PHONEME DURATION SCHEME FOR TAJWEED MEDD RULES RECOGNITION IN QUR'AN RECITATION

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

The speech recognition techniques can be used to implement a Computer-Aided Pronunciation Learning (CAPL) System, however, the Computer-Aided Holy Qur'an Learning still needs more research because of the great difference between Qur'an recitation and normal speech. The major difference is due to the Tajweed rules that control the Qur'an recitation, especially those rules that depend on the phoneme duration like the Medd rules. Current speech recognition applications recognize the phonemes regardless of their duration and are not sufficient to recognize the Quranic recitation. There are two stages to get acquainted with the Medd rules: classification and estimation of duration. The previous studies classified phonemes in Qur'anic recitation, such as the classification of Arabic speech with no concern the Tajweed rules' impact, especially the classification of vowels governed by Medd rules. Regarding phoneme duration estimation, previous studies suggested a specific range for each long vowel calculated in milliseconds, ignoring the difference in recitation speeds from one reciter to another. Neglecting Medd rules in classification and duration estimation stages leads to a lack of proper recognition of Medd in the Qur'anic recitation. In this thesis, a new phoneme duration scheme is proposed to enhance the Medd duration recognition based on speech recognition techniques. A standard Qur'an recitation corpus has been collected to be used in training and testing of Medd duration. 21 Qur'an verses were chosen to cover all types of Medd, 100 famous Qur'an reciters' recitations have been collected from Web and 30 reciters have been asked to record their recitations four times for each verse at different speeds. This corpus was used to develop a Hidden Markov Model (HMM) model to recognize the Qur'anic recitation. A rule-based phoneme duration algorithm for Medd classification (RPDMCA) classifies all phonemes based on their duration and adds the required duration to each phoneme in triphone tree, thus determining the required duration for each phoneme according to Tajweed rules. In addition, an Artificial Neural Network-based Medd duration model was proposed to estimate the actual duration of phonemes. Moreover, a phoneme alignment algorithm based on the Qur'an acoustic model was developed, and the recitation rate was calculated to be used as input of the Artificial Neural Network (ANN) model. The results obtained demonstrated the high efficiency of the proposed scheme to recognize Medd types correctly. The accuracy of the phoneme classification algorithm was high ranging from 98% to 100% depending on the type of Medd. The proposed algorithm for phoneme alignment based on the Qur'an phoneme model gives a significant improvement in phoneme segmentation compared to the existing HMM Toolkit (HTK) forced alignment algorithm, where 30% of phonemes have time-error less than 30 milliseconds with manual segmentation reference. Likewise, for the Medd estimation model, it achieved results that significantly outperform the previous techniques, as its accuracy reached 86% when using manual segmentation and 70% when using automatic segmentation

