

English Speech Synthesizer with Speech Error Processing Features: Elision and Assimilation

By

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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in partial fulfilment of the requirement for the
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Approved by


(Norshuhani Binti Zamin)

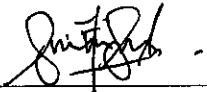
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December 2005

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgments, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



SITI SARAH BINTI MOHS HARUS

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ABSTRACT

Speech synthesis is one of the in Natural Language Processing (NLP). NLP is a subfield of artificial intelligence and linguistic. It studies the problem of processing and manipulation natural language and from the studies it process to make the computer understand human language. NLP have a lot of major task such as text to speech that is speech synthesizer, speech recognition, machine translation, information retrieval, and many more

In this projects, the system are involve a massive usage of rules to syllabify the words into their respective syllables and to check for English elision and English assimilation rules if any before the correct output of sound can be produced. Elision is omission of one sound or more. The letter that involves elision is sounded unfamiliar for the speaker. Whereby, assimilation is concern with one sound becoming phonetically same with the adjacent sound.

In this project, I demonstrate the syllabification approach that been introduced to me by Norshuhani, and will also adopt the English elision and assimilation rules to the speech synthesizer.

TABLE OF CONTENTS

ACKNOWLEDGEMENT	i
ABSTRACT	ii
TABLE OF CONTENT	iii
LIST OF FIGURES	v
LIST OF TABLES	vi
CHAPTER 1: INTRODUCTION	1
1.1 Background	1
1.2 Problem statement	2
1.3 Objectives and scope of study	2
CHAPTER 2: LITERATURE REVIEW	4
CHAPTER 3: METHODOLOGY	15
3.1 Methodology.....	15
3.1.1 Initial Investment.....	16
3.1.2 Requirement Definition.....	16
3.1.3 System design.....	16
3.1.4 Coding, testing.....	16
3.1.5 Implementation.....	16
3.1.6 Cut Over.....	17
3.2 Tools.....	17
3.2.1 JAVA 2 SDK 1.4.....	17
3.2.2 Sun One Studio 4.....	17
3.2.2 Microsoft Access.....	17
CHAPTER 4: RESULT AND DISCUSSION	19
4.1 Process.....	19
4.2 Interface.....	20
4.3 Syllabification rules.....	21
4.4 Elision rules.....	24
4.5 Assimilation rules	24
4.6 System.....	25
4.6.1 Screen shot.....	25
4.6.2 Testing.....	31

CHAPTER 5: CONCLUSION AND RECOMMENDATION	32
REFERENCES	35
BIBLIOGRAPHY.....	37
Appendix A: History of language	39
Appendix B: IPA Symbol.....	41
Appendix C: Articulation Manner.....	43
Appendix D: Project Timeline.....	44

LIST OF FIGURES

Figure 2.1 Structure of Birmingham Phonetic Approach.....	4
Figure 2.2 Three layers of Birmingham Phonetic Approach.....	5
Figure 2.3 Examples of English Word.....	5
Figure 2.4 Structure of syllable.....	10
Figure 3.1 Prototype model.....	15
Figure 4.1 Process flow.....	19
Figure 4.2 Draft Interface of the system.....	21
Figure 4.3 Interface.....	25
Figure 4.4 Clear Button.....	26
Figure 4.5 Quit Button.....	27
Figure 4.6 Process Text Button.....	27
Figure 4.7 Say It Button.....	28
Figure 4.8 Quit Selections.....	28
Figure 4.9 A sample input with assimilation.....	29
Figure 4.10 A sample input with elision.....	29
Figure 4.11 A sample text box.....	30
Figure 4.12 Sounds Database.....	31
Figure 4.13 List Sounds	31

LIST OF TABLES

Table 2.1 English open syllables.....	6
Table 2.2 English closed syllables.....	6
Table 2.3 Example of Text → Symbol → Syllable approach.....	7
Table 2.4 Graphotactic rules	8
Table 2.5 Digraph rules.....	9
Table 2.6 Elided form 1.....	12
Table 2.7 Elided form 2.....	12
Table 2.8 Assimilation word.....	12
Table 2.9 Consonant of English.....	13
Table 4.1 Graphotactic rules	22
Table 4.2 Digraph rules	22
Table 4.3 Silent rules	23
Table 4.4 Elision rules.....	24
Table 4.5 Assimilation rules.....	24
Table 4.6 Button Function.....	26
Table 4.7 Tested Words.....	32

CHAPTER 1

INTRODUCTION

Within the years of living, I never aware or never notice that there are concepts of syllable, elision and assimilation goes within the English language. This project will examine on the nature of syllable structure in English and how to produce a natural speech in computerized speech synthesizer by taking into consideration of English elision and assimilation problems in natural speech

1.1 BACKGROUND

Speech synthesizer is a system developed from speech synthesis. Whereby, speech synthesis is a process of an artificial production of human speech. The process is to convert text into speech. Naturalness is an important issue in speech synthesizer, when it usually refers to the output of sound that needs to be like the speech of real human. According to the wikipedia [1] the early examples of the creation of human speech is made by Gerbert of Aurillac (d.1003), Albertus Magnus (1198-1280), and Roger Bacon (1214-1294).

When we learn to spell in English, the words are closely connected together to syllable. Maybe if we look at any word we might not able to see how the sounds are make up, but certainly we know how many syllables that the word has. Syllables are used to help we pronounced words correctly and easily divide the words for writing and typing purpose. To make the speech synthesizer more natural the elision and assimilation of English need to be considered.

1.2 PROBLEM STATEMENT

Nowadays, from my observation there are lots of speech synthesizer software that can be downloaded freely or need to be purchased. But some the software are having the same problems of generating a natural speech sounds. There are lots of researches still in progress to make the English speech synthesizer sound as human speech.

1.3 OBJECTIVES AND SCOPE OF STUDY

The objectives of the project are to produce a natural speech sounds by taking into consideration of the English assimilation and English elision. Therefore to make the objective successful the understanding of syllable, assimilation and elision in English are highly needed.

The scope of the study is to do research on English syllable pattern for the syllabification process and the problem of elision and assimilation for the natural speech sound. In this project, the syllabification approach introduced by Norshuhani is adopted. Syllable is a basic unit of speech or words that contains only one vowel sound. For one written vowel syllable examples are cup, cop, and cat. Then the examples for two written vowels where the first vowel is pronounced like the letter of the alphabet are cape, site, cute and nite.

Few types of phonological problems are assimilation and elision. Assimilation is sounds that belong to one word which can change to sounds belong to the neighboring words. For examples postman will be sound posman. The 't' sound is elided from the words. Whereby, elision is loss of phoneme. For examples handbag will become hambag. The 'nd' when followed by 'b' will be change to 'm'. Phonemes are phonetic alphabet of the mind. Phonemes are represents speech or how the sounds are stored in the memory. It is also sounds that are distinguish one words from others. Symbols are used to identify the phonemes of the words. Assimilation and elision is occurs in English when people talk in fast speech.

A computer program will be written in Sun One Studio 4 software. This software is using Java 2 SDK 1.4.2 as compiler for the Java codes. There will be given a text box as input, a process to syllable the words and attach the methods of assimilation and elision, and lastly the mapping to the database to map the sounds according to the syllable that have been process. I will use Microsoft Access (MS Access) as the database for storing the sounds.

CHAPTER 2

LITERATURE REVIEW

In this literature review, the objective is to understand and learn more on my project scope. From here it will help me to identify or gain more relevant materials for my projects.

The most basic element of a language is syllable. There are lots of definition can be found by the words syllable. According to Wikipedia.com [1] syllable is a unit of speech that is made of with one or more optional phones. It claimed that “syllable is made up of a syllable nucleus (most often a vowel)”. In answers.com [2] says that, syllable is define as part of word that represents a unit of single impulse of the voice. This is where each word in English will consist either a vowel sound or a vowel sound followed by a consonant. One or more letters or phonetics symbols are written or printed to approximately a spoken syllable.

Norshuhani [3] mentioned that “Words are composed of one or more syllable”. Syllable consists of phonological unit. She also explains about Birmingham Phonetic Approach that is focusing on the **syllable** as an articulatory unit. The approach describes the concept as follows:

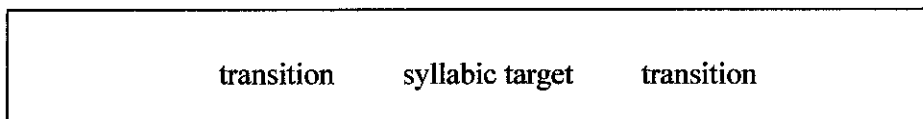


Figure 2.1 Structure of Birmingham Phonetic Approach

The figure 2.2 in the next page depicts the above structure in three layers, where ‘s-tar’ means syllable target, ‘d-tar’ means dynamic target and ‘tr-tar’ means transition target while ‘tr’ means transition.

In the scheme activity must consist of tr, x-tar, tr, x-tar, tr, x-tar etc. Syllable nuclei are marked by x = s and where phonetically irrelevant tr are tr.

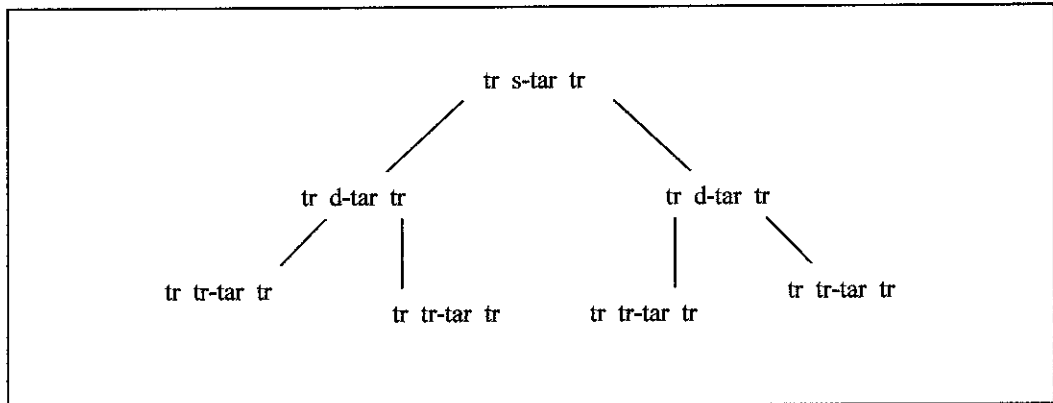


Figure 2.2 Three layers of Birmingham Phonetic Approach

Examples how the approach can be used in English word ‘apt’ are shown at figure 2.3 below:

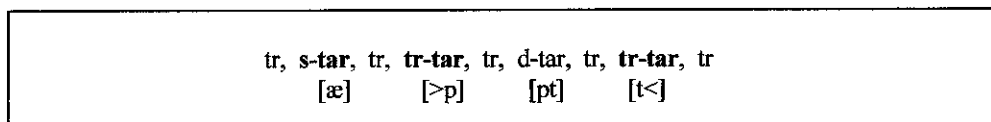


Figure 2.3 Examples of English Word

From the example, it shows that articulatory detail can be labeled ‘phonetically’. Each of [p] and [t] is just a closure and release phase and it does not associate to phone. A phone is a sound that has a definite shape as a sound wave.

