UNIVERSITY OF THE WITWATERSRAND

Abstract

School of Electrical and Information Engineering

Master of Science

Automated Quantitative Discrimination of Parkinson's Disease Stages using Signal Processing and Machine Learning

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Current clinical methods that determine Parkinson's Disease (PD) stages are mostly qualitative. The quantitative methods necessitate expensive equipment and/or cumbersome wearable devices, which limits their usability. This research presents a quantitative discrimination of PD stages using kinematic signals obtained from low-cost walker mounted sensors. Signal processing, machine learning and statistical methods are applied to extract and select features pertaining to PD patients' gait at the different stages of the disease. The research re-uses accelerometer, force sensors and distance encoder signals acquired in an experiment of a movement disorders clinic. The study consists of five key areas. (1) Signal pre-processing where signal denoising is applied and a novel footfall detection algorithm is proposed (2) Feature extraction which produces different categories of features. (3) Feature selection using both machine learning and statistical methods, (4) Classification and regression machine learning paradigms using clinical labels, where several machine learning methods are compared (5) Statistical analysis and modelling of the probability distributions associated with PD feature manifestation. The results indicate that the different PD stages can be discriminated using a Random Forest classifier with a 93% accuracy. The majority of the features most relevant to this discrimination belong to the information theoretic and statistical feature sub-classes. Confidence intervals analysis validated the class separability and a generalized pareto distribution was indicated as the best fit distribution for PD features. These findings may provide an insight into the disease progression. Additionally, a novel footfall detection algorithm, which has higher accuracy when compared to methods from literature, could be useful in other gait analysis studies. The research indicated the feasibility of signal processing and machine learning tools to accurately classify PD stages and implies the potential of affordable, simple walker-mounted sensors to aid medical practitioners in a quantitative assessment of PD stages.