# Parkinson's Disease Tremor Characteristic Identification: An Experimental Study

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Abstract—Parkinson's Disease is one of the neurologic disease which affects a person body movements and the condition tend to gradually worsen with time. The person experiencing this type of disease usually suffers from three main symptoms which are rigidity, bradykinesia and tremor. The reason for these three symptoms is said to be due to the degeneration of dopaminergic neuron which produce a chemical to assist signal transfer inside the brain especially for the part that control body movement. The degeneration in turn disrupts the ability of the brain to control body movement. This paper intends to identify the characteristics of tremor produced by Parkinson's Disease patients. A triaxes accelerometer was used in this study to record the tremor signal generated from the patient's hand and leg. The experiment was conducted on the body parts based on two activation condition of tremor which is resting condition and postural condition. The analysis done on the data collected showed that the tremor recorded had a mean peak frequency of about 5.89Hz, and this corresponds with the frequency range stated in the previous publication. Furthermore, based on the frequency plots of the tremor signals, it shows that for postural condition it is possible to measure the tremor from only one axis as the all three axes shows similar dominant frequency.

Index Terms-tremor, Parkinson's disease, accelerometer

## I. INTRODUCTION

Tremor is a type of hyperkinetic movement disorder which is responsible in the presence of involuntary movement at the patient body part and tremor appeared to be the most common one of all [1]. Descriptively, tremor is characterized as movement of body parts in involuntary, oscillatory and rhythmic manner caused by alternating contraction of muscles [2], [3]. Tremor can be diagnosed based on the activation condition that causes the tremor to occur in the affected body part or region; in most cases, it affects the patients' hands and fingers [1]. Tremor activation conditions could be divided into two main conditions, which are resting condition and action condition. Rest tremor is the symptom in which the person will experience tremor under the condition whereby the affected body part is fully supported against gravity, such as placing the arm on top of a table [4]. Generally, action condition is the condition where the tremor was activated during contraction of muscle for the

affected body part and it could be further classified into five more conditions ranging from postural condition, kinetic condition, intention condition, task-specific condition and isometric condition. Postural condition is the condition where the muscle contracted in order to maintain the position of the body part against the gravity and the example of this condition is situation when we are trying to the position of our hand while extending it forward. Kinetic condition on the other hand is the condition where the tremor is presence only while the body part is undergoing voluntary movement. Intention condition is almost similar to kinetic condition, where the tremor occurred as the body part is undergoing voluntary movement but the separation point is that the tremor tend to intensify as the body part is reaching the movement goal such when trying to touch the tip of our nose. As for task-specific condition, as the name suggest, the tremor occurred only during certain task which required a level of concentration and skill; such as writing. While for isometric condition, it is the condition where the body part is under condition where the muscle required to contract against rigid object such as pressing your hand against a wall or table. Furthermore, the types of tremor condition applied to tremor patients depend on the tremor actiology exhibit by the patient and Parkinson's Disease (PD) is one of them. The diagnosis on which aetiology is affecting the patient can be further explained by examining the tremor attribute; the presence of other factors, which could affect the tremor, and the presence of other neurologic symptoms.

Among various types of parkinsonism, Parkinson's Disease is the one which is mostly encountered, leading to the numerous studies done to further understand the cause and come out with possible treatment [5]. PD is said to a sporadic type of disease as it affected people randomly and most are not related with environment or the genetic. In other words, it means most of the PD patient does not have familial history of other family members experiencing same type of disease. Most PD patients experience three common symptoms; rest tremor, bradykinesia and rigidity. The rest tremor experienced by PD patients occurs at a frequency of 4-6 Hz with medium amplitude, and the rest tremor will vanish as the patients execute voluntary movement [1], [6]. However, about 60% of the PD patients also suffer from postural tremor [3].

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As for bradykinesia, it is the symptom in which the patient experiences slowness in their movements, especially in repeating or alternating manoeuvres [7], [8]. Rigidity is the symptom in which any passive movement applied to a body part will be countered by some resistance, and usually identified by moving the patient's limb. The examiner will experience some increase in resistance during the movement [5], [9]. Tremor in (PD) Parkinson's Disease originates from the degeneration of an area in the brain; specifically the degeneration of excitatory and inhibitory of dopaminergic neurons in the substantia nigra pars compacta which leads to the reduction of movement controlling chemicals, and as the result, PD will gradually become worse over time [6], [10]. Fig. 1 shows the comparison in between the condition of the substantia nigra of healthy person and person with PD.



Figure 1. The substantia Nigra region of healthy person and PD patient [11].

# II. METHODOLOGY

The respondent selected for this analysis is a 42 yearold male and was diagnosed with Parkinson's Disease. Body parts of the respondent, which are affected the most from the tremor, are the respondent's left hand and leg, which is also the respondent's dominant side. Therefore, the measurement of the tremor will be made on the respondent's left hand and leg.

The sensor used to acquire the hand movement due to tremor is three axes accelerometer, ADXL330. This model of accelerometer required a supply voltage ranging from 1.8V to 3.6V and supply current at about 320 µA. As for this study, an Arduino Uno board was used as the mean of power supply for the accelerometer as the board capable of supplying 3.3V and due to its small size feature allow it to be easily carried along for this data collection process instead of dragging along a humongous power supply unit. The information obtained from the three different axes measured by the accelerometer help to identify the direction with respect to the body parts that are affected by the tremor. The accelerometer is hooked up to a Data Acquisition (DAQ) module, which acts as the medium to collect data from the accelerometer. The data is then transferred to the computer for further handling. The model of DAQ module used for this study is an USB-4716 Portable Data Acquisition Module produced by Advantech. As the name suggest, this DAQ module used USB 2.0 as the medium for it to communicate with a computer and as the source of power. This DAQ module also comes with 16 analog input channels, 8 digital input channels, 8 digital output channels. 2 analog output channel and it also had the capability of sampling data at the rates 200k samples per second. Furthermore, the DAO module also comes with a size of 132mm x 80mm x 32mm which is guite small. The data for this study are sampled by the DAQ module with a sample rate of 1kHz to minimize the effect of aliasing. The data transferred from the DAQ module is recorded by the computer through Advantech DAQ Data Logger software. The experimental setup of the instruments is as shown in Fig. 2.