In the mini project [3] also mentioned that “the greatest challenge face for syllabic juncture is transition from one syllable to another”. It is hard to separate the spoken language when we listen others speech. When a person speaks, they tend to speaks in many ways in fast manners, in medium manner and in slow manner. It is easy when people are speaks in slow manners in English like people in Malaysia. But in English country like United Kingdom, America, and many more elision and assimilation phenomena are major problems in automatic recognition that are leads from rapid speech of the articulators or we can say fast speech manners.

Sonority can be defined as the opening of the air routes; the more it opens the more sonorous the element will be [4]. In a syllable there will be high sonority peak and low sonority peak on each side. Whereby the high sonority is the nucleus and the low sonority is the onset or coda. There are possibility that an English words, there will be no coda in the syllable. It means the syllable will be ended with a vowel CV. This term is called “open syllable”. Then the opposite term “closed syllable” where the syllable will be end with at least one consonant after a vowel (C) VC.

C refers to consonant and V are refers to vowels. Consonants and vowel are the major classes in speech sounds [4]. Consonants and vowels are happens from the lungs of the mouth that blows the flow of air. A consonant is when the flow is having obstacles or restriction over the flow, and if the air coming out freely and easily without any barriers is called vowel. The following examples are some words explain about the English Open Syllable and the English closed syllable:

TYPE OF CV STRUCTURE	EXAMPLE OF WORD
V	A
CV	we
CCV	cry
CCCV	slow

Table 2.1 English open syllables

TYPE OF CV STRUCTURE	EXAMPLE OF WORD
VC	up
VCC	act
VCCC	acts
CVC	him
CVCC	hand

Table 2.2 English closed syllables

To solve the problem of syllable, the syllabification approach that been introduced by Norshuhani [4] is used. She demonstrates the syllabification process via two types of approach. The approaches are “Text → Symbol → Syllable” and “Text → Sound → Syllable”. But in this project I will use the “Text → Symbol → Syllable” approaches. This approach will convert a word or a sentence into writing symbols or also known as grapheme. The following example should be able to give a better view on this approach:

Input word: **competition**

Processing Stage	Output	Description
1	compatitVn	In the graphotactic rules, ‘io’ is found to be a vowel therefore it is replaced by a symbol ‘V’.
2	com-patitVn	In the syllabification rules, ‘mp’ is found NOT to be permitted consonant clusters therefore a hyphen is inserted to mark the bundary.
3	com-pa-ti-tVn	In the syllabification rules, vowel is taking the left consonants first. Then consider the right consonants.
4	com-pa-ti-tion	A mapping between the initial word and the output produced in the stage 3 is made to give the final result.

Table 2.3 Example of Text → Symbol → Syllable approach

The longer the word or text may require a longer processing stage. Each stage, the word will be check with a set of predefined rules, and the rules that are match will be used for necessary changed to update for the next process.

To segmentize the words according to their syllable, one of the rules used is graphotactic rules. Graphotactic rules use symbols to identify grapheme of the word syllables. The process is much simpler from using sounds. Each of the processing

stages are different from one another depending on the rules that are match for graphotactic rules. Some of the graphotactic rules are:

<i>NO</i>	<i>Rule's description</i>	<i>Simplified form</i>
1	Any combination of 'ey', 'ay', 'ew', 'or', 'ar', 'oy', 'ow', 'ur', 'ir', 'uy', 'ye' is substituted for 'V'	ey,ay,,ew,or,ar,,oy,ow,ur,ir,uy,ye, → V e.g.: bowl, fork, buy, toy, torch, car
2	The spelling 'ough' is substituted for 'V' followed by 'f'	ough → Vf e.g.: though, cough
3	The spelling 'ight' is substituted for 'V' followed by 'f'	ight → Vf E.g.: fight , might

Table 2.4 Graphotactic rules

Grapheme represents a character and symbol. It also a written symbol to represent speech. According to Rubba [5] English language and English spelling are different. Where, English spelling is a traditional way to represent English language in a written form. Grapheme is created from 26 letters of alphabets. It is different from other symbol systems. There are several examples of graphemes taken from Rubba [5], to get a clear understanding on types of English graphemes:

1) **Single Letter Vowel:** a e i o u

E.g. cat, set, fit, mop, cut

2) **Single Letter Consonant:** b c d f g h j k l m n p q r s t v w x y z

E.g. home, name, moon

3) **Double Letter Vowel:** ee oo

E.g. heel, book

4) **Double Letter Consonant:** all consonant can appear double except h, j, k, q, w, x, and, y. E.g. summer, apple, cross,

5) **Letter Combination Grapheme:**

a. Digraph: two different letters used for a single sound. E.g. 'th' = three

b. Blends: two letters that represent two sounds in sequence.

E.g. queen.

6) **Silent Letter:** letter that not represent sound, that appear in words.

E.g. game, time, knee

The other rule is when at least two consonants form a single speech sound in a word or syllables are called diagraph rules. Using this rule it would reduce the complex form of the words from it initial words. It is important not to split up words that have two middle consonants, because in diagraph rules it represents one sound. Some example of the diagraph rules is as below:

No	Rule's description	Simplified form
1	'd' followed by 'g' is substituted by 'JH'	dg → JH E.g: budget, judge, ledge
2	'q' followed by 'u' is substituted by 'kw'	qu → kw E.g: quick, request
3	'p' followed by 'h' is substituted by 'f'	ph → f E.g: phase, photograph
4	'w' followed by 'h' is substituted by 'w'	wh → w E.g: when, whip, why
5	'c' followed by 'h' is substituted by 'CH'	ch → CH E.g: church, chain

Table 2.5 Diagraph rules

Syllable also can be defined as sequence of segment [6]. That is there will be zero or more consonant that followed by a vowel and vowel must be replaced by a syllabic consonant. It represents one impulse of voice. In English, voice are stressed that others for the syllable in words or from sentence. From lecture notes of a website [6] claimed that, the basic structures of syllable are onset, nucleus and coda. Onset is initial segment of a syllable, whereby rhyme is core of syllable that consists of nucleus and coda. Nucleus is central segments of syllables and coda is closing segments of syllable.

Linguists have attempted to combine the definition to get a basic structure for syllable. The structure is as below:

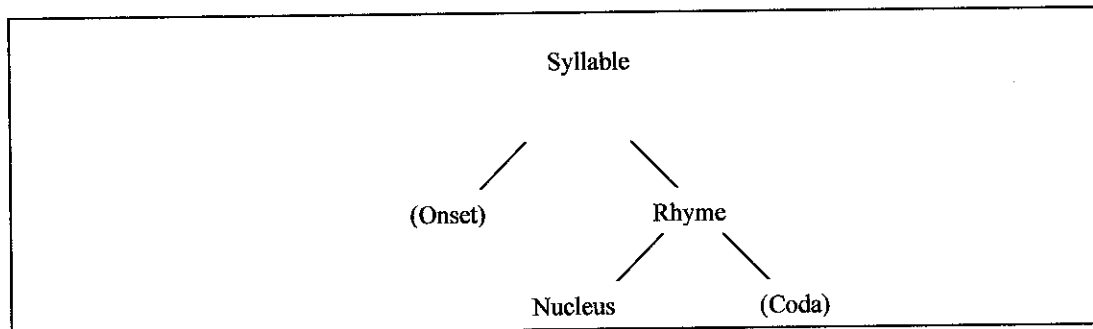


Figure 2.4 Structure of syllable

“Where C = any number of consonant and V = vowel” [6]. This is where we can defined that CAR = CVC. The most preferable structure of syllable as below:

(C) (C) (C) V (C) (C) (C)

The structure above was introduced by Dr. W H Edmonson, a lecturer of University of Birmingham [4]. There are three consonant on the right and three consonant on the left. We can define that onset is three consonant before the vowel and coda is after the vowel. Then the vowel can be defined as nucleus.

Besides the syllabification approach, elision and assimilation rules also need to be considered. Elision is the omission of one or more sounds in a word or sentence. Some sound can be dropped or left out without damaging the shape of the words. From the view point of coarticulation studies [7], elision is not a different process of assimilation. It is a simply tremendous result whereby when two sounds are articulate closely in time to each other, the sounds between them will be hidden. Assimilation is concerned with one sound becoming phonetically similar to adjacent sound [7]. Assimilations are traditionally classified into three main types. The types are assimilation of voice, assimilation of place, and assimilation of manners [8].

The three types of assimilations use the International Phonetic Symbol (IPA) Symbols. IPA is widely used across the nations, for transcription of English language and also other languages. IPA offers a set of symbols, and some general guidelines on how to use the symbols. It is also used to do broad phonetic transcriptions that will show the gross characteristics of speech, or distinctive sounds. The descriptions of the types are mention below:

1) Assimilation of voice:

Assimilation of voice is found across word boundaries, it also may take a form of voiced segment becoming voiceless. It is all depends on the final consonant of the noun. If final consonants is voiced the suffix will be pronounced as [z], but if it voiceless it will be pronounced as [s].

Example: Cats = kæts voiceless final consonant and suffix
Dogs = dogz voiced final consonants and suffix

2) Assimilation of place:

Then assimilation of place also occurs regressively across when boundaries same with assimilation of voice. But it will occurs only with alveolar consonant that is like z change to S and Z when words followed by j or S.

Example: This shoe = DIS ʃu: (regressive)

3) Assimilation of manner:

Then the last type is assimilation of manner have a different whereby it will only be found in very fast casual speech. It means that the changes are generally involving a change from a stronger consonant.

Example: Good Night = gu:n Naɪt a final plosive become nasal.

