Evolution in Electrical and Electronic Engineering Vol. 2 No. 1 (2021) 165-176

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Development of Automated Tajweed Checking System for Children in Learning Quran

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DOI: https://doi.org/10.30880/eeee.2021.02.01.019
Received 11 April 2021; Accepted 10 May 2021; Available online 30 April 2021

Abstract: Quran is learned at the early stage of Muslim children and usually taught by the religious teachers. It must be recited with precise and correct tajweed in order to avoid the misunderstanding of its meaning. Sometimes the children recite Quran without the presence of the teacher which the children tend to recite Quran wrongly since there is no guidance. Besides, different children have different learning style since some are visual learners and others are audio learners. In order to help the children to learn Quran in an attractive way, an Automated Tajweed Checking System for Children in Learning Quran is proposed. This system not intended to replace the role of the teachers but to attract the children in learning Quran and help the children to learn Quran without the presence of the teachers. The method of the project uses the concept of voice recognition. In voice recognition there are a few steps involve which are pre-processing, feature extraction, feature classification and recognition. The feature extraction technique used is Mel-Frequency Cepstral Coefficient (MFCC) while for feature classification and recognition technique used is Hidden Markov Model (HMM). This proposed system is believed to recognize recitation efficiently, thus helping children in learning Quran once completed.

Keywords: Quran Recitation, Voice Recognition, Tajweed Detection

1. Introduction

Quran is a Holy book which consists of the word of Allah. Besides the deep meaning of Quran verses, its beautiful language also makes Quran different from any of the world's writing in general and Arabic in particular. The Holy Quran is the book where Allah Almighty has blessed the Muslims with a comprehensive code of life. Moreover, with regard to Quran learning, the following hadith of Prophet Muhammad (PBUH) speaks for itself, "The best among you (Muslims) are those who learn the Quran and teach it." (Sahih al-Bukhari 5027). Thus, learning and teaching Quran are one of the sacred acts that a Muslim can perform.

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Reading Quran must with correct Tajweed. Tajweed means “proficiency” or “doing something well”. There are many rules of Tajweed such as Iqlab, Mad, Ghunnah and Harakat. These rules are to avoid any kind of confusion or misunderstanding of the Quran. Allah spoke to His Messenger, Prophet Muhammad sallallaahu ‘alaihi wa sallam (may Allah exalt his mention), in Quran, saying (which means): “…And recite the Quran with measured recitation.” [Quran 73:4].

Quran has been recited at the early age of a child and usually taught by the religious teachers which they will listen to the recitation and re-correct the exact recitation. With the vast of technology, children nowadays are more attracted to gadget. Therefore, a project named Automated Tajweed Checking System for Children in Learning Quran is developed to improve the Quran teaching style. The teachers can use this checking system to attract the children in learning Quran. Additionally, the learning process will become more interactive and interesting.

As known, reciting Quran is usually taught by the religious teachers which they will listen to the recitation and re-correct to the exact recitation. Not all learners however understand the same teaching style since some are visual learners and others are audio learners [1]. Besides that, sometimes, Muslim children recite Quran without the presence of the Quran teachers. For those who are in learning process, they will face problem in reciting Quran without the teacher by their side to guide them.

Thus, by developing a recitation checking system, the system will able to recognize and point out any mismatch or inconsistency between the recitation of the children and the correct recitation by the experienced teacher which are stored in a database. The system also can help the audio learners to learn Quran effectively. A decision-making module will be implemented in the system in which the user can decide to check the recitation or not to make the system more user-friendly.

In this project, the audio signal of respondent recitation (reciter) with the correct Quran recitation (database) was analyzed. Then, an algorithm for voice recognition of Quran verse recitation and tajweed mistake classification were applied and modified. Finally, a graphical user interface for the system was designed. The system was focusing on Surah Al-Fatihah because this is the main Surah in Quran. Targeting group of user for this system is from ages 7 to 12 who can recognize the Quran alphabet since most of the children in those range of age are able to recognize the Quran alphabet. Moreover, the system can detect the tajweed rules of the diacritical mark (fatha, damma and kasra), Mad Aridh Lissukun and Alif Lam Syamsiyah. For training purpose, 10 audios of children recitation in mp3 format were used for testing purposes and an audio of correct recitation in mp3 format for training purposes.

