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Tremor Quantification and its Measurements Using Shimmer

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Abstract. This study aimed to provide a quantitative assessment of parkinsonian tremor through the precise measurement of tremor among Parkinson patients while taking into consideration specific parameters including acceleration, velocity, and displacement. The parameters were obtained by using transducers. For this assessment, three-axis accelerometer and three axis gyroscopic transducers embed in one device called shimmer. In this present paper, sensitivity assessment was used to measure the severity of hand tremors in two positions; resting and postural. Besides, the researchers obtained rotational movement along with tremors' acceleration movements. The amplitude and frequency was taken from Parkinson patients' hand. Shimmer sensor showed excellent correspondence of amplitude and frequency measurement with rotational transducer. The frequency of the patient's hand tremor occurred between 1.594 Hz and 4.813 Hz. However, the accelerometer showed poorer correspondence compared to gyroscope measurement. At the end, gyroscope responses are more remarkable because of the low level of muscle activity required in the task for precise tremor measurements to appear in high sensitivity to this impairment tremor.

1. Introduction

Parkinson's disease (PD) is the second common neurodegenerative disease after Alzheimer's. One of the most visible signs of this disease is tremor. Other diseases have similar oscillation movements, but each disease has a different recognition and specification. Parkinson's patients face challenges in terms of managing active life due to the oscillation movement of the hand or any body part affected by PD. Significantly, the involuntary movement brings about frustration and depression among patients [1-2]. Patients should undergo medical diagnosis as soon as they develop early signs of Parkinson's disease to monitor the disease progression and find optimal treatment regimens.

Medical scientists and drug developers are searching for alternative ways to minimize the cost and efforts for tremor validation. In return, patients wish to increase their life quality at the same time reduce clinic visits. Surgeries may involve some risks, and patients have different responses to treatment. For this reason, alternative solutions caught researchers' interest to suppress the tremor with the least adverse effects.

Measuring tremor assists researchers to save their time and efforts during conducting experiments and use collected data as a reference. [3]. Parkinson's disease is recorded from all limb segments under resting, postural or movement conditions [4]. Kinetic tremor happens when a voluntary contraction of a muscle follows a specific action like holding a cup [5]. Rest tremor occurs when the body part is wholly



sported against the gravity just like a sported hand on a table [6] while postural tremor occurs when the body part maintains its position against gravity like extending the arms in front of the body [7].

Numerous studies have been conducted to obtain the most important parameters in tremor assessment including acceleration, velocity and displacement [8-9]. Researchers agree that it is possible to obtain those parameters by using differentiation for the velocity then finding displacement [9]. Realistically, the velocity and displacement can be found by using transducers to eliminate the noise amplification resulted from differentiated signal [10-11]. For displacement signal, it can be obtained by the double integration of the acceleration signal. However, the result is not satisfying because of the amplified noise produced by the first and second level of integration process [12]. Besides, whenever an integration part is needed, filter application with time and efforts is required to tune the filter's parameter for getting realistic output.

Generally, there are three approaches for measuring the hand tremor; acceleration transducer, velocity transducer and displacement transducer. Digital technology, such as cameras, graphical tablets and laser, is essential for the displacement sensor to present the coordinates for hand motion [13-15]. However, using the accelerometer for hand tremor measurement is more convenient for its lightweight and low cost [16].

Combining medicine and engineering fields promises great invention in technologies and enhances patient's comfort. This study demonstrated how acceleration and angular velocity, using Shimmer, could record arm tremor. The tremor behaviour was displayed in the time and frequency domain. Identified tremor parameters, in terms of amplitude and frequency, were essential in developing the test rig that can emulate human hand tremor.