The terms of sounds can be left out are called **elision**. Some examples of elided form are listed below [9]:

Citation form	Elided form	Natural form in IPA Symbols
postman	pos(t)man	pou smən
mashed potatoes	mash(ed) potatoes	mæʃ pətetəʊz
next week	nex(t) week	neks wɪk

Table 2.6 Elided form 1

There are also English words that quite hard to pronounce without any elision, such as asthma, facts, twelfth. In some word the weak vowels can be elided [9]:

Citation form	Elided form	Natural form in IPA Symbols
library	lib(ra)ry	laɪbrɪ
history	hist(o)ry	hɪstri
policeman	p(o)liceman	plɪsmən
government	gov(ern)ment	gʌvnmənt

Table 2.7 Elided form 2

English online [9] has mentioned assimilation in English as a process where when sound in a word or a sentence accompanies of other sounds, certain adjacent will change. Assimilation are not really represented in spelling, it is more on speech. Therefore it is really good for hearing other people speech to know better on the assimilation. Some examples given in the English online are like below [9]:

Words	Changes	New sound in IPA Symbols
ten boys	n > m	tem bɔɪz
good bye	d > b	gʊb baɪ

Table 2.8 Assimilation word

Besides syllable, elision and assimilation manner of articulation also important to make sure that the word or sentences are pronounced well. Table below shows the manner of articulation for English consonants:

		Place of Articulation												
		Bilabial		Labiodental		Interdental		Alveolar		Palatal		Velar		Glottal
Manner of Articulation	Stop	p	b					t	d			k	g	ʔ
	Fricative			f	v	θ	ð	s	z	ʃ	ʒ			h
	Affricate									tʃ	dʒ			
	Nasal		m						n				ŋ	
	Lateral Liquid								l					
	Retroflex Liquid								r					
	Glide	w	w									y		

State of the Glottis: Voiceless Voiced

Table 2.9 Consonants of English

Several explanations of the table are as below [10]:

- 1) Stop: Airflow is stopped completely in the mouth.
- 2) Nasal: Beat vs. meat, dear vs. near.
- 3) Fricative: Obstructed airflow.
- 4) Affricate: Stopped then slow release (church, judge)
- 5) Glide: Tongue glides to or away from vowel.
- 6) Liquid: Some obstruction, but no friction or constriction.

In my research in understanding the speech synthesizer I have found several methods that been used by other in developing speech synthesizer. One methods that been explains by John Coleman [11] in his report is transformational grammars.

He use three non-invertible mapping “grapheme → phonemes → allophones → parameters” [11] based on the phonological theory of Halle (1959) and Chomsky and Halle (1986). He explains that grapheme to phoneme mapping is an inverse spelling rules use with exception dictionary, phoneme to allophone mapping is for pronunciation rules and last allophone to parameter mapping is for interpolation rules. Allophone is one of several similar phones that belong to the same phoneme. As mentioned above phone is a sound that distinguishes the shape of wave and phoneme is a basic group of sounds that can distinguish words.

Another method that found is using algorithm for realizing the scheme in a system [12], and also it evaluate through listening test. In the basic scheme they use two stages of process. First is to find an optimal decomposition of the input phoneme and the second is to find the most appropriate extraction and concatenation condition for each sequence. For the first stage, conventional fixed-length system is used to encode the input string as a unit sequence. Second stage is using a simple concatenation using a phoneme sequence with prosody control symbols. In the report, claims that besides CV syllables there are also several more phonemics sequence used to identify synthesis units [12]. For example, CVV, VCV, CVCV, and several more phonemes sequence. The most important part of the approach is the use of non-uniform speech segments adapted to the input string.

For this project, I will used the syllabification approach that been introduced by Norshuhani [2]. To complete the project, set of rules for elision and assimilation are identified. The methodology and implementation are discussed in the next chapter.

CHAPTER 3

METHODOLOGY

The methodology that is used to conduct the project better is the prototype model. The tools that will be used is Java 2 SDK 1.4.2, Sun One Studio 4 and also Microsoft Access (MS Access) as the database.

3.1 METHODOLOGY

I chosed this methodology because it can reduce the amount of time until the user begins to see a working prototype. Figure below shows the prototype model:

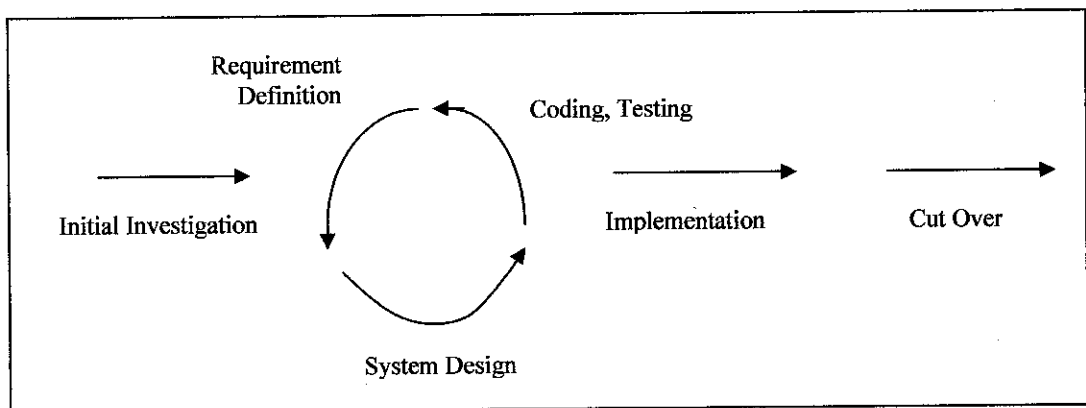


Figure 3.1 Prototype model

Prototyping works well in situations where project objectives are unclear, requirements are unstable, or users are not highly knowledgeable. There are six stages in this model.

3.1.1 Initial Investigation

In this stage the analysis and initial investigation of this project is done. Whereby the topic of the project need to be clarified and need to be understood. The project area of study also needs to be analyzed, whereby the area of study for this project is about Natural Language Programming. This project is narrowed down under the speech synthesis topics.

3.1.2 Requirement Definition

Then in the requirement definition is the stage to clarify the methods that is used in this project and also need to identify the approach that is used for this project. In this project the method that used is the rule based approach. The rules of the project are diagraph rules, elision in English rules, and assimilation in English rules.

3.1.3 System Design

After the requirements gathered, the interface for the system is designed taking into consideration all the specification required for the project. The designs consist of process flow, and interface designed. The tools used for design is Microsoft Windows 2003.

3.1.4 Coding, Testing

After that the coding and testing stage is implemented. The coding part is done using the Forte and the testing part will be done with my supervisor, and also the English lecturer from the general studies.

3.1.5 Implementation

Implementation phase is a stage where the final software is tested by the user. Before the cutover or delivery done, the documentation for the software is also created to assist users in using operating the software.

3.1.6 Cut Over

The cut over stage is actually the maintenance stage. In this project there will be no maintenance stage involve. This is because the project will only be handed over to the supervisor. There is where the stage of cut over used to replace the maintenance stage because cut over it self explain the hand over the entire program to user. All the changes or future work that need to be done for the project will be carried out by future student.

3.2 TOOLS

3.2.1 Java 2 SDK 1.4

It is a set of command line programs used to create, compile and run Java program. Java program is an object-oriented programming language for portable interpretive code that supports interaction among remote objects. Java was developed and specified by Sun Microsystems, Incorporated.

3.2.2 Sun One Studio 4

Sun One studio 4 is a Java Programming tools available to make the development of program easier. Sun One Studio 4 is offered by Sun Microsystem. It is easy and simple to use. In this project Community Edition is used because it is free software available from a compact disks (CD) when buying the books of 'Rapid Java Application Development using Sun One Studio 4'. It offers a built in text editor, graphical user interface and also project management tools. The Sun One Studio 4 can support Java 2 SDK 1.4 and can be configured to support for higher version.

3.2.2 MICROSOFT ACCESS

MS access is a relational database management system developed by Microsoft. It is packaged with Microsoft Office Professional which combines the Jet relational database engine with a graphical interface intended to make it possible for relatively

unskilled programmers and non-programmer "power users" to build front ends to databases. For skilled developers and data architects, it can allow for the rapid development of applications.

CHAPTER 4

RESULT AND DISCUSSION

4.1 PROCESS FLOW

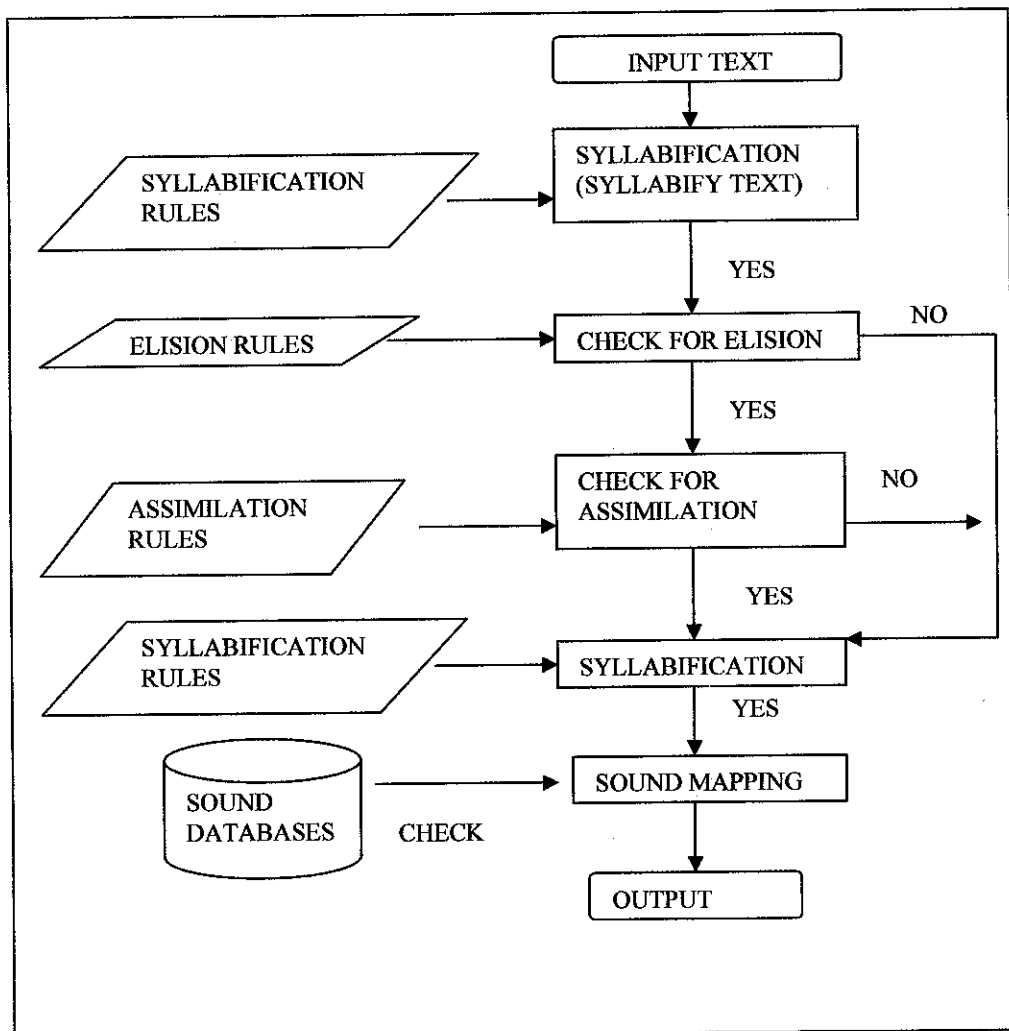


Figure 4.1 Process flow

Figure 4.1 above is a figure that shows how the process of the project works. Each process flow is explained briefly as follows:

- **Input Text:** In the process user will input the words or sentences that they want to use.

