Poster: Kinetic Tremor Measurement via IMU Sensing Data Analysis

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Tremor is a common symptom among all stages of Parkinson's Disease (PD) patients. To measure daily tremor events, we utilized IMU sensing data from wrists while PD patients were drawing. We secured 30 patients' IMU sensing data, following standard rating scale activities. With the collected data, we conducted data analysis for identifying any tremor episodes and extracting tremor amplitude. Our preliminary analysis and results show the potential of measuring kinetic tremors effectively. We plan to further analyze tremor events of PD patients via wearable sensing devices.

Additional Key Words and Phrases: IMU dataset, tremor detection, FAHN, UPDRS, Parkinson's Disease

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1 INTRODUCTION

Tremor is a common symptom among all stages of Parkinson's disease (PD) patients. Measuring tremors accurately is critical to gauge treatment response, both clinically and in the context of clinical trials. Traditionally, this has been accomplished through the use of standardized scales administered by trained professionals. However, the administration of these scales, such as the UPDRS and Fahn-Tolosa-Marin Tremor Rating Scale [5] is cumbersome and subject to inter-rater reliability limitations, as well as the limitations of what frequencies and amplitudes the human eye can accurately perceive and classify. A more accurate, reproducible, and non-intrusive method to measure tremor is needed [1].

Drawing (or writing) is a common daily activity that is impacted by tremor. Many standardized tremor rating scales include a writing and drawing assessment. The Fahn-Tolosa-Marin Scale requires participants to draw spiral circles and straight lines. Thus, we secure a vast number of drawing events from an IMU-based Fahn-Tolosa-Marin dataset. We then propose data analysis with a Continuous Wavelet Transform (CWT) technique to measure the tremor of PD patients.

Our study objective was to measure and detect the occurrence of PD tremor episodes in IMU sensing data. To achieve this goal, we first convert the raw data into CWT images so that the input data includes meaningful information both in time- and frequency-domains. Our preliminary experiments demonstrate that monitoring drawing activities with wearable prototypes, such as a smartwatch, can possibly be used to quantify tremor.

2 TREMOR DATA COLLECTION

Though PD patients have different types of tremors (rest, postural, and kinetic), our study focused on detecting kinetic tremors. Kinetic tremor is measured when a body part is moving. In the Fahn-Tolosa-Marin rating scale, different levels of tremors are graded using a Likert scale between 0 and 4, in which the maximum 4 represents the most severe tremor.

In our data collection procedure, 30 participants were asked to conduct a standardized set of different behaviors. Spiral-drawing test is one of the included behaviors that can capture kinetic tremor. Figure 1 illustrates template drawings provided to PD patients during our data collection. In all of the tests, participants also wore our UG devices, which is an experimental IMU sensing device [8], on each wrist for collecting movements in their hands and arms.

Overall, IMU data were collected from de-identified footage from all 30 participants of our tremor study. For each wrist of a participant, 3-axis accelerometer, gyroscope, and magnetometer data were secured under a sample rate of 100Hz. Video data were also recorded as ground truth for further analysis. Figure 2 shows an example of data collection.

Fig. 1. Template Drawings during the FAHN Rating Scale

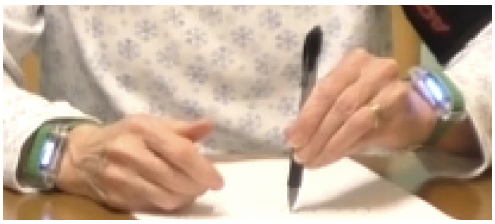

Fig. 2. Participant conducting a Spiral-Drawing Test

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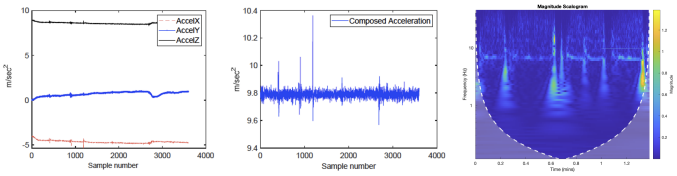


(a) Raw Accelerometer (b) Composed Accel. (c) CWT Converted Image

Fig. 3. Samples Outcomes of Tremor Data Analysis Procedures

3 TREMOR DATA ANALYSIS

Our data analysis is twofold; we 1) generate CWT images to extract time- and frequency-domain features and 2) differentiate data to get tremor amplitude.

3.1 Frequency Domain Analysis

IMU sensors generate time-domain features. Figure 3a shows raw accelerometer data on a tremor hand during a spiral-drawing test. The raw data itself cannot provide much information about tremors. When we calculate the composed accelerometer data (Figure 3b), we observe that it can be segmented into drawing parts and transition parts. Still, it is hard to distinguish tremors from the signal. As shown in Figure 3c, when we convert the composed accelerometer data into a CWT image, it is noticeable that the CWT image consists of two circle parts and three straight-line parts. Moreover, we can see that there is a dominant tremor frequency of around 8Hz across times. This is possible since the CWT conversion allows us to have frequency-domain features. We plan to analyze these CWT images for further tremor research.

3.2 Tremor Amplitude Analysis

To obtain tremor amplitude, we first segment raw accelerometer data into a single event data. From the composed accelerometer data (Figure 3b), we can easily extract accelerometer data from different events. For example, Figures 5a and 5b correspond to the ground truth drawings in Figures 5c and 5d, respectively. After segmentation, we conduct differentiation from raw accelerometer data to obtain velocity data. Assuming tremors often occur in the X-axis of UG devices, as described in Figure 4, we compute velocity data of accelerometer data in the X-axis for both hands. While non-tremor hands do not show obvious tremor results (Figure 5a), data from tremor hands include dominant tremor episodes (Figure 5b). From these observations, we plan to measure tremor events more accurately in future work.

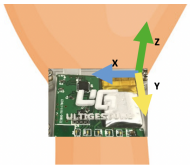
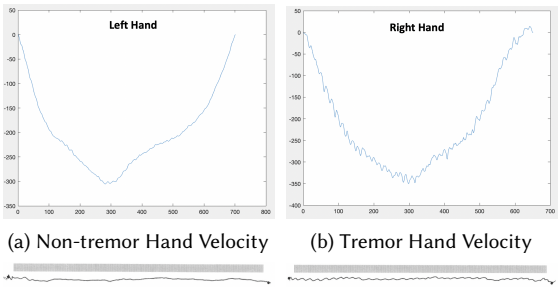


Fig. 4. UG Device Deployment on Wrist



(a) Non-tremor Hand Velocity (b) Tremor Hand Velocity

(c) Non-tremor Hand Drawing (d) Tremor Hand Drawing

Fig. 5. Sensing Data Analysis of Kinetic Tremor in Hands

4 RELATED WORK

Several studies have been done working to measure tremors while drawing using different sensors, including IMU sensors [4, 6, 7]. Work has also been done using deep learning networks to infer tremor episodes [2, 3]. In this study, we aim to provide an accurate and non-invasive solution that utilizes CWT images derived from IMU sensing data while drawing. We also plan to secure a comprehensive dataset and use deep learning techniques for better classification performance.

5 CONCLUSION

This study aims to analyze kinetic tremor events of PD patients via IMU sensing data. For easier tremor screening, we focused on the spiral-drawing tests of the Fahn-Tolosa-Marin scale. With the IMU dataset collected from 30 PD patients, we analyzed tremor episodes in converted CWT images and obtained tremor amplitude in IMU velocity data. Our preliminary analysis demonstrates that IMU sensing data can identify potential tremor events in daily drawing or writing activities, which will be beneficial for screening and monitoring PD tremors at all stages.

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