ABSTRAK

Teknik pengecaman pertuturan boleh digunakan untuk melaksanakan Sistem Pembelajaran Sebutan Berbantukan Komputer (CAPL). Namun, pembelajaran Al-Quran berbantukan komputer masih memerlukan lebih banyak penelitian kerana perbezaan yang besar antara pembacaan al-Quran dan pertuturan biasa. Perbezaan utama adalah terdapat hukum Tajwid yang mengawal bacaan al-Quran, terutama hukum yang bergantung pada jangka masa fonem seperti hukum Medd. Aplikasi pengecaman pertuturan semasa mengecam fonem tanpa mengira jangka masa fonem menyebabkan pengecaman pembacaan Al-Quran kurang berkesan. Terdapat dua peringkat dalam kajian pengesanan peraturan Medd: klasifikasi fonem dan anggaran tempoh. Kajian terdahulu mengklasifikasikan fonem dalam bacaan Al-Quran, seperti klasifikasi pertuturan Arab tanpa mengambil kira peraturan Tajwid, terutamanya klasifikasi vokal yang dikawal oleh peraturan Medd. Jangka masa fonem ditetapkan pada julat khusus di setiap panjang vokal dan dikira dalam kiraan milisaat dengan mengabaikan perbezaan kelajuan bacaan qari. Mengabaikan peraturan Medd di peringkat klasifikasi dan anggaran tempoh menyebabkan kegagalan pengecaman terhadap hukum Medd di dalam bacaan Al-Quran. Tesis ini mencadangkan satu skema tempoh fonem baharu untuk meningkatkan pengecaman tempoh panjang Medd berdasarkan teknik pengecaman pertuturan. Korpus piawaian bacaan Al-Quran telah dikumpulkan untuk digunakan dalam latihan dan ujian tempoh panjang Medd. 21 ayat Al-Quran dipilih merangkumi semua jenis Medd, 100 bacaan Al-Quran qari terkenal telah dikumpulkan dari Web dan seramai 30 qari telah diminta untuk merekodkan bacaan mereka sebanyak empat kali untuk setiap ayat pada kelajuan yang berbeza. Korpus ini digunakan untuk membangunkan model Hidden Markov Model (HMM) bagi pengecaman bacaan al-Quran. Satu algoritma jangka masa fonem berasaskan peraturan untuk klasifikasi Medd (RPDMCA) telah dibangunkan bagi mengklasifikasikan semua fonem berdasarkan jangka masa Medd. Ia menambah jangka masa yang diperlukan untuk setiap fonem di dalam pepohon tripon, dengan itu panjang fonem mengikut peraturan Tajwid dapat ditentukan. Di samping itu, satu model tempoh panjang hukum Mad berasaskan Rangkaian Neural Buatan (ANN) telah dicadangkan untuk menganggarkan jangka masa sebenar fonem. Satu algoritma penjajaran fonem berdasarkan model akustik Al-Quran pula telah dibangunkan bagi mengira kadar bacaan untuk digunakan sebagai input kepada model ANN. Keputusan yang diperoleh menunjukkan kecekapan tinggi skema yang dicadangkan untuk mengenali jenis Medd dengan betul. Ketepatan algoritma klasifikasi fonem adalah tinggi antara 98% hingga 100% bergantung pada jenis Medd. Algoritma yang dicadangkan untuk penjajaran fonem berdasarkan model fonem Al-Quran memberikan peningkatan yang ketara dalam segmentasi fonem berbanding dengan algoritma penjajaran HMM Toolkit (HTK) sedia ada, di mana 30% fonem mempunyai ralat masa kurang daripada 30 milisaat dengan rujukan segmentasi secara manual. Begitu juga, untuk model anggaran Medd, ia mencapai keputusan yang ketara mengatasi teknik sebelumnya, di mana ketepatannya mencapai 86% apabila menggunakan segmentasi manual dan 70% apabila menggunakan segmentasi automatic.

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LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
ANN-PDEM	-	Artificial Neural Network Based Phoneme Duration Estimation Model
ASR	-	Automatic Speech Recognizer
CALL	-	Computer-Aided Language Learning
CAPL	-	Computer-Aided Pronunciation Learning System
CAQL	-	Computer-Aided Qur'an Learning System
CN	-	Channel Normalization
CV	-	Consonant Vowel
CVC	-	Consonant Vowel Consonant
DA		Dialect Arabic
DCT	-	Discrete Cosine Transform
DFT	-	Discrete Fourier Transform
DTW		Dynamic Time Warping
EM	-	Expectation-Maximization HMM Hidden Markov Models
FFT	-	Fast Fourier Transform
FIR	-	Finite Impulse Response
FN	-	False Negative
FP	-	False Positive
FS	-	Sampling Frequency
GA	-	Genetic Algorithm
GMM	-	Gaussian Mixture model
GUI	-	Graphical User Interface
HMM	-	Hidden Markov Model
HsMM	-	Hidden semi-Markov Model
HTK	-	Hidden Markov model Toolkit
Hz	-	Hertz
ICT	-	Information & Communication Technology
IDFT	-	Inverse Discrete Fourier Transform

ISLE	-	Interactive Spoken Language Education
J-QAF	-	Jawi, Qur'an, Arabic and Fardhu Ain Islamic obligatory duty
k-NN		k-Nearest Neighbor
LLR	-	Log Likelihood Ratio
LPC	-	Linear Predictive Coding
LVQ		learning vector quantization
MAP	-	Maximum A-Posteriori
MFCC	-	Mel-frequency Cepstral Coefficients
MLE	-	Maximum Likelihood Estimation
MLLR	-	Maximum Likelihood Linear Regression
MLP		Multi-Layer Perceptron
MMSE	-	Minimum Mean Square Error
MSA	-	Modern Standard Arabic
MSE		Mean Square Error
NN	-	Neural Network
PLP	-	Perceptual Linear Prediction
QAMPAA	-	Qur'anic acoustic model based phoneme alignment algorithm
QRAM		Qur'n Recitation Acoustic Model
RNN	-	Recurrent Neural Network
RPDAMC		Rule-based Phoneme Duration Algorithm for Medd Classification
SD	-	Speaker Dependent
SI	-	Speaker Independent
SQTC		Standard Qur'an recitatoin Tajweed Corpus
SVM		Support Vector Machines
TN	-	True Negative
TP	-	True Positive
UTM	-	Universiti Teknologi Malaysia
VQ	-	Vector Quantization
WDFT		warped discrete Fourier transform
WER	-	Word Error Rate

LIST OF SYMBOLS

C	-	Constant
V	-	Vowel
V:	-	Long Vowel

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In this technological era, the tremendous advances in all fields of technology, especially advances in computer technologies, permitted computers to effectively contribute in various fields of human lives. That contribution promotes the need for a more efficient human-computer interaction.

