
# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## CLASSIFICATION OF NORMAL PEOPLE AND PEOPLE WITH PARKINSON'S DISEASE BASED ON SPEECH SIGNALS USING SIMULATION OF MATLAB

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.

by

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# APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor's Degree in Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

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# ABSTRAK

Parkinson’s disease (PD) adalah disebabkan oleh kematian dopaminergic sel dalam otak manusia. Ia biasanya akan dihadapi oleh orang berumur 50 hingga 60. Kehilangan dopamine sel ini menyebabkan pelbagai jenis kekurangan motor dan bukan motor. Statistik terkini menunjukkan bahawa kejadian orang yang menghidap PD menunjukkan tren yang meningkat di mana lelaki yang mempunyai kemungkinan yang lebih tinggi mengalami penyakit ini berbanding wanita. Walau bagaimanapun, peringkat awal penyakit ini adalah sukar untuk didiagnos apabila gejala sering salah didiagnos dengan symtom kesihatan yang lain. Walaupun penyakit ini adalah sukar untuk mendiagnosis pada peringkat awal, diagnosis awal penyakit ini adalah perlu perubatan paling berkesan pada peringkat awal penyakit. Kemerosotan Ucapan adalah salah satu petunjuk yang paling awal untuk PD. Oleh itu, diagnosis awal penyakit itu boleh dilakukan dengan menggunakan isyarat bersuara. Kriteria untuk mereka bentuk satu sistem yang boleh digunakan untuk mengesan PD adalah pra-pemprosesan melalui pengesanan titik akhir, teknik pengekstrakan ciri, klasifikasi, dan penilaian prestasi. Data ucapan diperoleh daripada rakaman isyarat ucapan 40 subjek (20 pesakit PD dan 20 subjek biasa). Dalam kajian ini, algoritma pengekstrakan ciri yang digunakan adalah Linear Predictive Cepstral Coefficient (LPCC), Mel Frequency Cepstral Coefficient (MFCC), dan Wavelet Packet Transform (WPT). Ketika diklasifikasi, dua jenis teknik digunakan iaitu Support Vector Machinw (SVM) dan Probabilistic Neyral Network (PNN). Analisis ini menunjukkan bahawa SVM mengelas dengan baik untuk LPCC manakala PNN mengelas dengan baik dalam MFCC dan WPT.

# ABSTRACT

Parkinson's disease (PD) is due to the death of dopaminergic neuron in the human brain. It will normally affect the people around the age of 50 to 60. Progressive loss of these dopamine neuron causing a various kind of motor and non-motor deficits. The latest statistic shows that the incident that people are suffering from PD is showing an increasing trend where men are having the higher possibility of suffering from the disease compared to women. However, early stages of the disease are difficult to diagnose when symptoms are often misdiagnosed with other medical conditions. Though the disease is hard to diagnose in its early stages, early diagnosis of the disease is necessary since medications are most effective at an early stage of the disease. Speech impairment is one of the earliest indicators for PD; therefore early diagnosis of the disease can be performed by using the speech signals. The criteria for designing a system that can be used to detect PD are pre-processing through end-point detection, feature extraction techniques, speech classifiers, database, and performance evaluation. The speech data acquired from the recording of speech signals of 40 subjects (20 PD patients and 20 normal subjects). In this project, feature extraction algorithms used are Linear Predictive Cepstral Coefficient (LPCC), Mel Frequency Cepstral Coefficient (MFCC), and Wavelet Packet Transform (WPT). While in classification, two types of classifiers are used which are Support Vector Machine (SVM) and Probabilistic Neural Network (PNN). The analysis shows that SVM classifier performs well in LPCC features while PNN classifiers perform well in MFCC and WPT features.

# DEDICATION

To my beloved parents

Woon Kim Kuang and Low Lam Bee

for raising me become who I am today.

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# LIST OF ABREVIATIONS, SYMBOLS AND NOMENCLATURE

| | | |
|---|---|---|
| MFCC | - | Mel Frequency Cepstral Coefficient |
| LPCC | - | Linear Prediction Cepstral Coefficient |
| LPC | - | Linear Predictive Coefficient |
| WLPCC | - | Weighted Linear Predictive Cepstral Coefficient |
| WPT | - | Wavelet Packet Transform |
| SVM | - | Support Vector Machine |
| PNN | - | Probabilistic Neural Network |
| $\alpha$ | - | Alpha |
| $\beta$ | - | Beta |
| % | - | Percentage |
| $D(x, y)$ | - | Euclidean distance |
| $u_{ij}$ | - | Membership in the *ith* class of the *jth* vector |
| $u_i(x)$ | - | Membership of vector x |
| $P_1$ | - | Probabilities of class 1 |
| $P_2$ | - | Probabilities of class 2 |
| $S_w$ | - | Within-class scatters measures |
| $S_b$ | - | Between-class scatters measures |

