Kinetic Tremor Measurement via IMU Sensing Data Analysis

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Introduction

Tremor is a common symptom among all stages of Parkinson's Disease (PD) patients. Measuring tremors accurately is critical to mitigate their symptoms, accordingly. To minimize these efforts, wearable technologies are often used because those devices can be accurate and objective to measure tremor events.

However, conducting standard protocols for tremor measurement, such as UPDRS and FAHN, is also time intensive and requires training to use. In addition, the ground truth data is obtained by experts' naked eyes and can be subjective. In this work, we use wearable sensing data of drawing activity to measure tremor events. We then secure a vast number of drawing events from an IMU-based FAHN dataset. Finally, we propose data analysis with a Continuous Wavelet Transform (CWT) technique to measure the tremor of PD patients.

The objective of this study is to measure and detect the occurrence of PD tremor events in IMU sensing data. To achieve this goal, we first convert the raw data into CWT images so that the input data include meaningful information both in time- and frequency-domains. Our preliminary experiments demonstrate that monitoring drawing activities can suggest potential tremors via wearable prototypes.

Tremor Data Collection

Among different types of tremors, our study focused on detecting kinetic tremors. Kinetic tremor is measured when a body part is moving. In the FAHN rating scale, different levels of tremors correspond to the range 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 set of different behaviors. Spiral-drawing test is one of the tests that can capture kinetic tremor events because PD patients often get tremors while being asked to draw circles or lines.

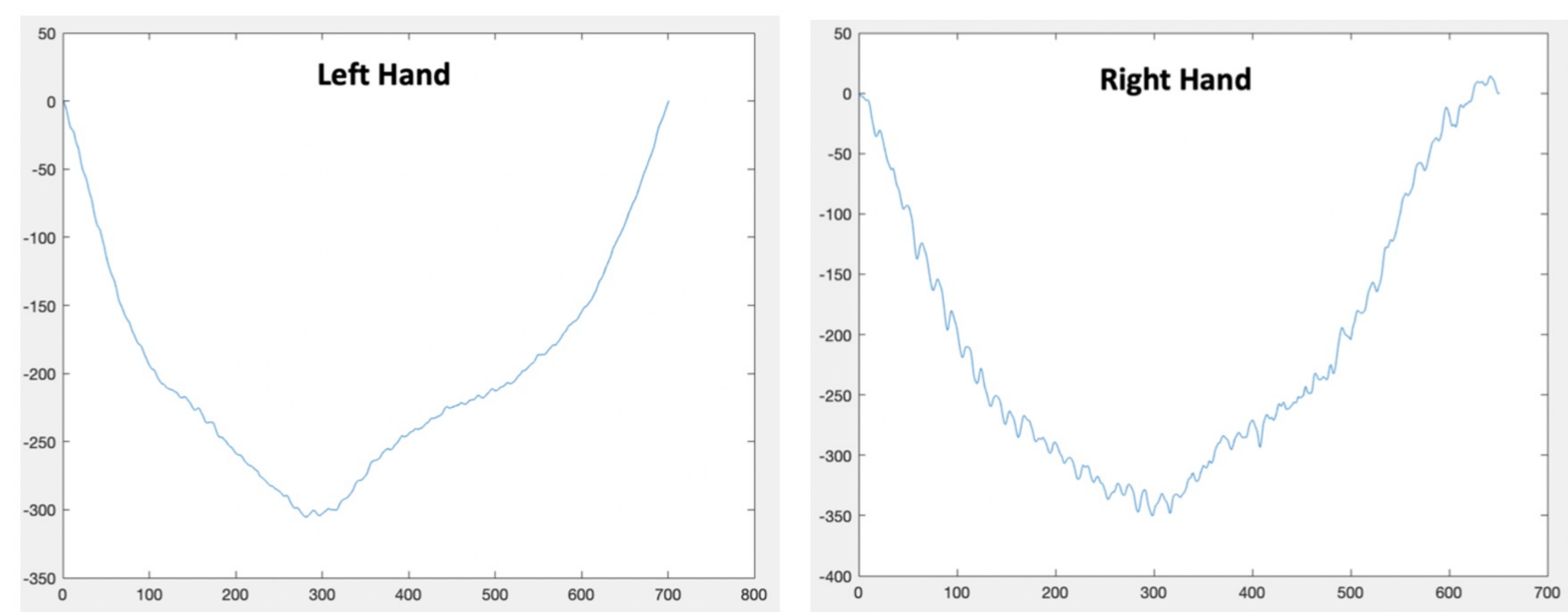
Figure 1 illustrates template drawings provided to PD patients during our data collection. In all of the tests, participants also wore the UG devices, which is a research-purpose IMU sensing device, on each wrist for collecting movements in their hands.