One of the most important technologies is Automatic Speech Recognition, which is defined as the process of converting speech acoustic signals to their corresponding set of sentences, words or other linguistic units based on specific techniques and algorithms.(He and Deng, 2008; Nahar *et al.*, 2012).

Applications of speech recognition have gained great importance in recent years. These techniques have been used for many applications such as human-computer interaction, automatic dictation, automatic translation, automatic query answering, government information systems, mobile communication with information systems, hands-free operation, and control as in cars or person with disabilities(Yekache *et al.*, 2012).

As a result of new advances in computer-aided learning systems (CALL), Computer-Aided Pronunciation Learning (CAPL), intelligent tutoring systems, dialogue systems, speech synthesis and speech recognition have allowed powerful computer-aided systems to be developed in language learning. Thus, these systems will offer easier solutions, more fun, greater efficiency and accessibility than traditional learning systems.

For this, the research studies that are related to Computer-Aided Pronunciation Learning (CAPL) increased and received considerable attention in recent years. Many research efforts have been done for the improvement of such systems especially in the field of second language teaching(Hussein *et al.*, 2010; Metwalli, 2005; Samir *et al.*, 2007).

With the tendency of many researchers to use speech recognition techniques in the language learning field, a number of researchers have attempted to adapt these techniques and systems to be used in the learning of the Holy Qur'an. However, in contrast to the foreign language training task, where native speakers will consider a wide variety of pronunciations as being correct, the Holy Qur'an recitation is very sensitive to error (Abdou *et al.*, 2006). It must be recited in the same way as in the classical Arabic dialect following Tajweed rules; in other words, mistakes are prohibited in Holy Qur'an recitation including Tajweed mistakes. Figure 1.1 represents the research area. The final focus area is shown, along with all open issues in ASR.

In addition, the difficulty and complexity of human-computer interaction in the field of the Holy Qur'an recitation learning has contributed to an apparent delay in the successful implementation of computers in these areas(Abdou and Rashwan, 2014). There are a number of reasons for this complexity, including those related to the educational process in general, and some that are related to the Holy Qur'an learning in particular. These reasons are:

(a) Education is a very complex process and is influenced by many factors. So, its computer simulation will be very complicated and it needs to evolve new technologies.

(b) The inherent complexity of the learning process requires that the human-computer experience be as natural as possible. A natural interaction can make this process even more difficult for humans, to the point that it might turn out to be unusable.