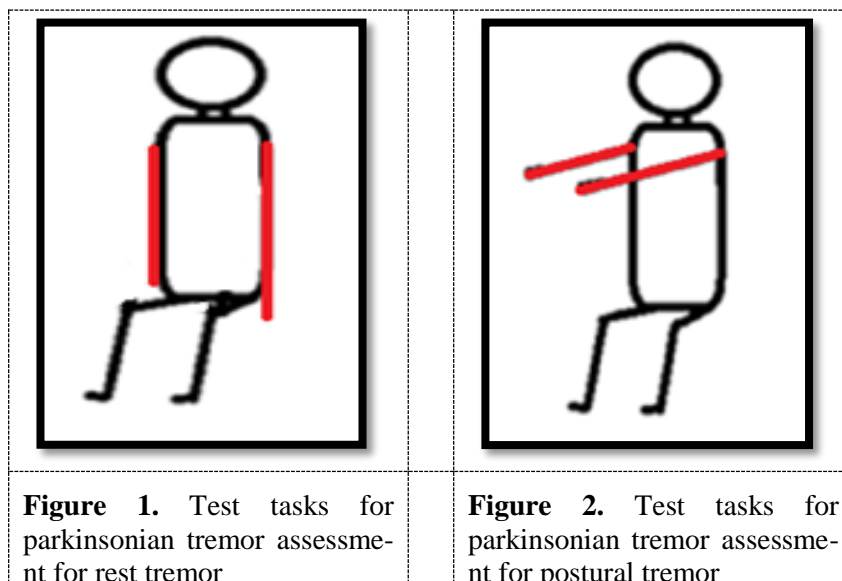
2. Experiment Method

For this raw data assessment there are few steps needed to be followed which are listed as:

2.1. Subjects and experimental protocol

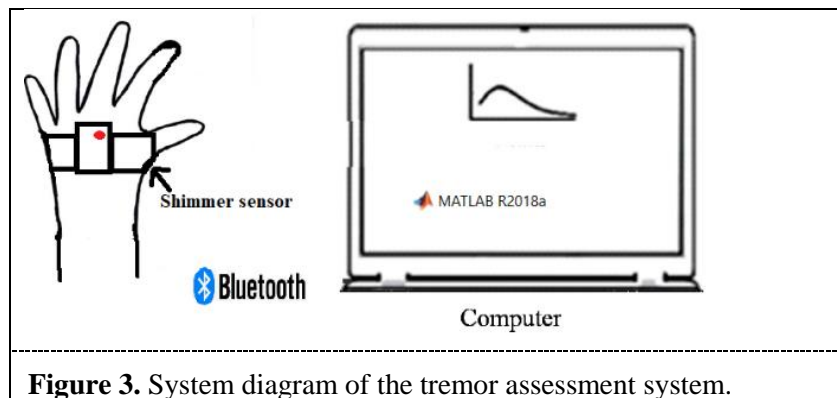
2.1.1 Test Tasks and Relevant Parameters

The present study collected data from a sample of ten human subjects; male and female. They ranged between 58 to 66 years old (mean age 26 years). All the subjects were physically active without any impairments whether in moving, hearing or seeing. They consumed their medication about four hours before the experiment. Written questionnaire form was collected from each patient to keep their personal record, followed by the collection of essential tremor record within one session for two trials including two tasks; one for the resting tremor while the other for the postural tremor as shown in Figure 1 and 2. Each task lasted for 10 seconds.



2.1.2 System Concept

Data was collected by applying ConsensysPRO Software, which worked alongside Shimmer sensors via Bluetooth and provided accelerometer data in unit of meters per Second Square and gyroscope data in unit of a degree per second. Transferred data from Shimmer to computer can be through two ways: by wires and wireless communication, while this data was recorded in real time. The sampling rate was 512 Hz [17]. To validate the tremor oscillation data in terms of the frequency domain, the acceleration versus time graph was converted to the frequency graph using MATLAB software. As shown in Figure 3, the system consisted of two parts; Shimmer part (left) and computer part (right). The lightweight Shimmer sensor is placed on the top of the hand for tremor assessment [14] [17]. The command module sent the sensor data to the computer via the wireless transmission of Bluetooth.



2.1.3 Procedure for Postural Tremor

Before measurement assessment, Shimmer needed to be calibrated. Calibration was done earlier in the lab by using calibrator then using calibration procedure on each patient to determine the sensor-to-segment coordinate systems. Patients were comfortably seated on a chair and asked to hold their hands at 90 degrees perpendicular to their body as shown in Figure 4. Then Shimmer sensor was placed on the hand to calibrate it and start recording the data.



Figure 4. Data collection from a PD patient

2.2 Data Collection and Analysis

Quantification of tremor oscillation severity is essential. It has been always done by using time-domain analysis, time-frequency analysis, spectral analysis, nonlinear analysis or spectral analysis [17-20]. After

that, the signal goes through some processes with PSD (auto power spectrum) calculation to detect tremor within time interval (10 seconds). However, gyroscope in Shimmer sensor measures the angular velocity for tremor that can be integrated over time for once to get displacement while for acceleration is required for double integration. Data collected was used for tremor quantification. The accelerometer and gyroscope outputs for three axis in addition to the gravitational acceleration, which is equal to 9.81 m/s² in vector product and linear acceleration. Using the calibration removed gravitational acceleration from Shimmer accelerometer output signal. The range of Parkinson tremor was 3.5-9 Hz which was it based on the dominant frequency of the tremor.