# CHAPTER 1
# INTRODUCTION

## 1.0 Introduction

Speech is a complex task which requires the parallel and sequential control of multiple mechanisms and systems in a highly specific and refined manner. Lungs are the primary source of the speech production where the voice produced through the glottis, modulated by the vocal-fold vibration and filtered by the vocal-tract resonances. The vibration of the vocal folds generates a source excitation signal holding the properties of pressure wave expelled from the lungs. The source signal is then passes through the vocal tract to be filtered by the spectral envelope to form a speech signal (T. Khan, *et al*, 2014).

Neurological diseases (ND) are affecting larger segments of aging population every year. It is expected that a large percentage of elders will suffer from ND in their last years, while the treatment for ND is dependent on expensive accurate and frequent monitoring. Many of these ND's affect voice and speech even at early stage (Gómez-Vilda *et al.*, 2013). One of the neurological diseases is Parkinson's disease (PD). Most of the people around the age of 45 to 60 will have a higher possibility of getting PD or suffering from PD (Tsanas *et al.*, 2010).The major cause of PD is due to death of dopaminergic neuron in the brain region (Shirvan and Tahami, 2011). Statistic shows that around one million people in North America affected by this PD apart from the thousands of undetected cases. As the world wide population getting older, number of people suffering from this disease is expected to increase (Eskidere, Ertaş and Hanilçi, 2012). This progressive dopamine neuron loss causing a various kinds of motor and non-motor deficits such as behaviors, moods, thinking, rest tremor, sensation, postural abnormalities and hypokinetic dysarthria which is speech impairment (Goberman, Blomgren and Metzger, 2010; Uma Rani and Holi, 2012)

According to the latest statistic shows that the incidents that people are suffering from PD is showing an increasing trend where men are having higher chances of suffering from this disease compared to women (Poirier, 1972). The method used by medical specialist for detecting Parkinson's disease symptom progression is called Unified Parkinson's Disease Rating Scale (UPDRS). This method is time ineffective and non-autonomous way to detect the disease. UPDRS is used to evaluate the behavioral and motor symptoms of Parkinson's disease (Kupryjanow and Kunka, 2010). It is an assessment form that including several components and each components consists of several sections to be evaluated on the PD patients. The first component of the assessment form is mentation, behavior and mood comprises of 4 sections, the second component is activities of the daily living comprises 13 sections, while the third component is regarding the motor function of the patient comprises 27 sections (Tsanas *et al.*, 2010). The speech examination is item 18 in UPDRS part III and is abbreviated as UPDRS-S. The UPDRS-S is ranged from 0 to 4, where '0' represents normal speech, '1' represents mildly impaired speech, '2' represents moderately impaired speech, '3' represents severely impaired speech and '4' represents intelligible speech (Khan *et al*, 2014). The assessment of PD symptoms using UPDRS is very time-consuming as the medical doctors or specialist need to evaluate their patients on so many aspects.

Laboratory or blood testing does not show a very compromising result for detecting or diagnosing the Parkinson's disease, and the prospect depends on the patient's age and symptoms. It is also based on the patient's medical history and neurological examination conducted by interviewing and observing the patient along with various signals such as EEG signals and images using MRI and CT scan. But these method are not so effective in diagnosing PD (Islam, Parvez and Deng, 2014).

There is a must of follow up treatments over time as PD is a progressive disease. Medicine dosing need to be adjusted frequently with respect to the patient's mood, food intake, and physical exercise. However, only a small percentage of the patients receive timely treatment. This may due to the reason that the individuals may facing some physical limitations which make them difficult to come for the treatment or they have the difficulty in easy access to the therapist for treatment (Khan, no date). Early stages of the disease are difficult to diagnose when symptoms are often misdiagnosed with other medical conditions (Poirier, 1972). There is no unique way of diagnosis of

the disease among the physicians and their diagnosis are mostly based on trial and error which is highly not desirable (Poirier, 1972). Through the disease is hard to diagnose in its early stages, early diagnosis of the disease is necessary since medication are most effective way at an early stage of the disease.

