Evaluation of bradykinesia in Parkinson's Disease using a computerised evolutionary algorithm

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Background:

Bradykinesia, the only obligatory physical sign for a diagnosis of Parkinson's disease, is a shorthand for complex disturbances of initiation and execution of actions and the ability to sustain them. This makes it difficult to identify reliably, particularly in the early stages of the disease or when bradykinesia is admixed with tremor.[1] There is evidence that different parkinsonian disorders have distinctive bradykinetic profiles (for instance, hypokinesia predominates in progressive supranuclear palsy).[2] If it were possible to more accurately distinguish these features in the clinic, diagnoses could be made earlier and with greater certainty. To this end, we applied a computerised algorithm to kinematic motor recordings to distinguish parkinsonian bradykinesia from normal movement.

Methods:

Cartesian Genetic Programming (CGP) is an evolutionary algorithm used to train and validate classifiers of a data stream. We applied this to movement recordings of the three upper limb bradykinesia tasks from the MDS-UPDRS motor subscale: finger tapping, hand pronation-supination and hand opening-closing. For each task, 22 patients with Parkinson's disease and 20 healthy controls were studied with an electromagnetic motion tracking system. The inputs to the computation were based on the characteristics of bradykinesia according to the MDS-UPDRS-III—speed and amplitude of movement, rhythmicity, decremental tendency. These motor features were adapted to the specific requirements of each task. A classifier was defined as the evolved algorithm, after 10,000 'generations' at a 'mutation' rate of 0.05. Three sets of classifiers were evolved, one for each movement task. The fitness assigned to each classifier was the proportion of samples correctly classified.

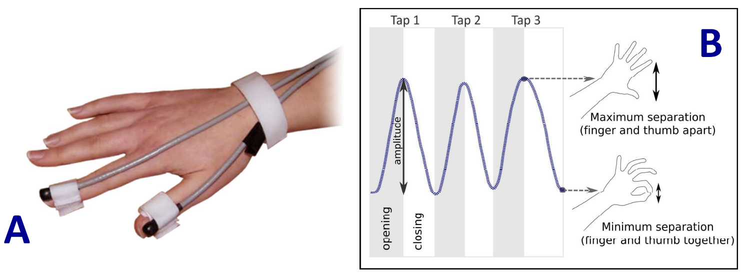

Figure 1: A: Two electromagnetic sensors attached to a subject's hand; B: Representational diagram of positional separation data, showing opening and closing phases of three finger tapping cycles.

Results:

For the finger tapping task, averaged accuracy for the best classifier was 82.66%; for the pronation-supination task, 80.54%; and for the hand opening-closing, 75.32%. Using the model's ability to recognise which inputs were used to evolve the strongest classifier, the most discriminating motor features for each task were derived.

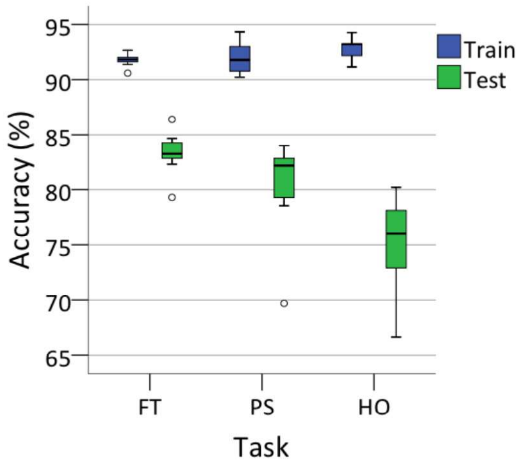

Figure 2: Boxplots showing the distribution of accuracies across ten runs for training and test data
FT = finger tapping; PS = pronation/supination; HO = hand opening. Box = interquartile range (IQR); whiskers = highest and lowest values within 1.5 x IQR; band inside box = median.

Conclusions:

- CGP can be applied to all three of the bradykinesia tasks of the MDS-UPDRS-III scale to develop effective classifiers.
- Application to a larger patient sample would improve accuracy allowing a more robust description of the most discriminative movement features.
- By accepting raw positional or speed data points, CGP has the capacity to perform unbiased searching, unconstrained by pre-defined characteristics.
- By using raw data to induce classifiers in this way, the fundamental defects in motor plan execution that give rise to parkinsonian bradykinesia may be better understood.

References:

1. Bajaj NPS, Gontu V, Birchall J, *et al. Accuracy of clinical diagnosis in tremulous parkinsonian patients: a blinded video study.* J Neurol Neurosurg Psychiatry. 2010; 81: 1223-1228.
2. Ling H, Massey LA, Lees AJ, Brown P, Day BL. *Hypokinesia without decrement distinguishes progressive supranuclear palsy from Parkinson's disease*. Brain. 2012; 135: 1141-1153

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