- **Syllabification:** After user input the word or sentences, the program will process the text by searching in the syllabification rules to get the syllable of the word and sentences.
- **Check for Elision:** Then after the program has finished the processes of the syllabification, it will start the process of checking for elision. The process is to check whether the syllable has meet any of elision rules in English.
- **Check for Assimilation:** Then the program will also check for assimilation rules in English.
- **Resyllabification:** After checking all the rules. The program will resyllabify back the syllable to get the words.
- **Sound Mapping:** The syllabify words will be checked to the sound database to get the exact sound of the words according to the English sounds.
- **Output:** The sounds that have been chosen will be the output to the program.

4.2 INTERFACE

The description below is for the graphical user interface (GUI) that been draft for the project.

- 1) Title of the project.
- 2) Text box to enter the text or word.
- 3) Clear button to clear the initial text box.
- 4) Process text button, where the program start to process text or word.
- 5) Quit Button to exit the program.
- 6) Text box where the processes text or word will appear.
- 7) Label YES or NO, if there are assimilation rules the label will appear YES and vice versa.
- 8) Label YES or NO, if there are elision rules the label will appear YES and vice versa.

- 9) Say It button where the program will speak the sound of the word according to the rules process.
- 10) Volume adjustment button where to control the volume of the program.
- 11) This group box is initially hidden. Once a text or word is processed then the box will appear to show the result of the process.

The drafted GUI for this project is below:

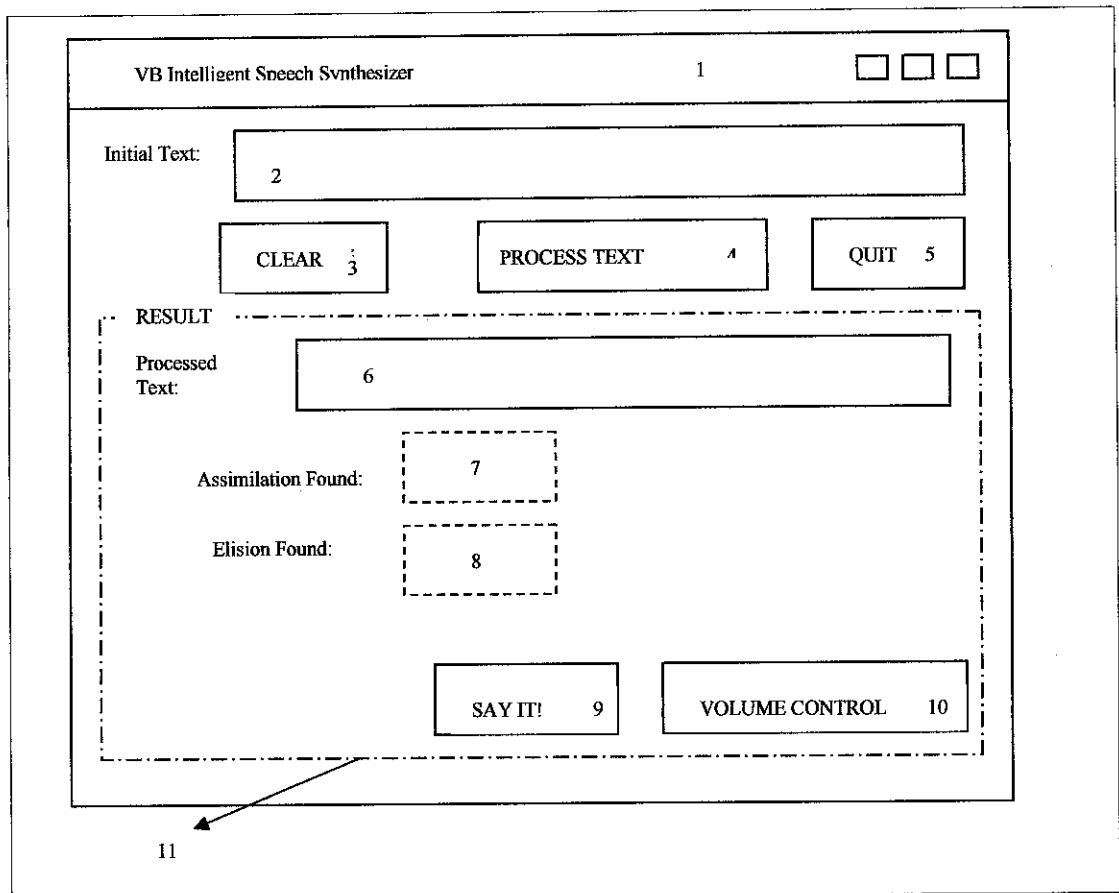


Figure 4.2 Draft interface of the system

4.3 SYLLABIFICATION RULES

There are two types of rules that will be used according to the approach of Text → Symbol → Syllable. The types are graphotactic rules and diagraph rules. Graphotactic rules are used to define possible sequences of grapheme in writing system.

The graphotactic rules are as below:

<i>NO</i>	<i>Rule's description</i>	<i>Simplified form</i>
1	Any combination of 'ey', 'ay', 'ew', 'or', 'ar', 'oy', 'ow', 'ur', 'ir', 'uy', 'ye', 'ai' is substituted for 'V'	ey,ay,,ew,or,ar,,oy,ow,ur,ir,uy,ye, → V E.g.: bowl, fork, buy, oyster
2	The spelling 'ough' is substituted for 'V' followed by 'f'	ough → Vf
3	The spelling 'ight' is substituted for 'V' followed by 'f'	ight → Vf E.g.: fight, might
4	Any consonant followed by 'y' is substituted for 'V'	Cy → V E.g.: lyric, python,
5	Any double consonants are substituted for a single consonant except for consonant 'c'	CC → C E.g.: diffuse, syllable, litter

Table 4.1 Graphotactic rules

Then the second rules are the digraph rules. Digraph rules is a cluster of at least two consonant forming a single speech sound in a word or in syllable. The rules are shown below:

No	Rule's description	Simplified form
1	'd' followed by 'g' is substituted by 'JH'	dg → JH E.g: budget, judge, ledge
2	'q' followed by 'u' is substituted by 'kw'	qu → kw E.g: quick, request
3	'p' followed by 'h' is substituted by 'f'	ph → f E.g: phase, photograph
4	'w' followed by 'h' is substituted by 'w'	wh → w E.g: when, whip, why
5	'c' followed by 'h' is substituted by 'CH'	ch → CH E.g: church, chain
6	's' followed by 'h' is substituted by 'SH'	sh → SH E.g: shake, shade, mash
7	't' followed by 'h' is substituted by 'TH'	th → TH E.g: them, think, thumb
8	'n' followed by 'g' is substituted by 'NG'	ng → NG

		E.g: sing, long, anger
9	'k' followed by 'n' is substituted by 'n'	kn → n E.g: knife, knew, knee
10	When 'b' is followed by 'u' and then followed by a vowel at the beginning of a word then it is substituted for 'bV'	#buV → bV E.g: build
11	When 'c' is followed by 'h' and then followed by 'e' end of a word then it is substituted for 'SH'	Che# → SH E.g: cache, moustache, gauche
12	When 'q' is followed by 'u' and then followed by 'e' end of a word then it is substituted for 'k'	Que# → k E.g: cheque, plaque
13	When 's' is followed by 'c' and then followed by 'h' and finally followed by a vowel at the beginning of a word then it is substituted for 'sk'	#schV → sk E.g: school, scheme, schism
14	'x' is substituted for 'ks'	x → ks E.g: deluxe, annex, approximate
15	When 'c' is followed by 'h' and then followed by 'l' or 'r' then it is substituted for 'kl' or 'kr'	chl, chr → kl, kr E.g: chloride, chronic
16	When 'c' is followed by 'h' and then followed by 'o' and finally by 'l' or 'r' at the beginning of a word then it is substituted for 'kol' or 'kor'	chol, chor → kol, kor E.g: cholera, chord
17	'd' followed by 'g' is substituted by 'JH'	dg → JH E.g: budget, judge, ledge
18	'q' followed by 'u' is substituted by 'kw'	qu → kw E.g: quick, request
19	'p' followed by 'h' is substituted by 'f'	ph → f E.g: phase, photograph
20	'w' followed by 'h' is substituted by 'w'	wh → w E.g: when, whip, why
21	'c' followed by 'h' is substituted by 'CH'	ch → CH E.g: church, chain

Table 4.2 Digraph rules

Besides graphotactic rules and diagraph rules there is also silent rules, the rules for grapheme that does not represent any sound. Silent letters are resulted from the historical change where it used to be pronounced in Old English period. The silent rules that have been defined are shown in table below:

No	Rule's description	Simplified form
1	A word begins with the spelling 'gn' or ends in the spelling 'gn' is substituted for 'n'.	#gn, gn# → n (g is silent) E.g.: gnash, sign, gnaw
2	A word begins with the spelling 'gh' is	#gh → g (h is silent)

	substituted for 'g'.	E.g.: ghost, ghoul, ghee
3	A word ends with the spelling 'bt' is substituted for 'y'	bt# → t (b is silent) E.g.: debt, doubt
4	A word begins with the spelling 'rh' is substituted for 'r'	#rh → r (h is silent) E.g.: rhyme, rhino
5	A word begins with spelling 'mb' or 'mn' is substituted for 'm'	mb#, mn# → m E.g.: lamb, damn

Table 4.3 Silent rules

4.4 ELISION RULES

Based from the research, elision rules that have been found are as below:

No	Rule's description	Simplified form
1	If 's' followed by 't' the sound of 't' is elided	st → s E.g.: postman, postcard
2	If 'x' followed by 't' the sound of 't' is elided	xt → ks E.g.: Next
3	If 'b' followed by 'ra' the sound of 'ra' is elided.	ra → * E.g.: library
4	If 'p' and 'st' followed by 'o' the sound of 'o' is elided.	o → * E.g.: history, policeman

