bratt, H. (1999), "Automatic Detection of Phone-Level Mispronunciation for Language Learning", Proc. Of Eurospeech 99, Vol. 2, 851-854, Budapest, Hungary.

Witt, S. (1999), "Use of Speech Recognition in Computer-Assisted Language Learning. PhD thesis, Cambridge University Engineering Department, Cambridge, UK.

Tabbal, H., W. El-Falou, B. Monla, 2006. "Analysis and implementation of a "Quranic" verses delimitation system in audio files using speech recognition techniques".In: Proceeding of the IEEE Conference of 2nd Information and Communication Technologies, 2006. ICTTA '06. Volume 2, pp. 2979 – 2984.

Ehab, M., Ahmad, S. & Mousa, A.,"Speaker Independent Quranic Recognizer Based on Maximum Likelihood Linear Regression," in Proceeding of World Academy of Science, Engineering and Technology Volume 20, 2007.

Sherif, M. A., Samir, A., Khalil, A.H. and Mohsen, R. 2006, "Enhancing Usability of CAPL system for Quran Recitation Learning," INTERSPEECH 2007, Antwerp, Belgium, 27-31 August.

Noor Jamaliah, I. "Automated Tajweed Checking rules engine for Quranic verse Recitation", MCS Thesis, University of Malaya, Faculty of Computer Science & Information Technology, Department of Computer System & Technology, Kuala Lumpur, April 2010.

Omar, M.K., "Phonetic segmentation of Arabic speech for verification using HMM," M.Sc. Thesis, Cairo University, Faculty of Engineering, Department of Electronics and Communications, Egypt, Jan. 1999.