Figure 1. Templates of the FAHN Rating Scale

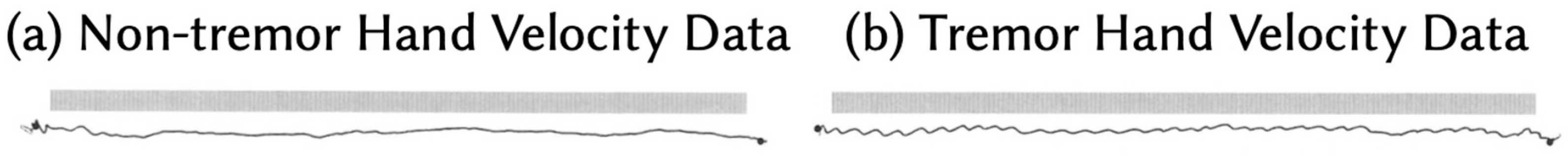
Figure 2. Participant conducting a Drawing Test

Figure 2 shows an example of data collection. 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.

Tremor Data Analysis



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



(c) Non-tremor Hand Ground Truth (d) Tremor Hand Ground Truth

Figure 4. Sensing Data Analysis of Kinetic Tremor

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 (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.

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 4a and 4b correspond to the ground truth drawings in Figures 4c and 4d, respectively. After segmentation, we conduct differentiation from raw accelerometer data to obtain velocity data. We then compute velocity data of accelerometer data in the X-axis for both hands. While non-tremor hands do not show obvious tremor results (Figure 4a), data from tremor hands include dominant tremor events (Figure 4b). From these observations, we plan to measure tremor events more accurately in future work.

Acknowledgements

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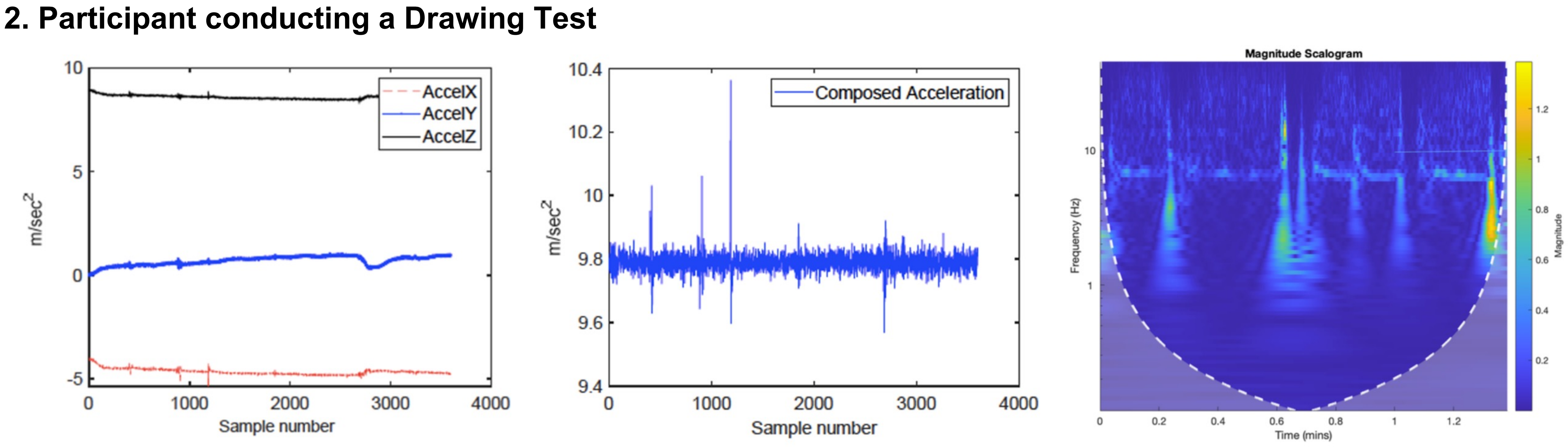

(a) Raw Accelerometer Data (b) Composed Accelerometer Data (c) CWT Converted Image

Figure 3. Samples Outcomes of Tremor Data Analysis Procedures