Table 4.4 Elision rules

4.5 ASSIMILATION RULES

Based from the research, assimilation rules that been found are as below:

No	Rule's description	Simplified form
1	If 'nd', and 'n' followed by '#b' and 'b' substituted to 'm'	n > m E.g.: handbag, ten boys
2	If 'n' followed by '#c' and 'c' substituted to 'ng'	n > ng E.g.: ten cups, pancake

3	If 'd' followed by '#b' substituted to 'b'	d > b E.g.: good bye
4	If 'd' followed by '#g' substituted to 'g'	d > g E.g.: good girl
5	If 'nt' followed by '#p' changed to 'mp'	nt > mp E.g.: mount pleasant , front paws

Table 4.5 Assimilation rules

4.6 SYSTEM

4.6.1 Screen Shot

The interface for the project is as below:

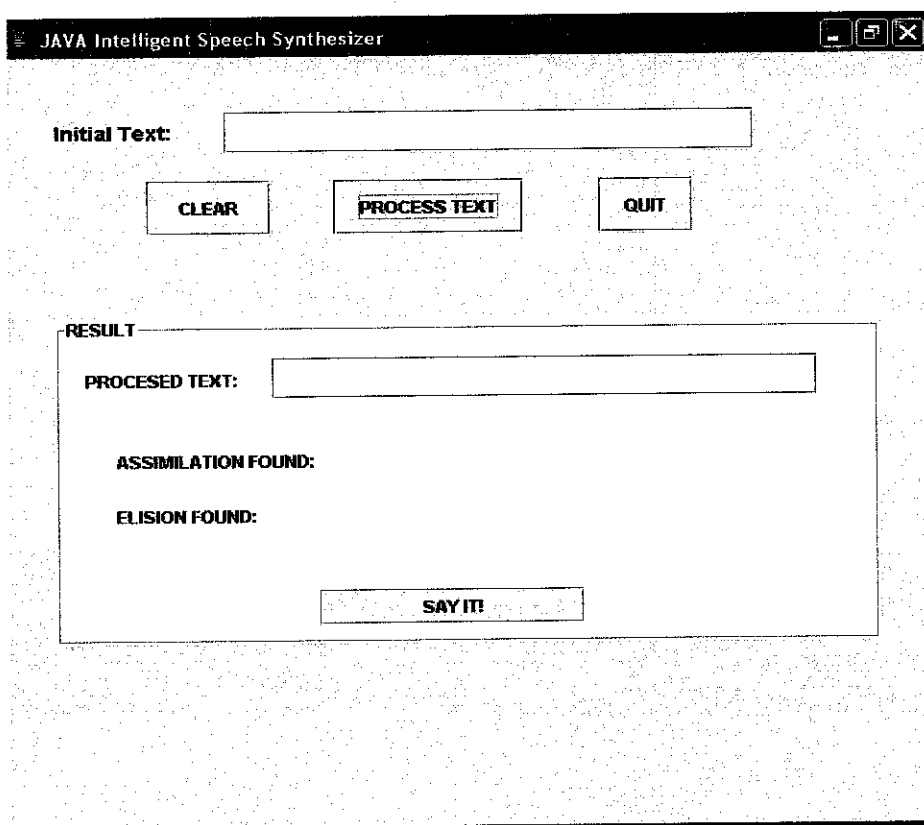


Figure 4.3 Interface

Table below describe the function of button in the interface of project:

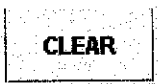

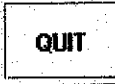

BUTTON	DESCRIPTION
	A button to clear both initial text field and process text field.
	A button used to process the initial text fields to get the syllable of the words. The process words appeared in the process text fields.
	A button to quit the program.
	A button to produce the output sound for the words.

Table 4.6 Button Function

Each of the buttons has its own description to make user easier to use the program.

The figure below shows the message box that explains about the button:

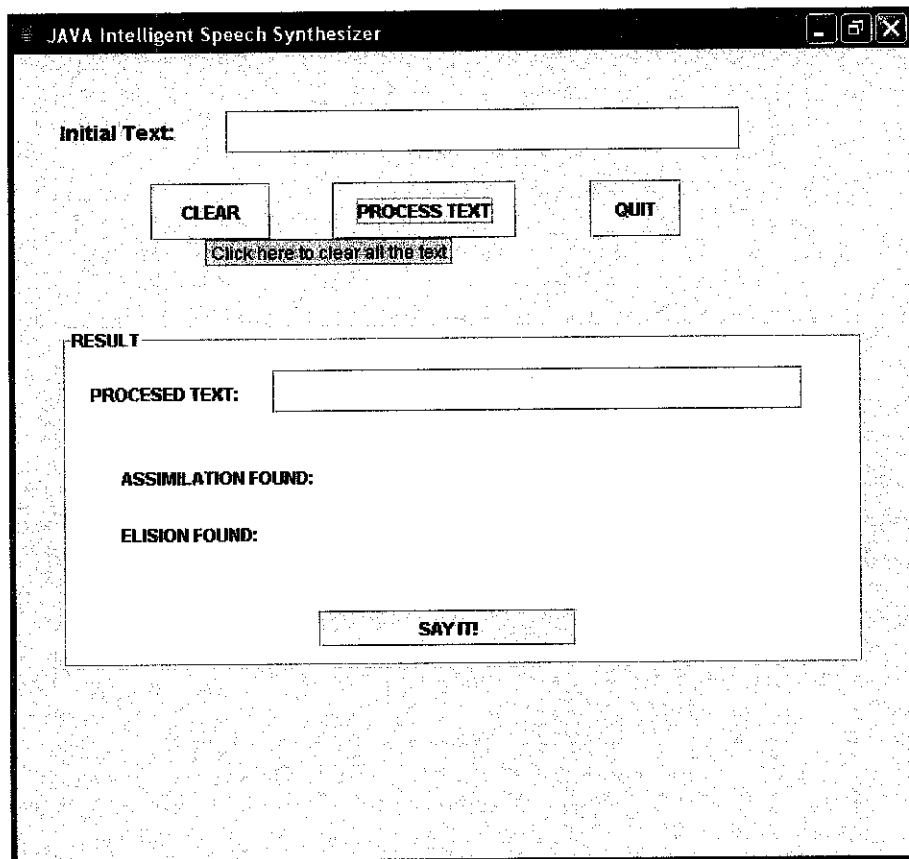


Figure 4.4 Clear Button

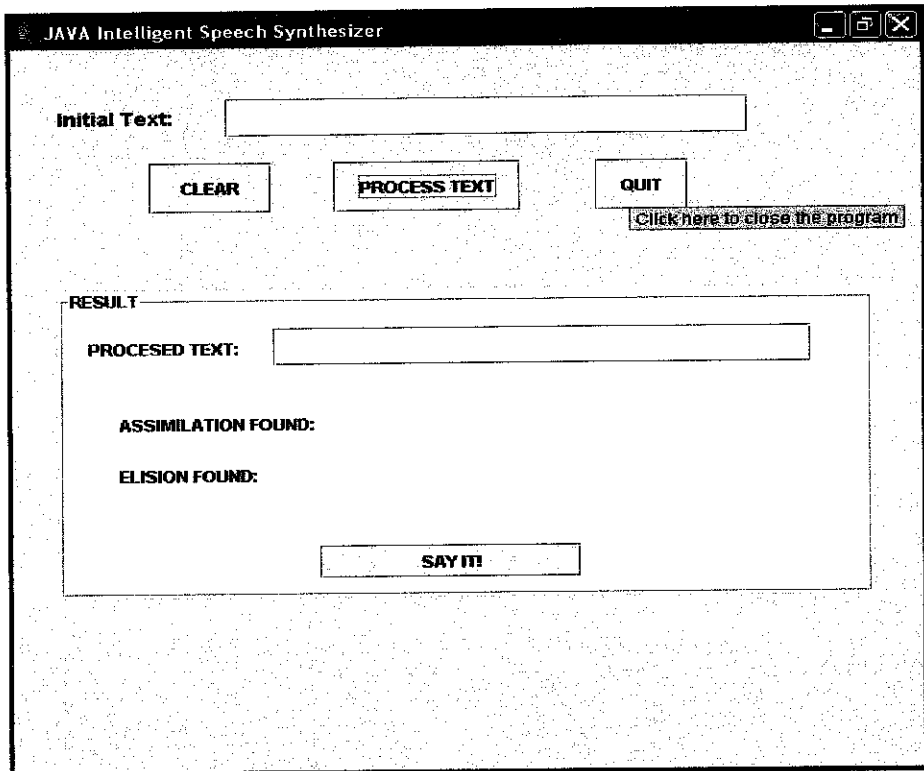


Figure 4.5 Quit Button

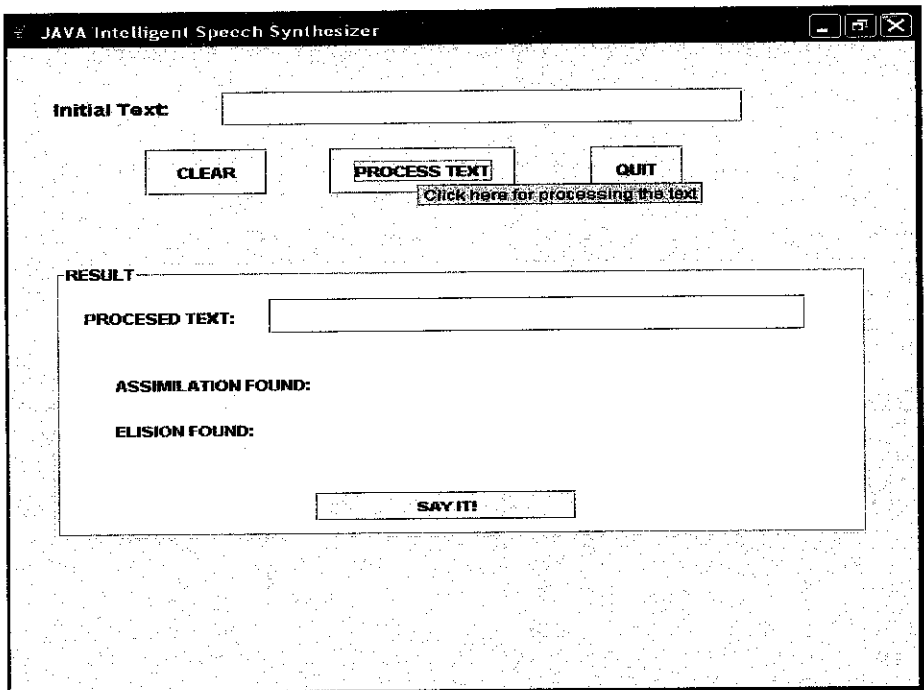


Figure 4.6 Process Text Button

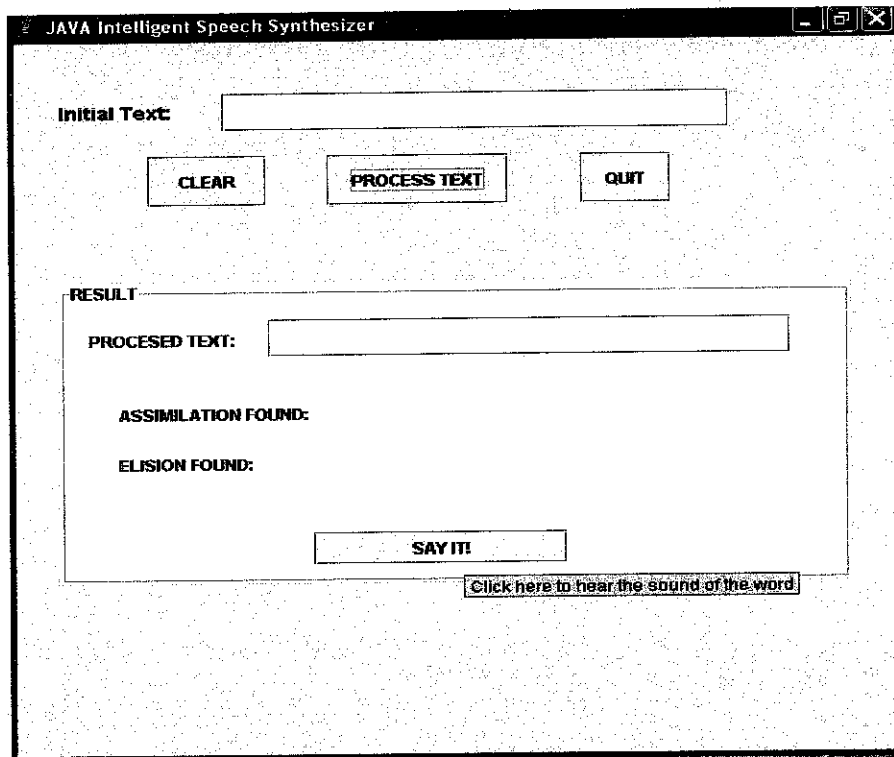


Figure 4.7 Say It Button

When user clicks the quit button, a message box appear to ask if the user really want to exit. The figure is like below:

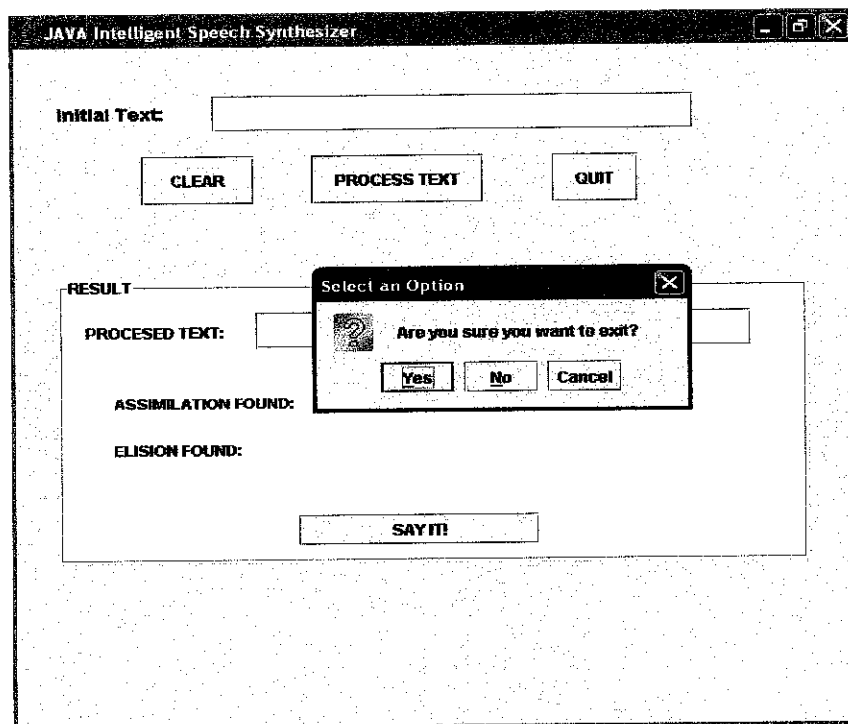


Figure 4.8 Quit Selections

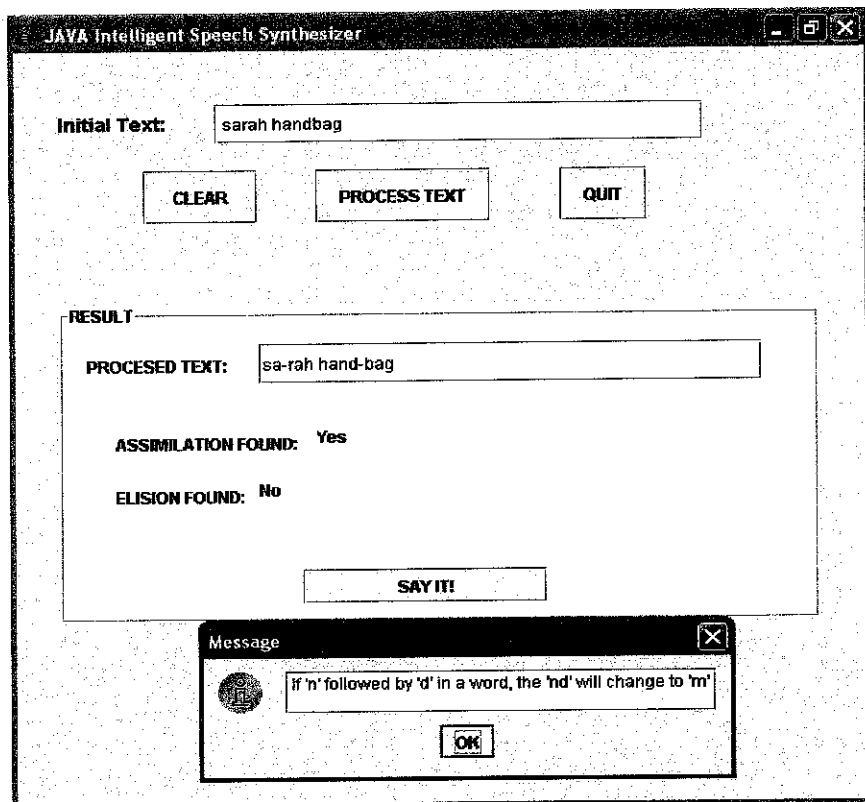


Figure 4.9 A sample input with assimilation

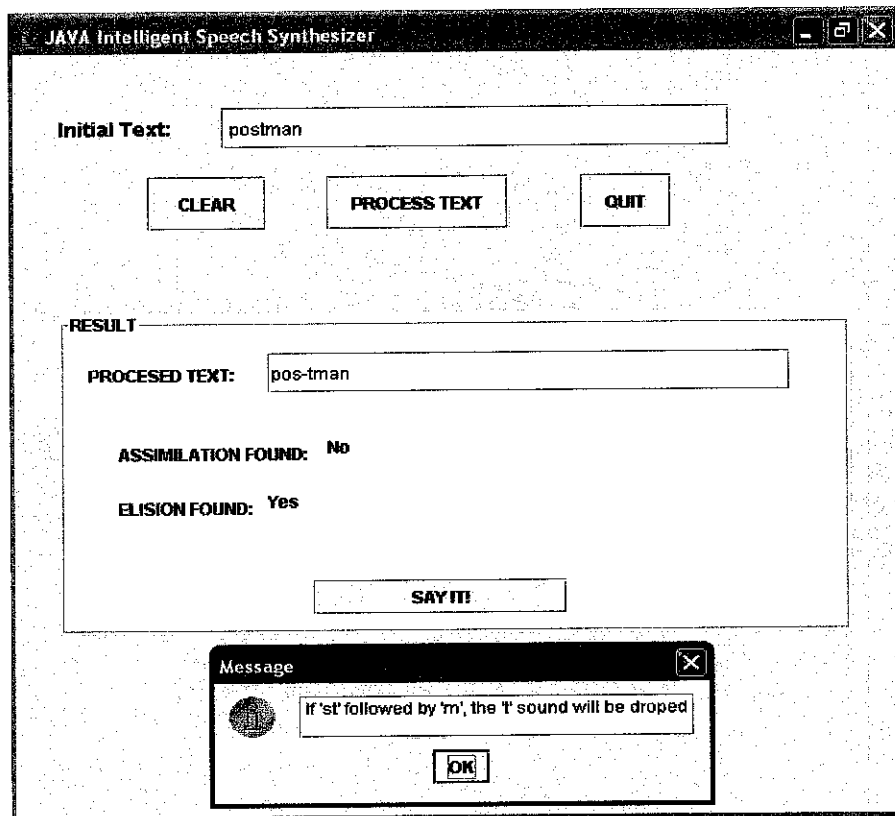


Figure 4.10 A sample input with elision

The examples for both assimilation found and elision found in figure 4.9 and figure 4.10. User will insert text to the initial text. When user pushed the button “Process Button”, the processed text will appear with the syllable boundaries within the text. In the assimilation label it will display “YES” if the text conform with any assimilation rules and “NO” if the text does not match with any assimilation rules. The same process is done for input with elision. Besides it also will display pop-up message to show the matched rules. User can listen to the sound of the word when they click the “Say It” button. This is to help user with better pronunciation of the words. Below is the process of pop-up menu if the user did not put any text in the program and they push the text process buttons.

