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University of the Witwatersrand

Masters Dissertation

Automated Discrimination of Tremor Severity in Movement Disorder Patients Based on Machine Learning of Hand-Drawn Spirals

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Abstract

The standard scales used to assess the severity of tremor in Parkinson's Disease (PD) and Essential Tremor (ET) are subjective and prone to human errors. One of these assessments involves performing the Archimedean spiral drawing task. Most attempts to computationally quantify the severity of tremor based on hand-drawn spirals required digital tablets, which are inaccessible to many clinical settings and foremost to telemedicine. Pen and paper hand-drawn spirals are more appropriate for these settings, and can still be scanned into a computer for automated processing. This study investigated whether deep machine learning could automatically discriminate the different severities of tremor using pen and paper drawings. The discrimination was performed using a Convolutional Neural Network (CNN). The spiral drawing dataset used for the study was small and imbalanced in terms of tremor severity groups. Data augmentation techniques were therefore studied in order to determine an optimal solution for these limitations. Binary classifications of patients with zero, mild, severe tremor and control subjects were performed. Classifications between the two movement disorders, ET and PD, and controls were also performed. The classifications were validated through a stratified 5-fold cross validation.

The accuracy of the discrimination of mild from severe tremor for both movement disorders was higher than 70.2%. The accuracy of the discrimination of control subjects from both movement disorders was higher than 85.1%. The discrimination of ET from PD yielded an accuracy of 82.4%. The discrimination of controls from zero tremor ET patients yielded an accuracy of 98.8%. The results revealed that the optimal augmentation method for this data included random translations of up to 2-4% of the spiral height and width. Data augmentation was found to improve classification accuracy by 4.6% and reduce standard deviation by 9.3%. The CNN was effective at automatically assessing the severity of tremor in movement disorder patients using pen and paper spirals. The results enable quantitative clinical insight into the manifestation of tremor in movement disorders. The methods employed indicate a feasibility to employ the simple tool of pen and paper drawings for automated screening and monitoring of tremor in movement disorders.