CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

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Project Number

35703

Project Title

Signal-Processing Driven Machine Learning Algorithms for Parkinson's Progression and Tremor-Based Disease Diagnostics

Abstract

Objectives/Goals

This project develops a system for rapid hand tremor analysis to diagnose neurological disorders and conduct stage classification of Parkinson's disease (PD). Lacking proper quantification, neurological diseases are often insufficiently supervised, contributing to a death rate of 6.8 million people annually. Hence, this study focuses on quantifying neurological disorders through signal-processing based algorithms (FFT, PSD) that conduct analysis of associated hand tremors. A trained Random Forests machine-learning model (QWK accuracy goal>0.85) allows for predictions of PD severity through passively collected tremor data from the engineered wearable device, therefore creating an autonomous diagnostic tool for multiple neurological disorders.

Methods/Materials

Methodology of this study is split into three segments: Active analysis, Passive analysis, and Integration of the Python algorithms in an iOS based diagnostic system. Through Fast Fourier Transforms (time domain to frequency domain conversion via Euler derivation) and Peak Detection Algorithms, features of dominant frequency and average amplitude are extracted from 10-second hand tremor examination. These features populate a binary classifier capable of distinguishing between multiple neurological disorders (Essential Tremor, PD, Multiple Sclerosis, etc.). The passive analysis system utilized Power Spectral Density estimates to construct passive tremor trends (used to train RF module for PD severity prediction) in Michael J. Fox foundation sponsored training data.

Results

The Random Forest ensemble was tested through a Quadratic Weighted Kappa k-fold cross validation, which evaluated inter-rater agreement (human gold standard vs. ML model). For 127 iterations the RF module outputted an average 0.864 kappa score, nearing perfect prediction accuracy of PD progression. The completed device was additionally validated through the use of real PD patients where 4 out of 6 were successfully diagnosed with Parkinson's disease solely based of the tremor trends detected on their hands.

Conclusions/Discussion

The results represent high accuracies for PD stage identification and validation for neurological disorder demarcation based on hand tremor. This mathematical analysis of tremor creates a novel method of disease diagnostic and quantification, especially useful in rural regions lacking trained neurologists to monitor involuntary-movement based diseases.

Summary Statement

This project creates a Random Forest based machine learning model and signal-processing algorithms to analyze hand tremor trends in order to diagnose neurological disorders and conduct Parkinson's disease stage classification.

Help Received

Dr. Brigitt Schuele from the Parkinson's Institute and Clinical Center provided information about PD progression and introduced me to the patients at the clinic; Dave Matsumoto from MakeXYZ provided assistance during the 3D printing process.