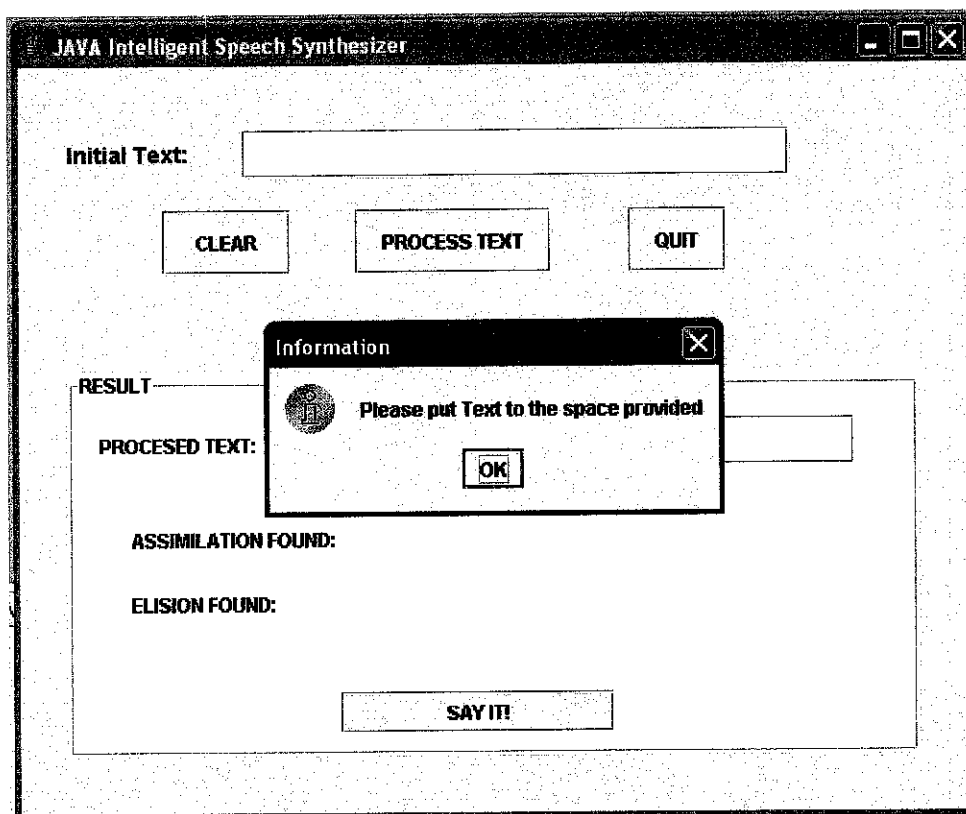


Figure 4.11 A sample text box

Below is the database sounds used to store the sound files using the Microsoft Access:

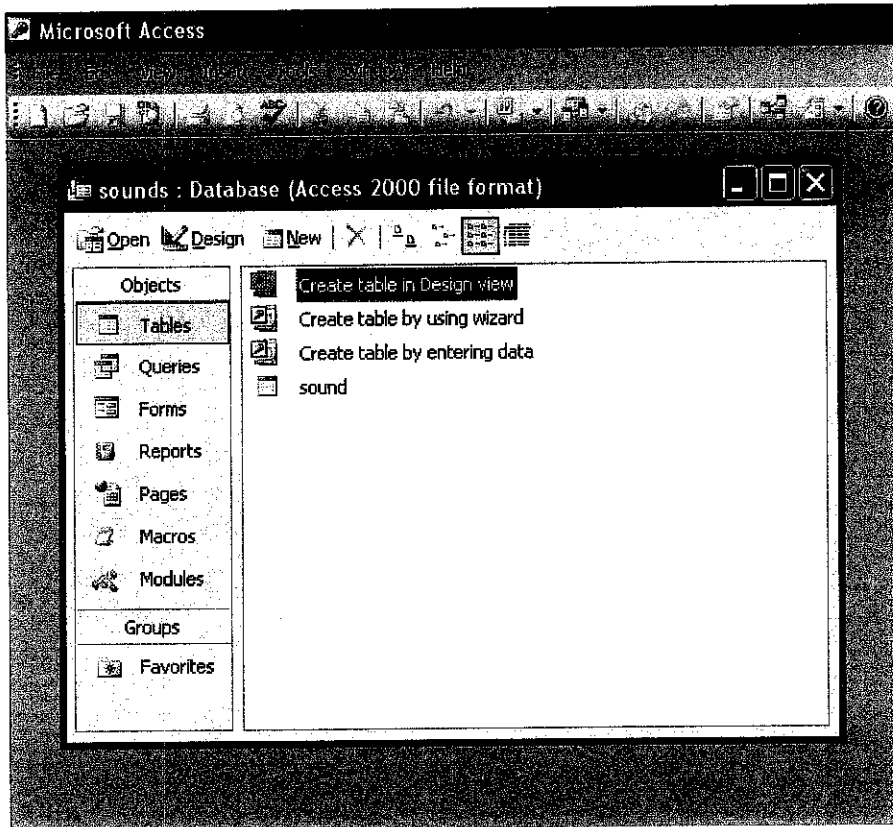


Figure 4.12 Sounds Database

no	name	sound
1	handbag	Wave Sound
2	handmade	Wave Sound
3	bottle	Wave Sound
4	pangcake	Wave Sound
5	seven	Wave Sound
6	motorcycle	Wave Sound
7	postman	Wave Sound
8	telephone	Wave Sound
9	additional	Wave Sound
10	affliction	Wave Sound
11	backstage	Wave Sound
12	baboon	Wave Sound
13	battlefield	Wave Sound
14	behave	Wave Sound
15	businessman	Wave Sound
16	calculate	Wave Sound
17	capacity	Wave Sound
18	cardboard	Wave Sound
19	headphone	Wave Sound
20	condominium	Wave Sound
21	delay	Wave Sound
22	defuse	Wave Sound
23	human	Wave Sound
24	department	Wave Sound
25	depart	Wave Sound
26	position	Wave Sound
27	devise	Wave Sound
28	devotional	Wave Sound
29	diamond	Wave Sound
30	freehold	Wave Sound
31	freepost	Wave Sound

Records: 14 of 33

Figure 4.13 List Sounds

4.6.2 Testing

Not all words can be processed using the software. Table below contains some of words that are successfully tested:

Word tested	Result
Sarah	sa-rah
sarah handbag	sa-rah hand-bag with one assimilation rule match.
Home	ho-me
Sarah made pancake	sa-rah ma-de panca-ke with elision rule match
Bottle	bott-le
Handmade	hand-ma-de
Handicap	handi-cup
Postman ride motorcycle	pos-tman ri-de mo-torcyc-le with elision rule match.
Seven	se-ven
Telephone	te-lepho-ne
additional	addi-tio-nal
address	ad-dress
affliction	aff-liction
backstage	back-sta-ge
baboon	ba-boon
battlefield	bat-tle-field
behave	be-ha-ve
businessman	bu-si-nes-sman
calculate	calcu-la-te
capacity	ca-pa-city

Table 4.7 Tested Words

CHAPTER 5

CONCLUSION AND RECOMMENDATION

In this project, three rules that are used are the syllabification rules to get the syllable boundaries, elision rules to find whether any elision going in the word or sentence and assimilation rules to found whether the word or sentences consists of any assimilation.

The elision and assimilation are clarified that it will only happen in a fast speech situation. That is why this project is call English speech synthesizer with speech error processing features: elision and assimilation. In developing the project there are lots of problems occurred one of it is the problems in coding. Not all words can be used in the software. This is because the rules are not yet complete. Words that only have a sound or when we clarified “CV” structure cannot be used for the software. For example the words “my” is a single structured that is unsolved.

Elision rules and assimilation rules are dependent to the syllable rules of symbols in the software. If the process of syllabification cannot generate, the process of elision rule and assimilation rule also cannot operate.

As to date, this is not a finished project yet. Lots of rules need to be constructed before a completion is reached. More research need to be done to complete the diagraph rules, graphotactic rules, the syllable rule, elision rules and also assimilation rules.

For future work, a good mapping rules need to be presented to increase accuracy. A modification to the existing Maximum Onset Principles algorithm might give great benefits to the result as well. The new algorithm should solve the problem in processing the word syllable for simple structure of “CV”. Besides the algorithm can

benefits the results, the new algorithm also can be used for the sound process. The sound accuracy can be increased using the new algorithm.

To make the program more useful, I suggest that this program can be do for teachers or lecturer that are interested in knowing the English Language. Because from this the user can know how each word can be clarified to English terms. More research on English Language can be made to make the scope of the project more interactive.

The program can be more interactive by adding some pictures, and also a text that can show the words that been changed to the rules. To make the program more effective in teaching people how to pronounce the words in English, one additional feature on teaching users can be added to the program.

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Appendix A: History of Language

Language is a *conventional, arbitrary system of sounds* used for communication in a *human* linguistic community.

I. Language is a **system** at many levels. All languages have two levels, called **duality of patterning**. This consists of meaningful and meaningless components.

A. **Meaningless components, the phonemic system:** Phonemes are the smallest meaningless components that constitute the sound system of a language.

B. **Meaningful components, or morphosyntax:** Morphemes are the smallest meaningful components of a language. For example, the word *cats* consists of two morphemes, {cat} and {-s}. Morphemes can be grammatical (having dictionary definitions) or lexical (affixes and function words). They can be free (able to stand alone) or bound (complete only when combined with other morphemes). Bound lexical morphemes (or affixes) can be either derivational (used to create new words) or inflectional (used to signal grammatical relationships). **Syntax:** Syntax governs the way words come together to create sentences. The syntax of English has become less *synthetic* (grammatical structures are signaled primarily by inflectional endings) and more *analytic* (grammatical structures are signaled primarily by word order and function words).

II. Language is a **human** activity. Though animals can communicate in a primal way, they do not have innate language abilities that allow for an unlimited number of novel utterances. Though some apes have been taught to use sign language (a paralanguage, or parallel system of communication), the breadth of ideas that they express are limited.

III. Language is **arbitrary**. Aside from echoic words, there is no intrinsic relationship between words and the objects or concepts that they represent.

IV. Language is **conventional**. Language is passed down from one generation to the next. It is the nature of language to change. Notions of absolute correctness are imposed by writers, linguists, scholars, etc. and may slow down but do not prevent the natural process of language evolution.

V. Language is **sound**. Linguists are primarily concerned with speech. Writing is a secondary activity.

(These notes compile information from my own lectures; from Pyles and Algeo's *The Origins and Development of the English Language*, 5th edition, Harcourt Brace College Publishers, New York, 2005; and from Baugh and Cable's *A History of the English Language*, 4th edition, Prentice Hall.)

[Back to Top](#)

Chapter 2: The Sounds of English

The **International Phonetic Alphabet (IPA)** is "an alphabet in which there exists a one-to-one correspondence between speech sounds and symbols; the IPA is used in transcription by [those] who study language" (glossary from Thomas Murray's *The Structure of English*, Boston: Allyn and Bacon, 1995). We will be using a simplified version of the IPA to do broad phonetic transcriptions that will show the gross characteristics of speech, or distinctive sounds. We will not distinguish nondistinct sounds, which include off-glides (or drawls) and sounds such as [t] in *stone*, without aspiration, as opposed to *tone*, in which the [t] is aspirated.

