THE DESIGN AND VERIFICATION OF MALAY TEXT TO SPEECH SYNTHESIS SYSTEM

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Dedicated to Jesus Christ,
my personal Savior and Lord,
my pastor, Church members,
my beloved mum, dad, sister, and brother.
ACKNOWLEDGEMENTS

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Most of all, thanksgiving, praise and glory is all to Jesus Christ, who gives me grace, love, patience, healthy, wisdom and ability to walk through all the problems and obstacles during the period of my study.
ABSTRACT

Synthetic or artificial speech has been developed steadily during the last decades. The intelligibility of synthetic speech has reached an adequate level for most applications, especially for communication impaired people. The first objective of this work is to design and develop a Malay Text to Speech (Malay TTS) system. This will include the design of Malay TTS diphone database, tokenization rules, letter-to-sound rules, Malay lexicon and prosody rules. Other focus of this work is to design a set of test methods specifically for verifying Malay TTS performance. This work has produced a diphone database with 1629 diphone file in residual-exited LPC (RELP) format and its total size is around 3.4 Mega bytes. Besides that, this work also has identify the possible tokenization area in Malay TTS and develop a digit tokenization for Malay TTS as the basic for further development of more complete tokenization rules. This work also has produced complete letter-to-sound (LTS) rules for Malay primary word that has high accuracy and almost 100 percent accuracy. A set of lexicon containing 1000 most common use Malay words also being setup as complement to the LTS coverage. A set of a prosody rules using a CART tree has been setup as the preliminary study in prosody design for Malay TTS. Finally, the very first try in designing the testing methods and procedures for Malay TTS has been completed. It will provide a more complete technique in verifying the performance of Malay TTS that will become the benchmark for Malay TTS evaluation and improvement in future.
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<td>the cross-sectional area</td>
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<td>$c$</td>
<td>the pressure waves</td>
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<td>CHART</td>
<td>Classification and Regression Trees</td>
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<td>CSTR</td>
<td>Center for Speech Technology Research</td>
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<td>CVV</td>
<td>Consonant-Vowel-Consonant</td>
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<td>DM</td>
<td>database module</td>
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<td>DSP</td>
<td>Digital Signal Processing</td>
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<td>FSS</td>
<td>Festival Speech Synthesis</td>
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<td>F0</td>
<td>The Fundamental Frequency</td>
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<td>$G(z)$</td>
<td>transfer function of the glottal waveform</td>
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<td>“filter”</td>
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<td>HAMLET</td>
<td>Helpful Automatic Machine for Language and Emotional Talk</td>
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<td>HMM</td>
<td>Hidden Markov Models</td>
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<tr>
<td>$H(z)$</td>
<td>the transfer function of a digital filter</td>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>IPA</td>
<td>International Phonetic Association</td>
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<td>IPS</td>
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<td>L&amp;H</td>
<td>Lernout &amp; Hauspies</td>
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<td>LP</td>
<td>Linear Prediction</td>
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<td>LTS</td>
<td>Letter to Sound</td>
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<td>LTSM</td>
<td>letter-to-sound rule module</td>
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<td>Malay TTS</td>
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<td>MOS</td>
<td>Mean Opinion Score</td>
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<td>MRT</td>
<td>Modified Rhyme Test</td>
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<td>Multimedia Super Corridor</td>
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NLP  
Natural Language Processing

PAT  
Parametric Artificial Talker

PSOLA  
pitch-synchronous overlap and add

$P_0$  
air density

RELP  
Residual Excited LPC

SIOD  
Scheme in one Defun

SPM  
simple prosody module

S.U.M  
Malay Speech Synthesis or in Malay language

“Sintesis Ucapan Melayu”

$S(z)$  
the z-transform of the speech signal

TTS  
text-to-speech

TM  
tokenization module

UKM  
University Kebangsaan Malaysia

$U(z)$  
an approximation to the excitation signal

$V(z)$  
transfer function of the vocal tract

VCV  
vowel-consonant-vowel

WG  
Waveform Generation

$R(z)$  
the radiation characteristic

?  
IPA symbol for Malay phoneme gh

?  
IPA symbol for Malay phoneme kh

?  
IPA symbol for Malay phoneme ng

s  
IPA symbol for Malay phoneme sy

e  
IPA symbol for Malay phoneme e (pepet)

e  
IPA symbol for Malay phoneme e (taling)
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CHAPTER 1