Speech impairment is one of the earliest indicators for Parkinson's disease, and most of the patients claimed that speech impairment caused by the disease bring a lot of inconvenience into their daily lives (Tsanas *et al.*, 2010). Present of this condition, early diagnosis of the disease may be successfully performed via acoustic voice analysis on the patients (Shirvan and Tahami, 2011). Speech is particularly suitable in detecting Parkinson's disease as it is simple to administer where patients can self-record their voice sample without supervision and expensive equipment (Khan *et al*, 2014). With this, the acoustic measurement can reduce the physical visits of the patients to the clinic, the whole measurement is done by using algorithm which can be installed in a personal computer. The results of the analysis can send to the patients' respective doctor via internet. It can save the energy and cost of the patients to be physically present to the clinics. Besides, acoustic measurement is also a non-invasive, signal features can be easily identified, digitally storable, easy recording using modern advanced technology, and cost-effective further encouraged in wider usage in medical field (Kupryjanow and Kunka, 2010; Shirvan and Tahami, 2011).

The speech impairment developed among the PD patients is due to the effect of the disease to all of the components involved in speech production such as laryngeal function, breathing, articulator movement, as well as their coordination of smooth and fluent speech (Asgari and Shafran, 2010). Typical symptoms of the impairment are the patient cannot pronounce words properly, decreased voice tone, dysphonia which is the failure to produce normal vocal sounds and dysarthria which is failure to articulate speech normally. Since the speech signals produced by PD patients are very different from the normal healthy people, it is encouraged more in-depth researches in detecting the early stages via speech signals.

## 1.1 Problem Statement

Parkinson's disease is a kind of disease that caused by death of dopamine-containing cells in human brain and it is highly affecting the normal life of the human with this disease. The standard reference clinical score, Unified Parkinson's disease Rating Scale (UPDRS) is the one of the effective method in determining the presence of PD symptoms in patients. However, UPDRS requires the patient's frequent visit to the clinic which will cause burden to the patients and their family. Thus, utilization of UPDRS in PD symptoms is inconvenience for the patients and medical doctors as well. In addition, there is a possibility that the medical doctors will misdiagnose the PD symptoms with other normal aging effects. Misdiagnosis of PD symptoms bring critical effects to the patients.

In previous studies, the speech impairment is one of the earliest symptoms or indicators for PD and majority of the PD patients also claimed that their impairment in speech had brought various kinds of the disadvantages in their daily lives. Logically, by analyzing the speech signal produced by PD patients may give useful information in classifying them from normal healthy people. Moreover, speech signal analysis is a non-invasive test which is the main advantage for introducing this method.

In order to solve the above problems, the ultimate goal for this research is to come out an algorithm that can help the inconvenience of the patients for frequent visits to clinics, ease the works of the medical doctors in doing UPDRS assessment and also to acquire precise and reliable data or results that accurately classify the PD patients from normal healthy people.

## 1.2 Objective

- To acquire Parkinson's disease subjects word database.
- To apply pre-processing algorithm (segmentation technique) on the audio signals.
- To apply the Mel-Frequency Cepstral Coefficient (MFCC), Linear Prediction Cepstral based method and Wavelet Packet Transform (WPT) as the feature extraction algorithm.

- To classify the extracted features by applying Support Vector Machine (SVM) and Probabilistic Neural Network (PNN).

## 1.3 Scopes

Overall, the process is divided into 5 stages which are data collection from 40 subjects (20 patients and 20 healthy people), pre-processing data using End-point detection technique, speech features extraction using Mel Frequency Cepstral Coefficient (MFCC), Linear Predictive Cepstral based method and Wavelet Packet Transform (WPT), speech classification using Support Vector Machine (SVM) and Probabilistic Neural Network (PNN), and performance evaluation using ANOVA.

# CHAPTER 2

# LITERATURE REVIEW

## 2.0 Introduction

This chapter reviews some of the various significant work that had been done by other author and relevant to this project. Literature that was investigated included various voice data acquisition methods, features extraction methods, classification methods and the accuracies achieved by the authors in their projects. Methods and results in previous papers were compared in order to produce good methodologies for the completion of this project.

## 2.1 Background

Parkinson's disease (PD) is a type of neurological disorder which is caused by the loss of dopamine neurons in human brain (Natili, 2013). Speech dysfunction caused by this disease is called hypokinetic dysarthria (HKD). Hypokinetic means reduced movement while "Dysarthria" means that a speech disorder due to a change in muscle used for speech production (Khan, no date). The symptoms are typically include breathiness, reduced loudness, decreased energy in the higher parts of the harmonic spectrum, roughness and exaggerated vocal tremor (Little *et al.*, 2009).

There are many vocal tests that can be used to access the severity of these symptoms in a patient. These include sustained vowel phonations and running speech tests. In sustained vowel phonations, the patient is required to pronounce a single vowel ad the pitch of the phonation is hold as constant as possible, for as long as possible. However in running speech tests, the patient is required to speak a standard sentences which is constructed to contain a representative sample of linguistic units

(Little *et al.*, 2009). There were many published research papers in these field implementing speech signals. Endpoint detection, various features extraction methods and classification method that applied on Parkinson's disease detection by other authors in their projects was presented.