2.3 Parkinsonian Tremor Assessment Methods

MATLAB software was used for data processing and analysis, providing displacement along the three axes X, Y, and Z, respectively. While, rotational data for angular movement for the hand was also inserted for gyroscopic movement directions were obtained for each marker. This assessment data presented in acceleration, velocity and displacement chart either in time domain series or in Fast-Fourier transformation (FFT) analysis [8-9], where raw data captured by Shimmer to analysis it using MATLAB.

3. Experiment Method

Tremor recording system consisted of lightweight Shimmer device, which was placed on the top of the patient's hand, and it had acceleration sensor and gyroscope sensor. Both sensors were used to record the six axis data while the gyroscope recorded the rotational movement. The current study focused on the resting and postural tremor along with Z axis for ten PD patients with different rhythmic movements and amplitude ranged within 10 seconds. Firstly, data was collected from PD patients while they were holding their hands in rest position. Secondly, the PD patients held their hands at 90 degree upright the body. The sensitivity of Shimmer sensor was 5.5389 Hz as calculated from the graph in figure 5. The researchers discussed the data related to the postural tremor only.

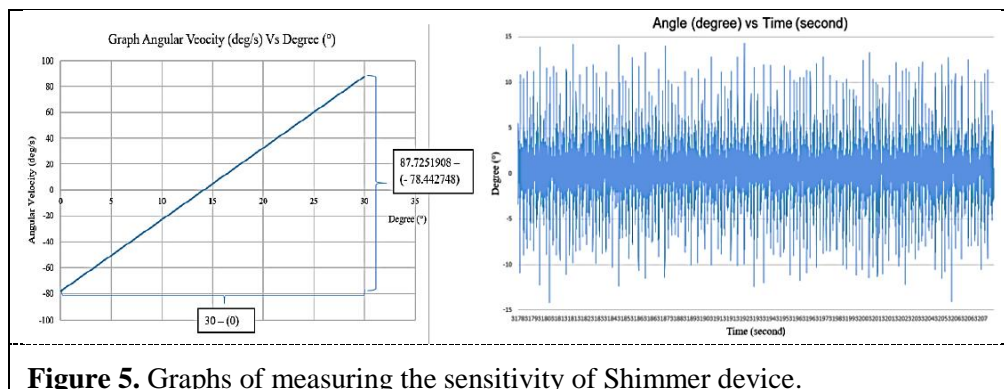


Figure 5. Graphs of measuring the sensitivity of Shimmer device.

Based on the graph, the sensitivity was calculated by,

X-values = 0 degree to 30 degree

Y-values = -78.442 degree to 87.725

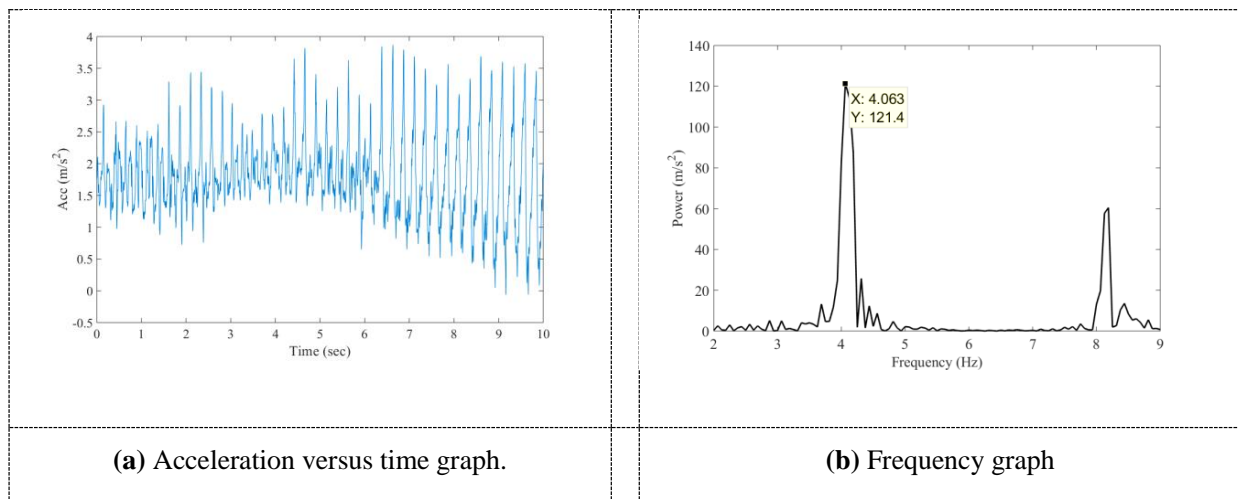
By applying these values into the equation, we got:

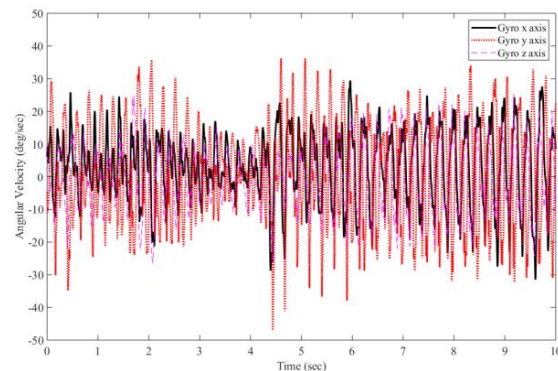
$$\frac{87.725 - (-78.442)deg/sec}{30 - (0)deg} = 5.538 \text{ Hz}$$

Table 1. Results of Parkinson hand tremor

Patient	Time Domain		Frequency Domain
	Acceleration (m/s ²)	Angular Velocity (deg/s)	Acceleration (Hz)
1	-0.81 to 0.82	-7.5 to 11.1	2.031
2	-2.65 to 2.51	-64.8 to 44.2	4.813
3	-1.49 to 1.49	-28.0 to 46.1	2.125
4	-1.96 to 1.95	-48 to 36	4.063
5	-0.84 to 0.86	-33.9 to 61.9	3.188
6	-0.59 to 0.59	-8.8 to 8.8	1.844
7	-1.52 to 1.52	-74.5 to 105.3	4.813
8	-1.49 to 1.50	-19.9 to 20.1	1.75
9	-1.35 to 1.32	-15.1 to 26.1	4.188
10	-1.30 to 1.32	-10.8 to 10.8	1.594

Table 1 above presents the summary results of postural tremor for the ten patients in the Z-axis and rotational in the Y-axis. It shows the maximum and minimum of acceleration and rotational amplitude in time domain, vibration frequency in frequency domain. Every person had a different rhythmic movement. Within a time, interval of 10 seconds, some tremors vibrated extremely while some tremors vibrated a little. This was because some patients were under medication during the period of this assessment was conducted. Those obtained results are unpredictable. From figure 5, which shows the highest peak 121.4 Hz in frequency, domain graph represented the vibration frequency. Based on the present research, the range of tremor frequency occurred in Parkinson's disease was up to 9 Hz [5] [18]. The acceleration in time domain was converted to the frequency domain by using Fast Fourier Transform.





(c) Angular velocity versus time graph

Figure 6. The graphs for fourth patient

Figure 6 above shows the tremor behaviour in time and frequency domain for patient 4. It was noticed to be different from the other patients' because there was no effect of medication on this patient before the test was conducted. By comparing angular velocity, the Y-axis shows the highest amplitude compare to the X and Z-axes. Finally, the frequency occurred for this patient was at 4.063 Hz.

4. Conclusion

In summary, for this measurement for the features of Parkinson patients hand tremor frequency and its quantitative assessment method have been presented. A time-frequency and time-Angular velocity for tremor state detection was adopted. The task was conducted within 10 seconds for postural and another for rest positions, for both frequency and time domains. The peak power of measured frequency domain determined the quantitative the natural frequency of PD patients. However, this result is different from different tremor types.

An easy way to get precise measurement quantification for data collection which is collected by shimmer device. Based on the results of the present study, each patient have own natural identical frequency and rotational values. That can be attributed to the un-avoided noise during data collection process. Besides, some patients were tired, while most of them were under medication affect. Shimmer device is a very sensitive device that a slight movement affects the reading. As a result, it was challenging to make the Shimmer record the pure vibration of the postural tremor.

Then future works should involve following points:

1. Comparison among other latest sensor for tremor assessment as for this study where between Gyroscope and accelerometer placed in one Shimmer device.
2. The repeatability of tremor amplitude with the same patient at different times should be investigated further.
3. More verity tasks for the patients to declare the difference among tremor types where more experiments that are clinical are needed to modify the scale factors to be quantitatively assessed.
4. With medication, clinical history and more parameters should be evaluated for Patients to be monitored before conducting the assessment to have accurate overall assessment of Parkinsonian symptoms.