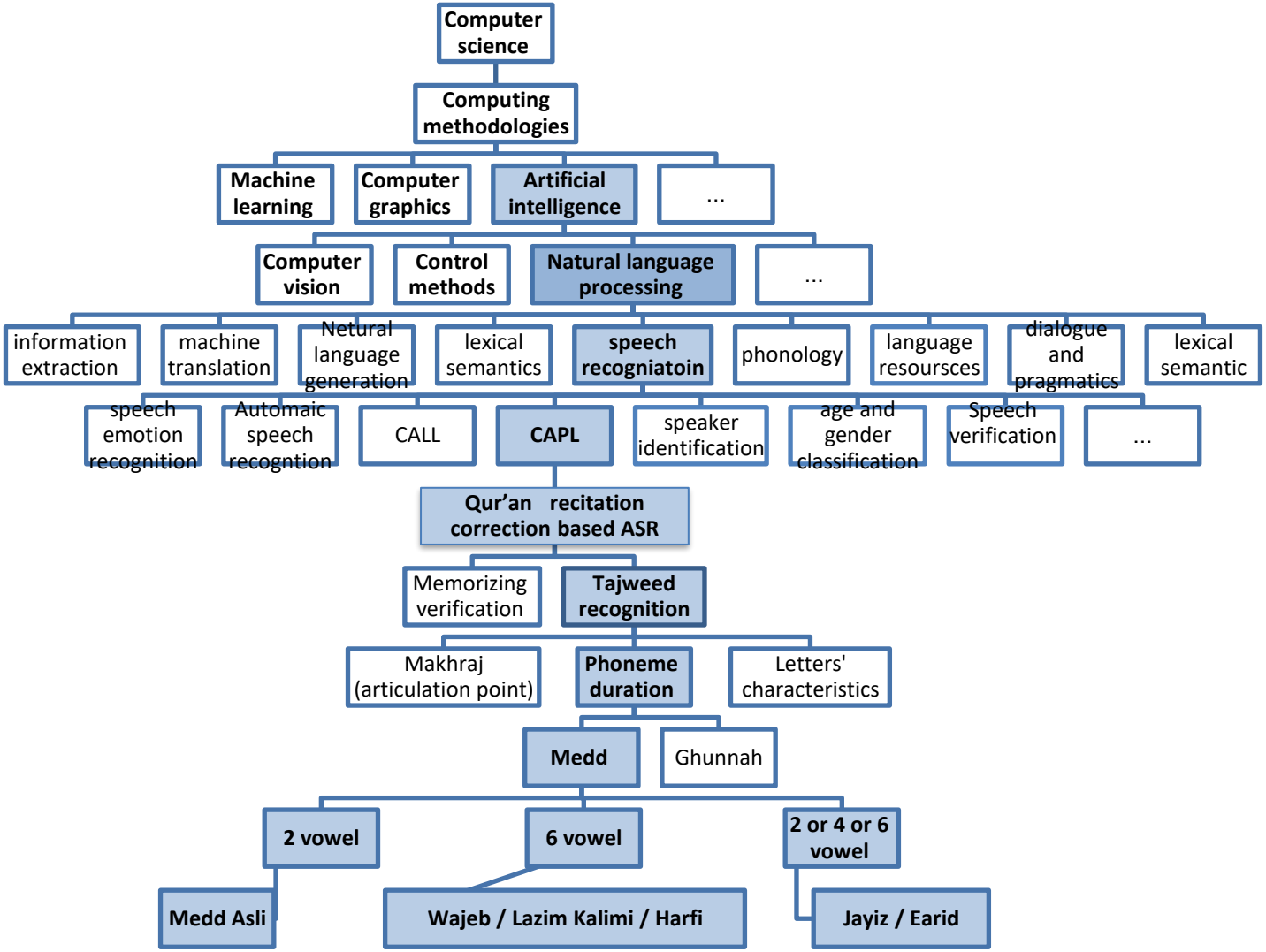

Figure 1.1 Research focus area (ACM Digital Library)

(c) The learning process of Al Qur'an required a special and effective way of reciting Al Qur'an (Tabbal *et al.*, 2006). In addition, the learning process of Al-Qur'an is still done using the traditional method, based on learning Al-Qur'an recitation skills by Talaqqi and Musyafahah method. This method is defined as a face-to-face learning process between students and teachers (Mudarris), wherein the teacher listens to the student's recitation and corrects the mistakes (Ibrahim *et al.*, 2008).

(d) Differences between the Qur'an recitation and normal speech, such as intolerance of pronunciation errors in Qur'anic recitation, Tajweed rules that control the Qur'anic recitation must be followed in recitation, letter duration is set by rules, which means that the recitation is sensitive to the time of the letters' pronunciation, differences between what is written and how to recite it (Abdou and Rashwan, 2014), and the different recitation rate (level of recitation such as slow, medium or fast recitation).

A successful speech recognition system must be able to comprehend these uncertainties. Thus, this thesis presented a model to improve the recognition of one of the Tajweed rules, which is the Medd, in an attempt to simulate the traditional method of Qur'anic teaching called "Talaqqi and Musyafahah".

1.2 Problem Background

One of the most difficult challenges in recognizing Arabic speech is the recognition of Qur'an recitation. This is because the Qur'an is being recited by many different reciters tends to differ a lot from one reciter to another even if they recite the same Surat (a chapter of the Qur'an), Actually, the reciter itself varies from one Surat to another because of the different performance way of reciting which include the Maqams and recitation rate. Maqams describe the different patterns of tunes used by reciters during their recitation, and recitation rate means the recitation speed style which is slow, normal and fast recitation. In addition, the recitation of the holy Qur'an differs from the normal reading of the Arabic language due to a specific art: "The

Tajweed ". These Tajweed rules make a major difference between normal speech and Qur'anic recitation, and the impact of these rules on analysis for the automatic speech recognition process, especially on the acoustic model.

Previous works have not focused on Tajweed rules which take into consideration the proper use of a phoneme duration model. Previous researchers just applied existing acoustic models which had been successfully used for other languages for recognition purposes, having enhanced the approaches to make it suitable for Qur'anic recitation(Ibrahim *et al.*, 2011; Mahmod, 2016; Nahar *et al.*, 2020; Shafie *et al.*, 2018; Tabbaa and Soudan, 2015). These approaches are not suitable and do not give correct results when dealing with the duration of the phoneme in the Qur'anic recitation, because the Tajweed rules need to be properly checked and one of the important elements in the Tajweed rule is to properly define the duration.