INTRODUCTION

1.0 Background of Research

Since the launching of Multimedia Super Corridor (MSC) project in Malaysia, the Information and Communication Technology (ICT) has been growing rapidly. As a result, computer system as a tool for information and communication medium is becoming more important since then. In addition, the human computer interaction system which involved speech recognition, synthesis etc. also experiences tremendous growth, resulting in many applications being developed and commercialized. For instance, Microsoft recently launched the Office XP that has the capability to pronounce (or read aloud) the text input using the Speech synthesis engine. Indeed, speech synthesis has been very useful in helping human in various areas such as telephone speech, application in cars, public information systems, education assistance tools, email reading etc (Mangold, 2001). The Text to Speech (TTS) system is also useful for the physically handicap. For example, speech synthesis has been used as reading and communication tools for visually impaired. The first commercial TTS system is Kurzweil Reading Machine for the blind introduced by Raymond Kurzweil in the late 1970’s (Klatt, 1987). For the hearing impaired and vocally handicapped, the TTS system has been used as a communication tool with people who are sign language illiterate (Gold and Morgan, 2000). Another application of the TTS system is Helpful Automatic Machine for Language and Emotional Talk (HAMLET), which is developed to help users to express their feelings (Lemmetty, 2001).
Unfortunately, all current available commercialize TTS systems are designed in other languages such as English, German, Japanese, Thailand and Chinese etc (Taylor et al, 1999). As for the Malay TTS system is still under research and is yet to be as famous as the others. Therefore, the aim of this project is to build a Malay TTS system as one of the preliminary step towards the development of the first commercialized Malay TTS system. Besides that, it is hope that the outcome of this work, which is the Malay TTS system, will be adopted and applied in the various aforementioned applications. Such use can benefit our country and other Malay speaking countries.

1.1 Overview of Malay Text To Speech System

Text to Speech (TTS) system is a Speech synthesis tools that is able to pronounce any input raw texts aloud (Tan et al, 2003). Basically TTS system is divided into two main components (Tan and Sheikh, 2003).

The block diagram of Malay TTS is shown in Figure 1.1. The first component of TTS system as illustrated in Figure 1.1 is the Natural Language Processing (NLP) module (Donovan, 1996). This component acts as a black box that processes the input raw texts using the linguistic rules that will then assign or output the phoneme and prosody for the input texts. For Malay TTS system, the NLP component consists of three modules: the letter-to-sound (LTS) rules, Tokenization rules, and Prosody Phrasing method such as intonation, phrase break assignment and duration setting (Black et al, 1998). The LTS module consists of a set of rules that associates each letters to its sound according to the Malay language pronunciation rules (Pagel et al, 1998). Meanwhile the Tokenization rules comprises of a set of rules to change token word (e.g. numbers, date, symbols etc.) to full text format such as the digit “100” is replaced with “seratus” and date “10hb Mei 2002” is replaced with “sepuluh haribulan Mei tahun dua ribu dua” (Tan and Sheikh, 2003). Finally, the Prosody Phrasing module involves applying the Malay language intonation rules and the duration pattern to enable the synthesized speech to have the Malay accent (Alan and Kevin, 2000).
The second component of the TTS system (as shown in Figure 1.1) is the waveform generator black box which uses the phoneme and prosody produced by NLP to match the phoneme to the pre-stored sound database and concatenate the phonemes to produce a continue set of waves file or speech sound that contain the prosody features (Taylor et al, 1999). Since this project not focus on building the wave generator, the residual-excited LPC wave generation method (the default wave generation module in Festival) has been chosen as wave generation method for Malay TTS (Macon et al, 1997).

![Figure 1.1: The Architecture of Malay TTS synthesizer (Tan and Sheikh, 2003).](image)

Typically in TTS system development, the first and of utmost importance would be the design of the database, which contains the small unit of speech such as phoneme, diphone, syllable, word etc (Gold and Morgan, 2000). But the diphone unit has been chosen for this project because of few specific reasons such as the size of database and it contain more articulate information than phoneme (Donovan, 1996). This will be discussed in details later in Chapter 3. A diphone unit is a combination of two phones such as “a-b”, “m-n”, “t-a” and “s-u” etc (Tan et al, 2003). TTS system using diphone concatenation method is also named as Diphone Synthesis TTS system (Tan and Sheikh, 2003), and this project will produce a Malay Diphone Synthesis TTS system.
1.2 **Objective**

There are four main objectives to be achieved in this project. The first objective of this project is to build a Malay TTS Engine through Festival Speech Synthesis system that is able to pronounce any input raw text with high accuracy.

Secondly, a survey or detail study of Malay Linguistic to find or design a best database for the Malay Text To Speech Synthesis system in defining the Phone Set, Phone Duration, Diphone List and recording of the database is hope to be realized.

The third objective of this project would be the design of Malay Lexicon, Malay Letter to Sound Rules, Malay Tokenization Rules and simple Malay Prosody.

Finally, a test or evaluation method will be designed carefully that can be used specifically for Malay TTS engine. This would be useful as though still lack of evaluation method for Malay TTS system.

But due to the time limitation, certain modules of the Malay Speech Synthesizer such as Tokenization rules, and prosody will only focus on preliminary study that will be the stepping-stone for further research purpose.