2. Materials and Methods

The development of Automated Tajweed Checking System for Children in Learning Quran has 3 phases as illustrate in Figure 1. The phase starts with the development of feature extraction algorithm for the Quranic verse. In this first phase, Mel-Frequency Cepstral Coefficient (MFCC) algorithm is applied to extract the input speech signal. Then, the development of comparing system between the children recitation and database recitation which Hidden Markov Model (HMM) algorithm is applied. Lastly, the development of graphical user interface for the user.

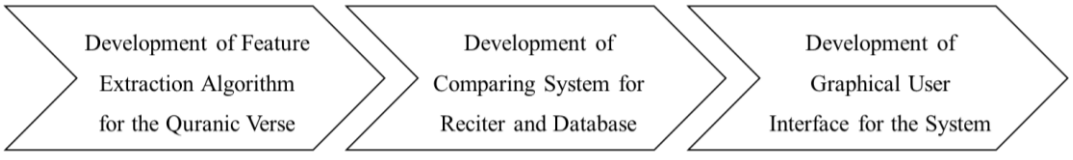

Figure 1: Phases involve in developing Automated Tajweed Checking System for Children in Learning Quran

The algorithm of feature extraction, feature classification and recognition technique are compiled in MATLAB software. MATLAB is chosen since it is a program that not only specializes in signal processing, but also has built-in library for deep learning.

2.1 Development of feature extraction algorithm

Mel-Frequency Cepstral Coefficient technique is used for the feature extraction. MFCC is frequently used nowadays for feature extraction technique in speech recognition which the used of Mel scale in the derivation of Cepstrum coefficients was introduced [2]. Figure 2 shows the steps involve in extracting MFCC for Automated Checking System for Children in Learning Quran. The MFCC computational process is underlined as the primary algorithm for feature extraction analysis.

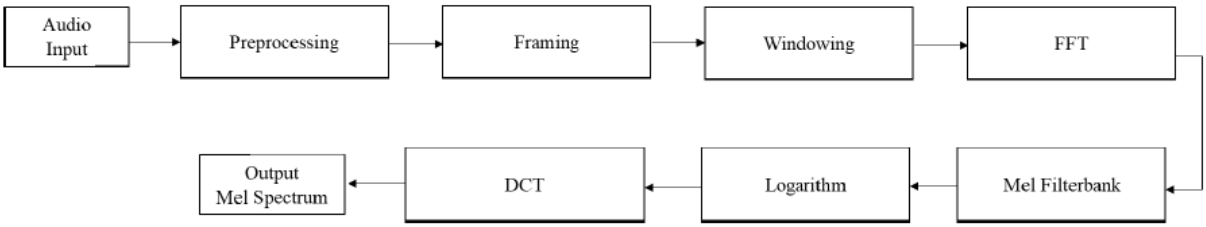

Figure 2: Steps in MFCC algorithm

From Figure 2, pre-processing is the first step in MFCC to converts the analog input signal into digital signal and filtered out the noise. Next, the filtered signal is framed in framing step. In framing, the columns of data from the specific input signal are determined. In windowing step, each of the individual frame of speech signal is windowed in order to minimize the discontinuities of the signal at the beginning and end of each frame. It is to minimize the spectral distortion and to enclose the signal to zero at the beginning and end of each frame.

Hamming window is used in windowing since most of the researchers use this type of windowing. Furthermore, the Discrete Fourier Transform (DFT) usually computed by Fast Fourier Transform (FFT) algorithm [3]. FFT is widely used to evaluate the frequency spectrum of the speech and converts from time to frequency domain. After that, the step of Mel-filter bank.

Mel scale is a unit of special measure or scale of perceived pitch of tone and it is applied in order to place more emphasize on the low-frequency components since the information carried by low-frequency components of the speech signal is more significant than the high-frequency components. Discrete Cosine Transform (DCT) is a Fourier transform, which is similar to the DFT, but using the real numbers only. DCT is used to extract the MFCC results and calculate the Cepstrum instead of inverse FFT.

DCT is the last steps of the MFCC. It required the computational of the logarithm of the magnitude spectrum in order to get the MFCC. The MFCC at this stage are ready to form in a vector format which known as features vector. Thus, this features vector is considered as an input for the next process which is concerned with training the features vector for recognition purposes.