The errors that occur in the Qur'an recitation with regard to the duration of the phoneme are divided into two categories: 1) reducing the required duration for each Medd type and 2) increasing the duration over the required Medd type, which include consonant or short vowel lengthening and lengthening a long vowel more than required in Tajweed rules, where duration of each Medd type is specified in the Tajweed rules (Czerepinski and Swayd, 2006; Rushdi *et al.*, 2000). To clarify this issue, a recitation of a Qur'anic Ayat (verse) was recited in four forms; "فَإِذَا جَآءَتِ ٱلطَّآمَّةُ ٱلۡكُبۡرَىٰ", where this verse contains four words that have Medd, which are: "فَإِذَآ", which has a Medd 'asli with 2 Harakah lengthening; "جَآءَتِ", which has a Medd Wajeb with 4 Harakah (vowels) lengthening; "ٱلطَّآمَّةُ", which has a Medd Lazim Kalimi with 6 vowels lengthening; and "ٱلۡكُبۡرَىٰ", which has a Medd 'asli with 2 Harakah lengthening. This verse was recited correctly, following the rules of Medd in Tajweed.

Figure 1.2 shows examples in recognizing a recitation of a Qur'anic verse incorrectly and three wrong forms using the existing method, but it has been recognized as a correct recitation, while Figure 1.2.A shows a correct recitation with correct Medd duration for all Medd types in Ayat. The recitation in Figure 1.2.B shows a mistake in recitation because the reciter does not lengthen the Medd as long as required, as the reciter makes Medd Wajeb and Medd Lazim only 2 vowels instead of

5 and 6 vowels. As shown in Figure 1.2.C, the reciter also makes a mistake, where the reciter lengthened the Medd more than the required duration, lengthening Medd Wajeb and Medd Lazim to 8 vowels. The last recitation shown in Figure 1.2.D describe a mistake in lengthening (4 vowels) the phoneme "فَ" which is a constant letter and its duration should be 1 vowel only.