1.3 **Scopes of the Project**

There were several concerns before defining the scopes of this project. Knowing the fact that the technique in developing TTS system has evolved and matured considerably for the last few decades, a dilemma arose whether to initiate the project from the scratch or to utilize currently available TTS development tool. If the project were to be started from scratch, it would take a very long time before the TTS system can be finalized, commercialized and used for detail and in-depth study. Alternatively, utilizing the available development tool can give a jump-start towards the creation of the TTS system, hence shorten the development time. Therefore, the
Festival speech synthesis system has been selected and used in the development of the Malay TTS system for this project.

By using Festival Speech Synthesis system, the project will concentrate mainly on the design of specific modules relevant to the Malay TTS system such as the database module (DM), letter-to-sound rule module (LTSM), tokenization module (TM) and simple prosody module (SPM). Currently, the NLP component which consists of the LTSM, TM and SPM are available in English and Spanish version. As such, it is vital to develop the NLP component specifically for the Malay language.

1.4 Research Methodology

There are five phases for designing the Malay TTS system as shown in Figure 1.2. The first phase involved the database design and the second phase involved NLP Configuration or Modification. When the NLP and database are ready, Malay TTS will be setup and then it will pass through the testing process to verifying the quality and performance of the system. Finally, it has deployed in two simulations such as Intelligent Security Door and Talking Clock to validate the system (Appendix E). The testing method will be the benchmark as though it is a very first try on designing the testing method and procedure specifically for Malay TTS.

1.5 Thesis layout

This thesis has been divided into five major parts. The first part of which is Chapter 1 has included the introduction, background, objective and scope of the project. It will briefly discuss the main idea and the aim of the project. It will also cover the scopes of the project that reflect the feasibility of this study.
Chapter 2 will discuss more about of the project background, history and related works in more details. This part will also highlight the important things or methods that would be useful for the preliminary study before starting of the whole project. This part will focus more on the TTS background, history, techniques, and speech processing tools that will be used for developing Malay TTS.

The third part of this thesis is database design in Chapter 3. This chapter will discuss the background of Malay linguistic. These linguistic rules will be applied to diphone database design at the end of Chapter 3 and NLP design in Chapter 4.

The fourth part of this thesis is about the design and implementation of Malay TTS system which will be elaborated in Chapter 4. This part will discuss in detail on how and what kind of method that would be used for the project. The types of methods employed to evaluate the system and the expected result would be mentioned as well.
The fifth part of this thesis will focus on how to test the whole system that has been developed. Results, which were obtained from the project and the evaluation for the result by comparing to earlier expected result, are discussed. Chapter 5 will include all the experiment, results and evaluation procedure.

The final part of the thesis would be the conclusion and recommendation for the project. Conclusion based on the results obtained through experiments in Chapter 5 would be made. Some recommendations for improvements of the project in the future are being suggested as well.

1.6 Contribution of the Thesis

This project has developed a set of diphone database with 1629 diphone units for Malay TTS system. The research is capable to minimize the database required for Malay Diphone Text To Speech system. For instance, if all the vowel combination (total 10) being putted in the database, the total phoneme plus vowel combination and diphthong will be 42 (32 phoneme and 10 vowel combination). This will result the total combination of diphone units as 42*42 or 1764. This thesis also provide a way for further study in improving Malay TTS’s phone set, phone definition and its duration in future.

A set of Malay TTS NLP engines such as Malay LTS modules, Malay tokenization rules, and basic prosody module have been developed. The study does not require the implementation of the whole library in the lexicon module for the Malay TTS system. It only requires 1000 words in lexicon database compare to over 20000 words in lexicon database for English TTS system (Alan and Kevin, 2000). The preliminary study on prosody and the development of basic number to word conversion in tokenization module has provided some basic ideas for future development of more complete Malay TTS system. The LTS module for Malay TTS system has been tested with small conventional Malay dictionary that contains over 4000 most common used Malay words and has almost 100% accuracy after the correction of the mismatch rules.
Finally, this project has produced a set of testing and analysis method and procedure specific for Malay TTS system that will be the benchmark of the testing procedure for future Malay TTS system. The intelligibility accuracy of over 85% has proved its quality in intelligibility test. Malay TTS project also has successfully validated through the implementation of two simulations such as Intelligent Security Door System and Talking Clock (Appendix E).
some lacking also in terms of its naturalness and some artifact. To solve these problems some newer waveform generation method such as PDSOLA and harmonic sinusoidal method can be used to improve its performance (Lemmetty, 1999).

6.2.4 Improvement in Prosody

As this system using simple prosody rules to predict its intonation and duration, it can be improved by improving the simple prosody rules with more rules to predict the intonation of the sentences. Some other prosody method such as TILT Model and ToBI can be used as the research method for the performance of the prosody rules (Black and Hunt, 1996).

6.2.5 Malay TTS Application

The Malay TTS system also can be applied in other areas such as Audio Visual- Talking Head, real security door system, Assistance tools for the blind, and SMS reader (Cox et al, 2000). This would be able to make it more popular in terms of its application and area of usage.
REFERENCES