2.2 Development of comparing system for reciter and database

In second phase, HMM is applied to train the database (correct recitation) and to recognize the children recitation by comparing both signals. For convenience and simplicity, a built-in deep learning library is used in MATLAB.

Hidden Markov Model is a statistical system model which is used in the field of pattern recognition, particularly in speech recognition. For some pattern, it is widely used to characterize the spectral properties of the frames. Using HMM, speech signal input is well represented as a parametric random

process and the stochastic process parameters can be determined in a precise and well-defined manner [4]. The training of this model is very important since it represent the utterances words.

There are two main stages in speech recognition [5]. The stages are training and recognition. For training stage, models which is the patterns, are generated from the input speech samples after the feature extraction process and modeling techniques. For recognition stage, the input speech samples will generate the features vector with the same extraction procedures in the training stage. Next, the classification and decision process are made and executed with some matching methods. Under the classification process, the recognition activity can be divided either identification or verification process [4].

2.3 Development of graphical user interface for Automated Tajweed Checking System for Children in Learning Quran

The final development phase of this automated tajweed checking system is the development of Graphic User Interface (GUI) to facilitate the user. Figure 3 shows the developed GUI in MATLAB for this system.

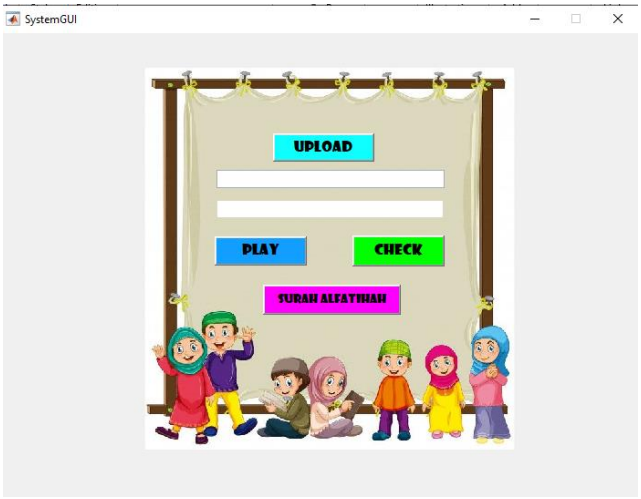

Figure 3: GUI developed in MATLAB

From Figure 3, there are 4 push buttons are used. UPLOAD button is used to browse the audio file, PLAY button is used to play the uploaded audio file, CHECK button is used to do the recognition process which is to check the tajweed for uploaded audio file and SURAH ALFATIHAH button is used to play the correct recitation of Surah Al-Fatihah. The upper white rectangular box is used to display the uploaded audio file name and the lower white rectangular box is used to display the wrong tajweed. Therefore, the attractive graphical user interface is developed to attract the children to use this system.

3. Results and Discussion

The automated tajweed checking system recognize the recited verses by extracting its features and characteristic before the system classify on which tajweed error that the voice has. Therefore, ten collected of children recitation audio and a correct recitation of Surah Al-Fatihah have been converted into signal waveform for analysis purposes. Moreover, the outcome of the compared recited verses with database audio and graphical user interface are also presented.

3.1 Audio samples collection

Aforementioned, this project is focusing on Surah Al-Fatihah. Surah Al-Fatihah has 7 verses. Ten respondents' recitation of Surah Al-Fatihah are recorded in mp3 format for testing purposes. One audio

of correct recitation of Surah Al-Fatihah is used for comparison with the respondents' audio. The audio signal pattern of correct recitation generated by MATLAB is shown in Figure 4.