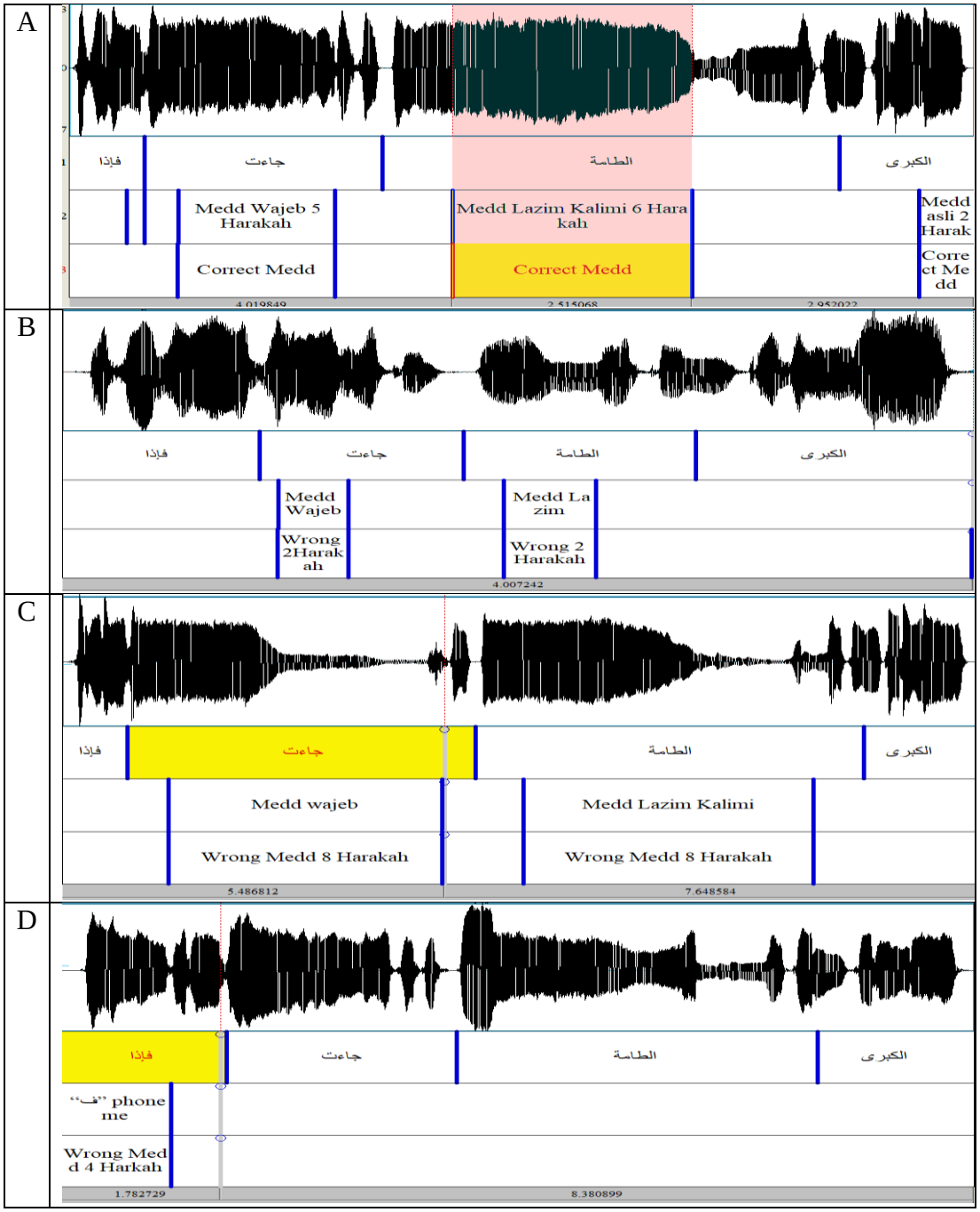

Figure 1.2 Examples of correct and wrong Medd rules in Qur'an recitation

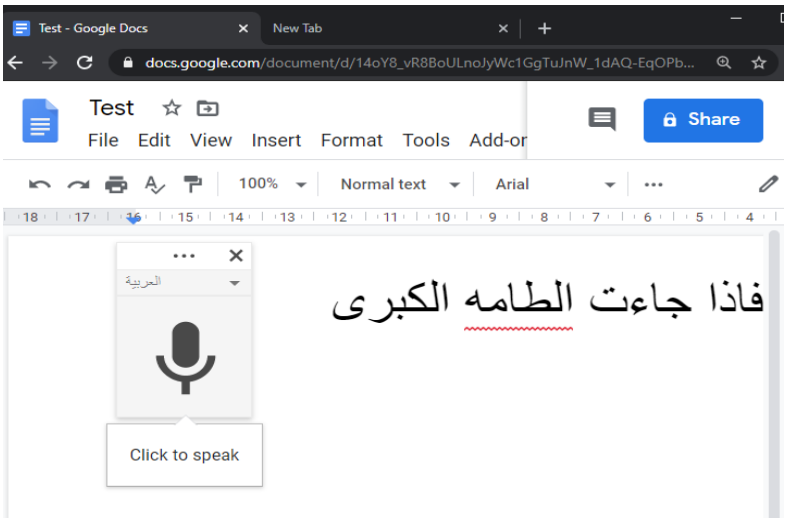

Figure 1.3 Result of recitation recognition in google voice typing

The recognition of these errors tested in the current application include RDI-Hafss(RDI, 2007), Tasmee (eqratech, 2019) and the voice typing tool in Google. Figure 1.3 shows the recognition result of voice typing; the result of the recognition of all recitations was similar with correct recitation, as it recognizes the phoneme without showing the errors of Medd duration. We conclude from this that the current applications recognize the recitation as correct even in the cases of errors related to the phoneme duration.

In addition, like any speech recognition system, The Qur'an recitation recognition goes through four stages: corpus preparation (a speech corpus is a database of speech audio files and text transcriptions) (Bauer and Aarts, 2000) and processing, feature extraction, classification, and recognition (Nahar *et al.*, 2020). Therefore, in order for a speech recognition system to be successful, it is necessary first to provide a good speech dataset (corpus). The dataset is required to be sufficient to cover all the cases studied because there is no standard speech database covering all rules and types of Medd in the Holy Qur'an. Since the Medd rules are affected by the speed of recitation, it is necessary that the entire Ayah (verse) be checked to measure the recitation rate; thus, it is important that the dataset be collected at the Ayah level. In addition, segmentation at the word level and phoneme level must be checked to verify the rules governing the type of Medd. Therefore, it was necessary to prepare a dataset at the Ayah level containing all types of Medd and also to segment these verses

to the words and phonemes. The second challenge is to determine the required duration for each phoneme in order to know the phoneme that should be prolonged and the phoneme that should not be prolonged, which required phoneme classification based on Medd rules. While previous research classifies the phonemes into consonants, long vowels, and short vowels, this is not sufficient to identify and recognize all types of Medd. In addition, in order to verify whether the Medd duration in recitation is correct according to the rules of Tajweed, the actual duration in recitation must be estimated or measured to determine whether the duration matches what is required in the rules of Medd. The duration of the phoneme in milliseconds is not accurate, and some researchers tried to solve this problem by estimating the duration of the Harakah in a range calculated in seconds, but it did not give an accurate recognition of the Medd duration. Figure 1.4 illustrates these issues that present a challenge in recognizing Medd in Qur'anic recitation.