The results showed different between gyroscope and accelerometer reading for time and frequency domain where the response of gyroscope for tremor osculation is more noticeable. For making comparison to the previous methods, the current one is more affordable, easier and higher in quality. It measured the signal main parameters to evaluate the tremor severity stage of Parkinson tremor. In this study, it is show that the influence of patients' medication should not be ignored in data assessment.

Acknowledgments

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References

- [1] C. G. Goetz et al., "Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): Scale presentation and clinimetric testing results," *Mov. Disord.*, vol. 23, no. 15, pp. 2129–2170, 2008.
- [2] K. D. Sethi et al., "Benefits and Risks of Pharmacological Treatments for Essential Tremor," *Drug Saf.*, vol. 26, no. 7, pp. 461–481, 2006.
- [3] S. Smaga, "Tremor," *Am. Fam. Physician*, vol. 68, no. 8, pp. 1545–1553, 2003.
- [4] J. H. McAuley and C. D. Marsden, "Physiological and pathological tremors and rhythmic central motor control," *Brain*, vol. 123, pp. 1545–1567, 2000.
- [5] G. Deuschl, P. Bain, and M. Brin, "Consensus Statement of the Movement Disorder Society on Tremor," *Mov. Disord.*, vol. 13, no. S3, pp. 2–23, 2008.
- [6] S. Morrison, G. Kerr, and P. Silburn, "Bilateral tremor relations in Parkinson's disease: Effects of mechanical coupling and medication," *Park. Relat. Disord.*, vol. 14, no. 4, pp. 298–308, 2008.
- [7] S. Morrison and K. M. Newell, "Postural and resting tremor in the upper limb," *Clin. Neurophysiol.*, vol. 111, no. 4, pp. 651–663, 2000.
- [8] E. Randall, "spectral analysis of finger acceleration," 2018.
- [9] R. H. Wyatt, "A Study of Power Spectra Analysis of Normal Finger Tremors," *IEEE Trans. Biomed. Eng.*, vol. BME-15, no. 1, pp. 33–45, 1968.
- [10] S. Gebai and M. Hammoud, "Parkinson's Disease Treatment as Seen from a Mechanical Point of View," *Adv. Park. Dis.*, vol. 05, no. 04, pp. 97–106, 2016.
- [11] Z. Ladin, W. C. Flowers, and W. Messner, "A quantitative comparison of a position measurement system and accelerometry," *J. Biomech.*, vol. 22, no. 4, 1989.
- [12] K. E. Norman, R. Edwards, and A. Beuter, "The measurement of tremor using a velocity transducer: Comparison to simultaneous recordings using transducers of displacement, acceleration and muscle activity," *J. Neurosci. Methods*, vol. 92, no. 1–2, pp. 41–54, 1999.
- [13] A. Izvorski, M. Michałek, R. Tadeusiewicz, J. Bulka, and I. Wochlik, "Acquisition and Interpretation of Upper Limbs Tremor Signal in Parkinsonian Disease Department of Automatics," no. January, pp. 2–6, 2005.
- [14] Z. Szabo, B. Storkova, J. Hozman, and V. Zanchi, "Objective assessment of patients with Parkinson's disease," *Challenges Remote Sens. Proc. 3Rd Wseas Int. Conf. Remote Sens. (Remote '07)*, pp. 39–42, 2007.
- [15] R. P. Meshack, "The effects of weights on the amplitude and frequency of postural hand tremor in people with parkinson's disease," p. 86 p, 2001.
- [16] M. Z. Md. Zain, A. As'arry, S. Kazi, M. Mailah, M. Hussein and M. Y. Abdullah "Development of experimental-rig for human postural tremor behaviour" , *International Journal of Human Factors Modelling and Simulation*, vol. 1, no. 3, pp. 339–351, 2010.
- [17] R. M. A. de Bie et al., "Quantification of Hand Motor Symptoms in Parkinson's Disease: A Proof-of-Principle Study Using Inertial and Force Sensors," *Ann. Biomed. Eng.*, vol. 45, no. 10, pp. 2423–2436, 2017.
- [18] F. W. Wittich, "Diagnosis and treatment of common forms of respiratory allergy," *Minn. Med.*, vol. 32, no. 7, pp. 702–708, 1949.