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# Parkinson's disease and essential tremor classification on mobile device

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ABSTRACT

Similarities in physiological and psychological symptoms of Parkinson's disease and Essential Tremor make accurate diagnosis of these conditions difficult. We have developed a smartphone-based application that uses discrete wavelet transforms and support vector machines to discriminate between Parkinson's and Essential postural tremors with over 96% of accuracy. We have demonstrated that attention and distraction can be used to efficiently discriminate between these two disorders and we propose a novel method that uses the influence of attention and distraction while recording the tremor. Our findings confirm that there are significant differences in postural tremors with different attention and distraction tasks. With respect to those differences we have effectively demonstrated that attention and distraction can be used to efficiently discriminate between the two disorders.

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## 1. Introduction

Similarities in the physiological and psychological symptoms of Parkinson's disease (PD) and ET make accurate diagnosis of PD and ET conditions difficult. One of the primary symptoms of both PD and ET is tremor. Both disorders have similar postural tremor characteristics, which makes it difficult to differentiate on the basis of tremor frequency and amplitude. Previous studies (e.g. [1,2]) that have classified PD and ET tremors used tremor frequency and amplitude alone as the input data to their classification systems. Such systems suffer problems with relatively large misclassification. In contrast, our work explored the use of cognitive distraction as an additional element of the classification process and achieves high accuracy of classification. The use of multiple distraction and attention conditions substantially help with the classification of patients.

We have investigated the influence of attention and distraction on tremor by comparing PD with ET tremors as the between-subjects factor and differing attention and distraction tasks as within-subjects factors. Our findings suggest that in the frequency band directly related to ET and PD tremors, there are significant tremor differences with respect to attention and distraction tasks between the two disorders. Our studies demonstrated that attention and distraction can be effectively used as input features in order to substantially improve the classification accuracy.

Based on the results of our studies we have developed a proof-of-concept smartphone-based application that outperforms existing accelerometer-only tests [1,2]. Our method yields a higher accuracy of classifying tremor as compared to existing state-of-the-art solutions. In addition, our prototype leverages the existing technology on the smartphones to give a cost effective portable solution to classification of tremor. The choice of smartphone-based tool was motivated by

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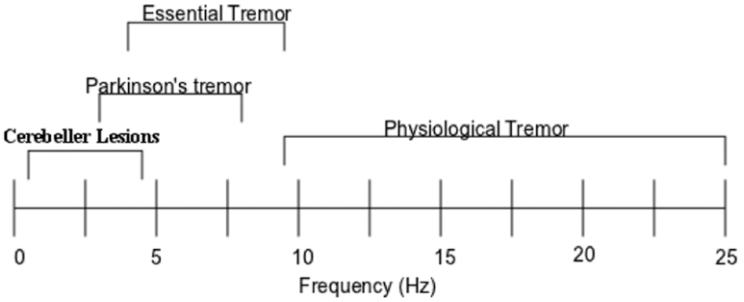


**Fig. 1.** Types of involuntary hand tremors [5].

addressing the needs of people living in rural or remote areas with limited access to health professionals. We aimed at making the tool independent of carriers or Internet access, so that it can be used as a self-contained appliance.

## 2. Related work

Previous studies by Ai [1,2] developed a classification method based on the evaluation of tremor frequency and amplitude and the distribution of power in differing frequency bands. To get sufficient accuracy these studies required the use of multiple computationally intense classification methods. This level of complexity was required to enable sufficient separation of the input feature space to detect the subtle differences of tremor frequency between the conditions. However, due to similarities in the tremor characteristics, this simple approach is inherently error-prone and leads to misclassification for diverse sample of PD and ET patients.

In our research we use an accelerometer-based paradigm and augment it with attention and distraction manipulations to differentiate between PD and ET tremors. Our study demonstrates that tremor in PD is affected differently in tasks that involve attention compared to those that involve distraction from the tasks. In other words, when PD patient directly attends to a task the tremor is reduced whereas with distraction the tremor increases. Our study confirmed the effect of attention and distraction on motor processes in PD [3,4]. These attention and distraction differences are not evident in ET. With ET, attention is associated with higher levels of tremor while distraction with lower levels, although not significantly and ET motor processes do not appear to be affected significantly by changes in cognitive load.

Overall, we have shown that the use of attention and distraction tasks reduces the need for complex feature separation of tremor frequency differences while maintaining a high classification accuracy of 96.4%.

## 3. Background

### 3.1. Tremor and its mechanisms

Tremor is a rhythmical involuntary continuous oscillation of any body part. It occurs in the normal population in the form of physiological tremor (PT). This tremor is usually low amplitude and interferes only with fine motor movement control. Muscular or neurological conditions can also cause tremor. There are different types of tremor that are associated with ET and PD disorders. The most common tremors are rest, postural and kinetic tremors. Postural and kinetic tremors are part of the action tremor family and are of particular interest due to their commonality in the two disorders. Fundamental frequency and the amplitude are the primary measurement features of tremors. The frequency components and the amplitude of the tremor can change depending on health status, attention, mental health and stress levels, and they also vary from individual to individual. This variability in basic aspects of tremor renders the accurate classification exclusively on the accelerometer data alone difficult. There is a need to provide additional features other than the frequency and amplitude of the tremor to aid the classification process.

A few different types of involuntary hand tremors and their characteristic frequency ranges are listed in Fig. 1. Note that the frequency ranges differ depending on the tremor condition suggesting that classification of tremor may be aided by measurement of the tremor frequency. Given the large overlap in tremor frequency and tremor characteristics between ET and PD (see Figs. 2 and 3), an accurate classification in these two disorder classes based purely on frequency spectrum is however not possible.

### 3.2. Parkinson's disease

Parkinson's disease (PD) is currently the second most commonly diagnosed neurodegenerative disease. PD affects approximately 1% of the world's population [6]. Reported prevalence is highest in developed countries. Its lower prevalence in developing countries could be due to lower life expectancy or later diagnosis of the disease due to reduced availability of diagnostic services [7]. One of the motivations for this research is to provide a self-contained solution that does not require

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