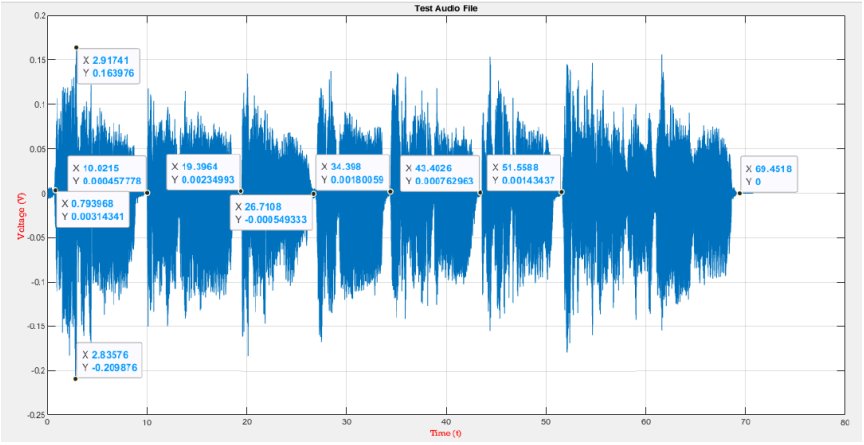

Figure 4: The audio signal pattern of correct recitation

Based on Figure 5, the correct recitation of Surah Al-Fatihah has different time length for each of the verse. The time length for each verse of Surah Al-Fatihah with correct recitation is shown in Table 1. The duration of recitation for the whole surah is 69.4518s.

Table 1: The separation each verse of Surah Al-Fatihah in speech waveform of the correct recitation

No. of verse	Surah Al-Fatihah in Quran	Time length, s
1	بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ	0.7940s ~ 10.0215s
2	ٱلْحَمْدُ لِلَّهِ رَبِّ ٱلْعَٰلَمِينَ	10.0215s ~ 19.3964s
3	ٱلرَّحْمَٰنِ ٱلرَّحِيمِ	19.3964s ~ 26.7108s
4	مَٰلِكِ يَوْمِ ٱلدِّينِ	26.7108s ~ 34.3980s
5	إِيَّاكَ نَعْبُدُ وَإِيَّاكَ نَسْتَعِينُ	34.3980s ~ 43.4026s
6	ٱهْدِنَا ٱلصِّرَٰطَ ٱلْمُسْتَقِيمَ	43.4026s ~ 51.5588s
7	صِرَٰطَ ٱلَّذِينَ أَنْعَمْتَ عَلَيْهِمْ غَيْرِ ٱلْمَغْضُوبِ عَلَيْهِمْ وَلَا ٱلضَّآلِّينَ	51.5588s ~ 69.4518s

Table 2 shows the maximum and minimum voltage as well as the duration of the recorded recitation of Surah Al-Fatihah for 10 respondents.

Table 2: Summary of audio signal analysis of ten respondents' recitation

Speech waveform recitation	Maximum Voltage, V	Minimum Voltage, V	Audio Duration, s
First respondent	0.7304	-0.7179	38.8091
Second respondent	0.5553	-0.4122	41.9589
Third respondent	0.1783	-0.1538	40.0449
Fourth respondent	0.1193	-0.1121	36.9376
Fifth respondent	0.6490	-0.6097	47.7788

Sixth respondent	0.3320	-0.3729	32.9572
Seventh respondent	0.1774	-0.2134	27.8237
Eighth respondent	0.3265	-0.2540	57.8450
Nineth respondent	0.2830	-0.2091	32.3617
Tenth respondent	0.1535	-0.1548	36.0971
Correct recitation	0.1640	-0.2099	69.4518

From Table 2, the first respondent has the highest maximum voltage value which is 0.7304V. the different of the maximum voltage value for the first respondent as compared to correct recitation is 0.5664V. the fourth respondent has the least maximum voltage value which is 0.1193V where the different of the maximum voltage value as compared to correct recitation is 0.0447V. the tenth respondent has the nearest maximum voltage value which is 0.1535V to the correct recitation. The first respondent has the highest minimum voltage value which is -0.7179V where the different of the minimum voltage value as compared to correct recitation is -0.5080V. The fourth respondent has the least minimum voltage value which is -0.1121V where the different of the minimum voltage value as compared to correct recitation is -0.0978V. the nineth respondent has the nearest minimum voltage value which is -0.2091V to the correct recitation audio. The correct recitation has the longest audio duration since the Surah Al-Fatihah is recited with the correct tajweed which is 69.4518s. the seventh respondent has the shortest audio duration which is 27.8237s. the eighth respondent has the nearest audio duration to the correct recitation which is 57.8450s. the loudness of the respondent voice and noise in the audio effect the maximum and minimum voltage value. Therefore, the eight respondent has the best recitation among the ten respondents since the audio recitation is the nearest to correct recitation.