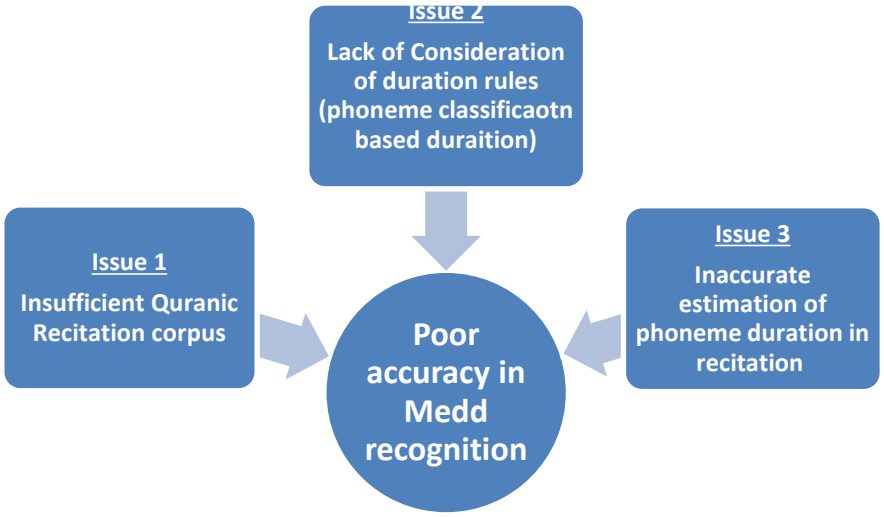

Figure 1.4 Issues of Medd recognition

Thus, this thesis focused on this issue which is the consideration of duration phoneme to improve the Medd rules recognition accuracy. With regard to the rule of Medd, reciters of the Qur'an may commit one of two errors: Extend the letter duration more than the required or the letter does not give the required duration. In addition, the Medd duration depends on several factors, including the recitation rate, and the duration of the letter that precedes Medd's letter was therefore emphasized in the study.

1.3 Problem Statement

The challenges of Recitation Recognition are numerous due to the differences between Qur'anic Recitation and normal speaking where the Qur'anic recitation is controlled by rules called Tajweed rules. One of the important rules of Tajweed is the Medd rules, which control the acceptable time duration of each phoneme. It could be argued that many problems in Qur'anic recitation recognition are a solved problem for some rules of Tajweed, but this research aims to focus on Medd rules in different recitation speed styles (recitation rate). As with any research in the field of speech recognition, this work goes through stages which are data preparation, feature extraction, classification, and recognition. There are some problems that this work encountered in these stages. One such problem is the lack of speech corpora of Qur'anic Recitation Rules. Only a few Qur'anic recitation corpora are freely available, and its limitations have led every researcher to start from zero and then spend considerable time compiling sufficient resources. This is what this study faced as the previous corpora do not cover all types of Medd, which makes the development of standard Qur'an corpus necessary, a Qur'an corpus that includes all types of Medd in the Qur'an (Almosallam *et al.*, 2013; Alsulaiman *et al.*, 2013b; Arafa *et al.*, 2018). Additionally, to recognize phoneme duration in Qur'an recitation, the phonemes must first be classified, then the required duration of each phoneme should be determined according to the Tajweed rules. Previous studies used the acoustic model for other languages (Alotaibi *et al.*, 2016), some studies have also focused on recognizing singing because singing is distinguished from speech by some features including the lengthening of vowels, Sharma *et al.* (2019) proposed an incorporated lexicon-modification based duration modelling to account for the long duration vowels in singing, the lengthening of vowels in singing is not governed by rules, while the lengthening of vowels in Qur'anic recitation is governed by the rules of Medd. This requires first classifying the phoneme correctly before recognizing it. Studies have focused on the classification of phonemes as the study carried out by Zangar *et al.* (2021) to improve the modelling of phone duration for Arabic statistical parametric speech synthesis using DNN-based models and classify the phoneme into four classes, which are short vowels, long vowels, simple consonants, geminated consonants in addition to pauses, however, these four classes were not enough to study Tajweed Medd rules. Therefore, the classification of phonemes as the first step to recognition

the Qur'anic recitation needs further research, so that phonemes are classified based on the Tajweed rules, especially the classification of vowels based on the rules of Medd. Moreover, duration measuring of the Medd by milliseconds or a specific range (Abdou *et al.*, 2006; Metwalli, 2005) leads to a weak accuracy of Medd recognition because the Medd duration rules depend on the speed of the recitation. This recitation may be quick (Hadr) or slow (Tahqiq) or medium (Tawast) which increases the difficulty in recognizing the Medd duration rules. Therefore, the current acoustic model is not sufficient to use to classify and estimate Medd based on its duration and type. These challenges encourage researchers to develop a model for Medd recognition, similar to the traditional method used by teachers of the Holy Qur'an.