All these reviews will focus on these themes which emerge repeatedly for the achievements for Parkinson's disease detection using speech signals. This literature presents these themes in various contexts and all the themes will be focused on and explain in details.

## 2.2 Parkinson's Disease Detection through Speech Signals

In recent years, various developments had been done in PD detection using speech signals. This field study has drawn attention in the medical area in detecting Parkinson's disease. Different methods had been used in the process of signal processing to acquire high accuracy in detecting the PD patients form healthy people.

### 2.2.1 End point Detection

After data collection step is completed, endpoint detection is the key processing step to segment the audio signals. The purpose of endpoint detection is to distinguish between the speech and non-speech segments in a total speech signal.

It is important to process the signal in utterances consisting of speech, silence, and other background noise in speech and speaker recognition (Li *et al.*, 2002). The end point detection is used to detect the presence of the speech in various types of non-speech events and background noise (Li *et al.*, 2002). Different algorithms are needed to meet the specific requirements for different applications in terms of complexity, computational accuracy, response time, sensitivity, robustness, etc. (Li *et al.*, 2002). A system performance in terms of speed and accuracy are often affected by the end point detection in both automatic speech and speaker recognition.

### 2.2.2 Feature Extraction

After the beginning and ending of the speech signals is detected by using endpoint detection algorithms in the key preprocessing steps, the significant features which are highly representing the speech signals are extracted from the speech signal which it can be used to detect the PD characteristic in speech signals. The extraction of acoustic features has been well determined under several common methods. The methods have been used for audio feature extraction included quantitative measurement techniques (Poirier, 1972; Bocklet *et al.*, 2011; Shirvan and Tahami, 2011; Uma Rani and Holi, 2012; Chen *et al.*, 2013; Shahbakhti, Taherifar and Zareei, 2013; Shahbakhi, Far and Tahami, 2014), Mel-Frequency Cepstrum Coefficient (MFCC) (Khan, *et al*, 2014; Bocklet *et al.*, 2011; Tsanas *et al.*, 2012). and Linear Predictive Cepstrum Coefficient (LPCC) (Bocklet *et al.*, 2011). The highest accuracy that has been obtained by using quantitative measurement technique is 98.2% (Shirvan and Tahami, 2011), MFCC is 98.6% (Tsanas *et al.*, 2012) and 90.5% (Bocklet *et al.*, 2011) by using combination of MFCC and LPCC.

### 2.2.3 Classification

The final stage of Parkinson's disease detection is the implementation of classification algorithms to detect the Parkinson's disease. After feature extraction is done on the acoustic signal, a classifier is required to classify the speech signal as speech sample from PD patients or healthy people. Various classifiers such as Support Vector Machine (SVM) (Khan, *et al*, 2014; Poirier, 1972; Bocklet *et al.*, 2011; Tsanas *et al.*, 2012; Shahbakhti, Taherifar and Zareei, 2013; Shahbakhi, Far and Tahami, 2014) , K-Nearest Neighbor (Poirier, 1972; Bocklet *et al.*, 2011; Shirvan and Tahami, 2011), discrimination-function-based (DFB) classifier (Poirier, 1972), Multilayer Perception (MLP) (Uma Rani and Holi, 2012), Radial Basic Function Neural Network (RBF), Random Forest (RF) (Tsanas *et al.*, 2012), Principle Component Analysis (PCA) (Shahbakhti, Taherifar and Zareei, 2013), Fuzzy K-Nearest Neighbor

(fKNN) (Chen *et al.*, 2013), Naïve Bayesian Classifier , are used in classify the speech signals.

The best being used methods for audio classification are Support Vector Machine (SVM) (Khan, *et al*, 2014; Poirier, 1972; Bocklet *et al.*, 2011; Tsanas *et al.*, 2012; Shahbakhti, Taherifar and Zareei, 2013; Shahbakhi, Far and Tahami, 2014), K-Nearest Neighbor (KNN) (Poirier, 1972; Shirvan and Tahami, 2011; Penyelidikan, Inovasi and Ii, 2014)and Fuzzy K-Nearest Neighbor (fKNN) (Chen *et al.*, 2013). The highest accuracy that had been obtained by using SVM is 98.6% (Tsanas *et al.*, 2012), 98.2% (Shirvan and Tahami, 2011) by using 9 significant features for KNN and 96.07% (Chen *et al.*, 2013) by using fKNN classifier.

Research on the classification of people with Parkinson's disease form healthy people based on the voice samples using Support Vector Machine (SVM) (Bocklet *et al.*, 2011).