3.2 Algorithm for voice recognition of Quran verse recitation and tajweed mistake classification

The process for voice recognition of Surah Al-Fatihah and Tajweed mistake classification will involve two algorithm as stated earlier. The algorithm of MFCC still in the development process while the HMM algorithm is successfully compiled in MATLAB. The implementation of these two algorithms is believed can recognize the recitation of Quran verses and classify the tajweed mistake efficiently thus helping the children learning Quran in a better way.

3.3 Graphical user interface

A user-friendly GUI is successfully developed in MATLAB. Once the user pressed on UPLOAD button, a “Choose Audio File” box will pop-up. Therefore, the user can choose the recitation audio in the personal computer simply double click on the audio file. However, other audio file format such as “OOG” and “MP4” format also can be chosen and the audio also can be played in the GUI. The chosen audio file name appears in the upper rectangular white box. The feature is developed to let the user knows which the current audio file that need to be generated in this system. Thus, the user can easily change to other audio file is the selected audio file is wrong. Figure 5 shows the selected audio files.

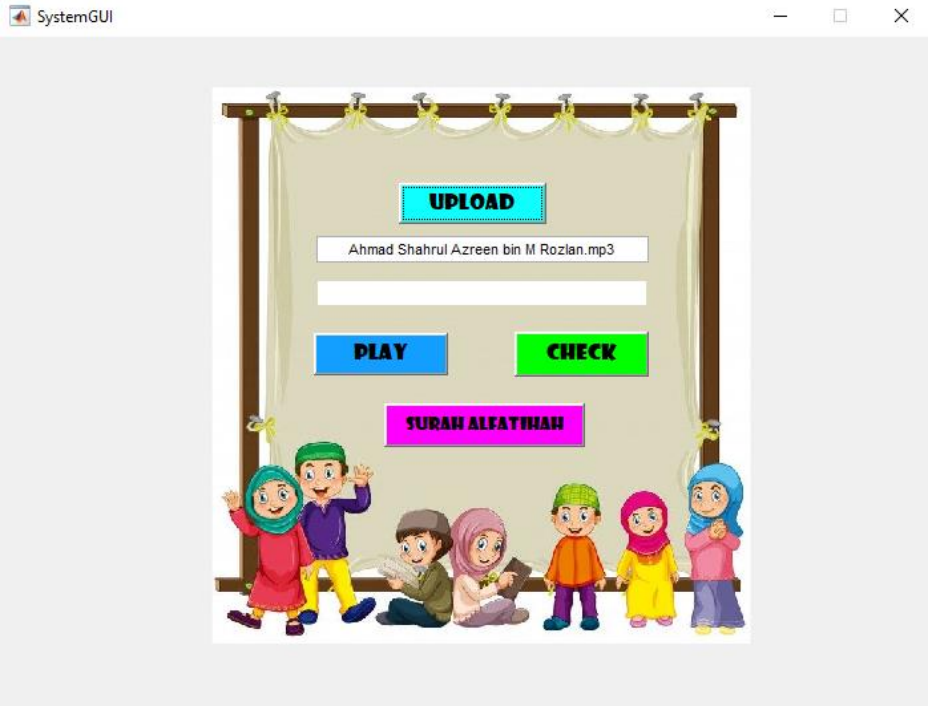

Figure 5: Audio file name for the first respondent

The UPLOAD button is functioned well. Same goes to PLAY button and the upper white rectangular box which display the audio file name. The user can listen to the uploaded audio file by pressing the PLAY button. The uploaded audio is played and stop once the audio is ended. The user can check the tajweed for the uploaded audio file by pressing the CHECK button. However, the CHECK button cannot function well since there is error in MATLAB code. Supposedly, the wrong tajweed will appear in the lower white rectangular box. Next, the user can listen to the correct recitation of Surah Al-Fatihah by pressing the SURAH ALFATIHAH button.

4. Conclusion

In this paper, the Automated Tajweed Checking System for Children in Learning Quran project has covered many elements in speech recognition system and the study is beneficial since it helps the children to learn Quran in more exciting way, while obeying with the Islamic ways and rules.

Acknowledgement

The authors would like to thank the Department of Electronic Engineering and the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

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