Remember the following rules when doing phonetic transcriptions:

1. Phonetic symbols should be printed, not written in cursive.
2. Always enclose transcriptions in square brackets.
3. If transcribing a sentence, paragraph, etc., use one bracket at the beginning and one at the end. Do not use separate brackets for each word.

Terminology:

Complimentary distribution: sounds that differ according to environment, as in stone and tone

Free variation: sounds that differ according to an individual's speech habits

Kinds of sound change

1. Assimilation: sounds become more alike
2. palatalization: a form of assimilation by which sounds become palatalized, as in "whatcher name" (what's your name?) and "jeet yet" (Did you eat yet?)
3. dissimilation: sounds become less alike, as in diphthong
4. elision: sounds are omitted due to lack of stress
5. aphesis: elision of initial unstressed sound, as in 'bout
6. apheresis: loss of any sound at beginning of word, as in 'most
7. apocope: loss of sounds at end of word, as in chile'
8. syncope: loss of a weakly stressed syllable in the middle of a word, as in fam'ly
9. intrusion: sounds are added
10. svarabhakti (from Sanskrit): intrusive schwa, as in ath"a"lete, also known as epenthesis or anaptyxis; consonants can also be intrusive
11. homorganic: intrusions that are similar to surrounding sounds, as in warmph
12. phoneme
13. allophone: similar sounds that are not distinctive

Language

The various dialects spoken by the Germanic tribes are known as **Pre-Old English**. The term *England* developed later from the tribal name *Angles*, possibly because this kingdom was dominant. The term *Anglo-Saxon* referred to the West Germanic tribes generally. Old English was not entirely uniform and four main dialects were predominant: Northumbrian, Mercian, West Saxon, and Kentish. Nearly all of Old English literature is preserved in the West Saxon dialect.

Periods in History of English

Old English: 449-1066

Middle English: 1100-1500

Modern English: 1500 on

Characteristics of Old English

Spelling and Pronunciation:

1. the long vowels have undergone extensive change due to the Great Vowel Shift.
2. different letters.
3. there were no unstressed syllables; primary stress usually occurred on the first syllable.

Appendix B: IPA Symbols

The sounds of English and the International Phonetic Alphabet

This table contains all the sounds (phonemes) used in the English language. For each sound, it gives:

- The symbol in the IPA (International Phonetic Alphabet), as used in phonetic transcriptions in modern dictionaries for English learners – that is, A. C. Gimson's phonemic system with a few additional symbols.

The table represents British and American phonemes with one symbol. One symbol can mean two different phonemes in American and British English. See the footnotes for British-only and American-only symbols.

- Two English **words** which use the sound. The underline shows where the sound is heard.
- The links labeled **Amer** and **Brit** play sound recordings (in mp3 format) where the words are pronounced in American and British English. The British version is given only where it is very different from the American version.

vowels

IPA	words	listen
ʌ	cup, <u>luck</u>	<u>Amer</u>
ɑ:	<u>arm</u> , father	<u>Amer / Brit</u>
æ	cat, <u>black</u>	<u>Amer</u>
e	<u>met</u> , bed	<u>Amer</u> ¹
ə	<u>away</u> , cinema	<u>Amer</u> ²
ɜ:ɹ	<u>turn</u> , learn	<u>Amer / Brit</u> ²
ɪ	hit, <u>sitting</u>	<u>Amer</u>
i:	<u>see</u> , heat	<u>Amer</u>
ɒ	<u>hot</u> , rock	<u>Amer / Brit</u> ³
ɔ:	call, <u>four</u>	<u>Amer / Brit</u> ⁴
ʊ	put, <u>could</u>	<u>Amer</u>
u:	blue, <u>food</u>	<u>Amer</u>
aɪ	five, <u>eye</u>	<u>Amer</u>
au	now, <u>out</u>	<u>Amer</u>
oʊ	go, home	<u>Amer</u> ⁵
eaɹ	where, <u>air</u>	<u>Amer / Brit</u> ⁶
eɪ	say, <u>eight</u>	<u>Amer</u>
ɪəɹ	near, <u>here</u>	<u>Amer / Brit</u> ⁶
ɔɪ	boy, <u>join</u>	<u>Amer</u>
uaɹ	pure, <u>tourist</u>	<u>Amer / Brit</u> ⁶

consonants

IPA	words	listen
b	<u>bad</u> , lab	<u>Amer</u>
d	<u>did</u> , lady	<u>Amer</u>
f	find, <u>if</u>	<u>Amer</u>
g	give, <u>flag</u>	<u>Amer</u>
h	<u>how</u> , hello	<u>Amer</u>
j	<u>yes</u> , yellow	<u>Amer</u>
k	cat, <u>back</u>	<u>Amer</u>
l	leg, <u>little</u>	<u>Amer</u>
m	man, lemon	<u>Amer</u>
n	no, <u>ten</u>	<u>Amer</u>
ŋ	sing, <u>finger</u>	<u>Amer</u>
p	pet, map	<u>Amer</u>
r	red, try	<u>Amer</u>
s	<u>sun</u> , miss	<u>Amer</u>
ʃ	she, <u>crash</u>	<u>Amer</u>
t	tea, <u>getting</u>	<u>Amer</u>
tʃ	<u>check</u> , church	<u>Amer</u>
θ	think, both	<u>Amer</u>
ð	this, mother	<u>Amer</u>
v	voice, <u>five</u>	<u>Amer</u>
w	wet, <u>window</u>	<u>Amer</u>
z	zoo, <u>lazy</u>	<u>Amer</u>
ʒ	pleasure, vision	<u>Amer</u>
dʒ	just, large	<u>Amer</u>

- ¹ The **e** phoneme is sometimes written as **ɛ** (do not confuse with **ɜ:**) in American sources to show that in AmE, the pronunciation falls between **e** and **æ**.
- ² In **a^r** and **ɜ:^r**, the **r** is not pronounced in BrE, unless the sound comes before a vowel (as in *answering, answer it*). In AmE, the **r** is always pronounced, and the sounds are sometimes written as **a^r** and **ɜ:^r**.
- ³ In AmE, **ɑ:** is pronounced instead of **ɒ**. This is so obvious that we don't need to provide separate transcriptions for AmE and BrE.
- ⁴ Many Americans pronounce **ɑ:** (**ɒ**) and **ɜ:** in the same way.
- ⁵ **ou** has been traditionally written as **ɔu** in British sources. Today, **ou** is probably more appropriate for both BrE or AmE.
- ⁶ In **ea^r ia^r uə^r**, the **r** is not pronounced in BrE, unless the sound comes before a vowel (as in *dearest, dear Ann*). In AmE, the **r** is always pronounced, and the sounds are often written as **ea^r (e^r) ia^r ur**.

special symbols

IPA	what it means
'	The apostrophe symbol (') is used to show word stress. Usually, it is placed before the stressed syllable in a word. For example, /'kɒntrækt/ is pronounced like this, and /kən'trækt/ like that. <u>Word stress</u> is explained in our article about phonetic transcription.
r	r is not a sound – it is a short way of saying that an r is pronounced only in American English. For example, if you write that the pronunciation of <i>bar</i> is /bɑ: ^r /, you mean that it is /bɑ: ^r / in American English, and /bɑ:/ in British English. However, in BrE, r will be heard if r is followed by a vowel. For example, <i>far gone</i> is pronounced /'fɑ: 'gɒn/ in BrE, but <i>far out</i> is pronounced /'fɑ: 'raʊt/.
i	i ('medium i') means that you can pronounce i: or i or something in between – a sound that is short like i but sounds like i:. Examples: <i>very</i> /'veri/, <i>create</i> /kri'eɪt/, <i>previous</i> /'pri:vɪəs/, <i>ability</i> /ə'bilɪti/.
əl	əl ('syllabic l') shows that the consonant l is pronounced as a separate syllable (it sounds like vowel). Examples: <i>little</i> /'lɪtəl/, <i>uncle</i> /'ʌŋkəl/. Instead of the əl symbol, some dictionaries use l /'lɪl/ or al /'lɪəl/.
ən	ən ('syllabic n') shows that the consonant n is pronounced as a separate syllable (it sounds like a vowel). Examples: <i>written</i> /'rɪtən/, <i>listen</i> /'lɪsən/. Instead of the ən symbol, some dictionaries use n or an.

Appendix C: Articulation manner

THE INTERNATIONAL PHONETIC ALPHABET (revised to 1993, corrected 1996)

CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

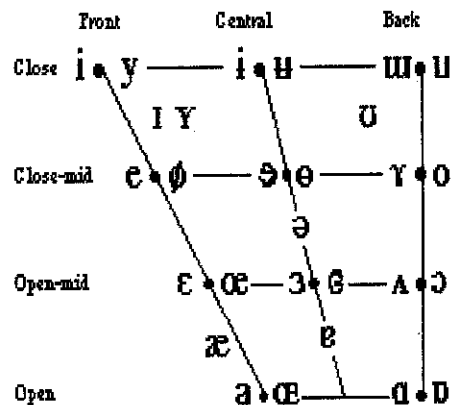
CONSONANTS (NON-PULMONIC)

Clicks	Voiced implosives	Ejectives
ʘ Bilabial	ɓ Bilabial	ʼ Examples
Dental	ɗ Dental/alveolar	ɸʼ Bilabial
! Postalveolar	ɟ Dental	ɾʼ Dental/alveolar
ɰ Dental/alveolar	ɠ Velar	kʼ Velar
Alveolar lateral	ʄ Velar	sʼ Alveolar lateral

OTHER SYMBOLS

ʌ Voiceless bilabial ejective	ɛ́ Alveopalatal ejective
	ɛ̀
ʷ Voiced bilabial approximant	ɹ Alveolar lateral flap
ʋ Voiced bilabial-pharyngeal approximant	ɿ Similar to: ʃ and x
ɦ Voiceless epiglottal fricative	
ʕ Voiced epiglottal fricative	Affricates and double affricates can be represented by two symbols joined by a tie bar if necessary.
ʔ Epiglottal plosive	

VOWELS



Where symbols appear in pairs, the one to the right represents a rounded vowel.

Click on any part of this chart to see the symbols and hear the sounds

Appendix D: Project Timeline

PROJECT TIMELINE

No	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic Topic assigned to students														
2	Preliminary Research/Design Work/ Preparation On Research Introduction Objective List of references/literature Project planning														
3	Research Work Research on Elision and Assimilation														
4	Data Analysis of Research														
5	Submission of Preliminary Report (Initial Proposal)														
6	Project Work List of Reference/Literature Practical/Laboratory Work														
7	Submission of Progress Report														
8	Project work continue Practical/Laboratory Work														
9	Submission of Dissertation Final Draft														
10	Oral Presentation														
11	Submission of Project Dissertation														