1.4 Research Goal

The main aim of this thesis is to develop a Medd recognition model in Qur'anic recitation by proposing a new algorithm to classify all phoneme based Medd duration rules and propose a predictive model to recognize Medd rules in Qur'an recitation.

1.5 Research Objectives

This study is aiming to solve the related problems in building a Qur'anic recitation recognizer. Therefore, the objectives are:

(a) To develop a standard Qur'an recitation dataset that covers all Medd rules.

(b) To introduce a rule-based phoneme duration algorithm in HTK tied-state triphone for Medd classification.

(c) To propose a new scheme for phoneme duration in Medd rules based on ANN.

1.6 Research Scope

The scope of this study includes greater focus on the acoustic model in Qur'anic recitation. Under this scope:

(a) The dataset (speech corpus) has been collected from several skilled reciters as well as from famous professional reciters' recitations.

(b) Each reciter has recited Ayat, which are chosen to cover all types and rules of Medd.

(c) This work focused on the Medd rules according to the rules of Qera'atu Hafss.

(d) This research covers all types of Medd: Medd 'asli (including the Natural Lengthening, the Lesser Connecting Medd, the Substitute Medd), the Medd Caused by the Hamzah (including Medd Wajib Mutasil, Medd Jayiz Munfasil, the exchange Medd, the Greater Connection Medd), and The Medd Caused by the Sukoon (including Medd Earid LilSukoon, The Leen Medd, Havey and Laight Medd Lazim Kalimi, Havey and Laight Medd Lazim Harfi).

(e) MFCC technique will be used to extract the features during feature extraction phase, and HTK tools as a tool of HMM model during training and testing phase.

(f) Phoneme segmentation has been done manually and automatically in three levels, Ayah, word, and phoneme.

1.7 Significance of the Study

All Muslims are interested in reciting and learning the Holy Qur'an. The traditional method is the method of Qur'an teaching, which is face to face teaching method, in which the student recites the Qur'an and the teacher corrects his mistakes, including mistakes in Tajweed rules because the Qur'an must be recited according to

Tajweed rules, by which all errors are prohibited. Some researchers seek to adapt speech recognition techniques in CALL and CPLL fields to support and facilitate the teaching of the Qur'an process, nevertheless, it still needs to improve the recognition accuracy of Tajweed rules, especially Medd rules, that control what the phoneme duration should be. This research contributes significantly to the field of computer-assisted Qur'an learning, as it focuses on developing a speech recognition system that can recognize a correct and wrong Medd duration in Qur'an recitation. Thus this work can improve Tajweed recognition accuracy of current applications in Qur'an learning, which in turn support the traditional method of Qur'anic education, especially the current busy lifestyle that requires a modern and technological approach for self-learning method to recite Al-Qur'an, which can improve the process of Qur'an learning and optimize study time as well.

1.8 Thesis Organization

This report is organized as follows:

Chapter 2 provides an in-depth review of relevant literature on current speech recognition techniques and includes an analysis of existing literature in relation to the subject matter of this work. The review covers most of the techniques of preprocessing and feature extraction and modelling.

Chapter 3 provides a clear roadmap of this work to direct the reader to get a fast grasp of the detailed research framework. The specifics of the experiments and the tasks planned for this work are underlined. It also illustrates the architecture of the whole research framework, processes, methods, and procedures.

Chapter 4 discusses the detailed design and development of Qur'an corpus and its creation procedures which include: Choosing Ayats, choosing reciters, designing transcripts. Moreover, this Chapter discusses the procedures of Qur'an acoustic modelling includes data preparation and HTK training, and testing.

Chapter 5 provides details of the design of the Medd classification algorithm, implementation, experimental results, detailed analysis, and discussions. It explains the implementation of the proposed algorithm into the experimental tasks within Medd rules in Qur'anic corpus, then explains the qualitative measurements that were carried out for performance evaluations.

Chapter 6 presents details of the duration estimation model devolvement. It explains the tasks design, data preparation, analysis, collect expert's estimation, automatic phoneme segmentation and explains the qualitative measurements that were carried out for performance evaluations. In relation to this, a series of experiments were conducted based on the tasks designed.

Chapter 7 concludes this work, summarizes the research achievements and suggests directions for future research work.

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LIST OF PUBLICATIONS

Indexed Journal

1. Mohammed, A., Sunar, M. S., and Salam, M. S. H. (2015). Qur'anic Verses Verification using Speech Recognition Techniques. *Jurnal Teknologi*, *73*(2).

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