Figure 2. Setup of the measurement tools

The data is collected from two different conditions and two different body parts. The tremor activation conditions measured are the postural condition, in which the muscle are required to contract continuously in order to maintain the measured body part in position that is opposing the gravity; and resting condition, where the body part is fully supported against the gravity and the muscle is in relaxed condition. The body parts involved are the respondent's left hand and left leg. Measurement done on the hand is performed while the hand is extended forward, away from the body as in Fig. 3a, and then the hand was placed on top of a table for the second measurement as in Fig. 3b. During the measurement of the patient's hand tremor, the accelerometer was attached to distal part of the hand, since it is parallel with the ground and farthest away from the shoulder. This is done to ensure that the tremor can be successfully measured, as this part is greatly affected by tremor. As for the leg, the measurement is done as the respondent assumes sitting and standing position as in Fig. 4. For the measurement of the leg tremor, the accelerometer is placed at the lower leg on top of the tibia bone, as this position is about midway between the hip and the feet. Furthermore, the accelerometer is placed in a location where it would almost be in the same orientation either when the respondent is sitting or standing. The condition or posture for the tremor measurement represents the activation

condition of tremor, which are resting and postural. The data for each measuring condition is measured repeatedly three times with each set having a measuring duration of 15 seconds. For each of the body parts, the data was collected alternately in between the two activation conditions; postural and resting condition. Before the resting condition data was collected, the patient was required to stay in the resting condition for about 45 seconds before the data in resting condition was recorded. This is done in such way to prevent patient for experiencing muscle fatigue from maintaining postural condition by allowing the muscle to relax.



Figure 3. a) Measurement of hand tremor in postural condition b) measurement of hand tremor in resting condition



Figure 4. a) Measurement of leg tremor in sitting position b) measurement of leg tremor in standing position

# III. RESULTS & DISCUSSION

The data obtained from the measurement of the tremor is filtered with a Butterworth low-pass filter in order to eliminate some of the noises which are mixed together with data. The filter is set with the cutoff frequency of 25Hz to filter out noises in the data which are larger than the expected tremor frequency produce by humans, as the frequency of human tremor is less than 16Hz [12]. This filtering process was conducted by using the tools available inside MatLab software through a program constructed. The program constructed using MatLab will load the tremor data which was recorded by the data logger in form comma-separated values (CSV) file. Fig. 5 showed a sample of the filtered tremor data collected from the accelerometer for the patient hand and leg in postural condition. With the data in time domain form, it is still not sufficient to provide us on the overview regarding the characteristic of the patient's tremor. This is because that most of the tremor characteristics are describe in the form of its activation conditions, affected body parts and frequency.



Figure 5. Plot of filtered data for a sample of respondent a) hand tremor in postural condition and b) leg tremor in postural condition.



Figure 6. Plot of frequency response for a sample of respondent hand tremor signal. a) Postural condition b) rest condition

Therefore, in order for the data to make any sense in identifying the characteristic of the patient's tremor, the filtered data, which is in time domain, is transformed to frequency domain with Fast Fourier Transform. Converting the data into frequency domain can provide a hint regarding the dominant frequency at which the tremor occurs. The frequency at which the tremor occurs is identified based on which frequency band has the highest amount of power. The tool used to perform this task of converting the filtered time domain data into frequency domain is a tool available in MatLab which are capable of performing Fast Fourier Transform. The data transformation process was conducted through the same program which performs the filtering process earlier. Fig. 6 shows the plot of frequency response for the hand tremor and Fig. 7 shows the plot of frequency response for the leg tremor.



Figure 7. Plot of frequency response for a sample of respondent leg tremor signal. a) Postural condition b) rest condition.

The mean dominant frequency for the three sample sets of hand tremor in postural condition is about 5.89Hz, while for the leg tremor in standing posture is about 4.51Hz. The frequency plots also indicate that for the hand tremor in postural condition, most of the tremors occur in an up and down motion. As for the leg tremor, most of the tremors occur in left and right motion. Furthermore, the data also shows that the tremor affects the body parts in all axes at the same frequency for the postural condition.

## IV. CONCLUSION

The results obtained from this study confirm the characteristic of Parkinson's Disease, which has a tremor frequency between 4 to 6 Hz. The data shows that the respondent also has tremor in postural condition, even though most Parkinson's Disease patients are synonym with tremor occurring in rest condition. It is also concluded that the experimental setup used for this study

could be used to record the behavior of tremor in other future studies. Moreover, the data collected both body parts; leg and hand showed that under postural condition, it is possible to measure the tremor only from one axis. This is because that under the postural condition, all three axes are showing the same mode of dominant frequency. Using this experimental setup as the base for the tremor recording, future research can be conducted to develop a system to diagnose tremor patients. Even though the results for this study agreed with the previous literature, further experimental study on the characteristic of tremor should be conducted on other PD patients to further clarify the characteristic exhibit by the tremor.

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