High-accuracy Discrimination of Parkinson's Disease Participants from Healthy Controls Using Smartphones

S Arora[1], MA Little[1], V Venkataraman[2], S Donohue[3], KM Biglan[4], ER Dorsey[5]

[1] Nonlinearity and Complexity Research Group, Aston University, Birmingham, UK

[2] Duke University School of Medicine, Durham, NC, USA

[3] Johns Hopkins University, Baltimore, MD, USA

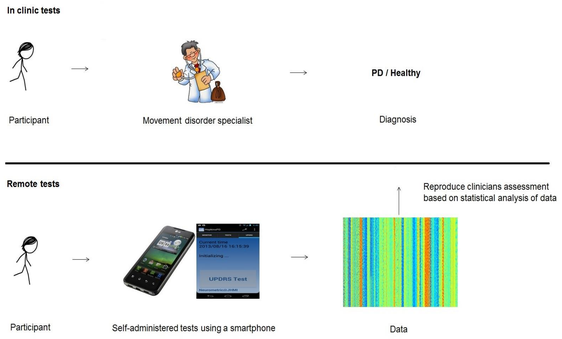
[4] Department of Neurology, University of Rochester Medical Center, Rochester, NY, USA

[5] Center for Human Experimental Therapeutics, University of Rochester Medical Center, Rochester, NY, USA

Contact: Siddharth.Arora@maths.ox.ac.uk

Aim

- To assess the practicality and effectiveness of inexpensive, commercially available smartphones to discriminate Parkinson's disease (PD) participants from healthy controls.
- Using self-administered tests of gait and postural sway, recorded via smartphones, we try to reproduce clinical assessments using statistical analysis techniques.



Background

- Existing tests for the diagnosis of PD are based on subjective neurological examinations, performed in-clinic.
- Objective movement symptom severity data, collected using widely-accessible technologies such as smartphones, would enable the remote characterization of PD symptoms based on self-administered, behavioural tests.
- To date, the compliance rate of testing using smartphones has not been assessed.

Methods

- We conducted a one-month controlled study with twenty participants, comprising 10 PD participants and 10 controls.
- Using smartphones, participants conducted self-administered, short (less than 5 minutes) controlled gait and postural sway tests.
- We objectively measured and quantified key movement severity symptoms of PD and analysed a wide range of summary measures extracted from the accelerometry data.
- For data analysis, we used a statistical technique called Random Forest.

Participant Characteristics

Baseline characteristics of study participants

Characteristic	Parkinson's disease participants (n= 10)	Control participants (n=10)
Age (SD)	65.1 years (9.8)	57.7 years (14.3)
Percentage women	30%	40%
Percent taking levodopa	90%	0%
Baseline motor UPDRS score (SD)	19.6 (6.7)	NA
Baseline Parkinson's Disease Questionnaire 39 score (SD)	18.5 (16.9)	NA

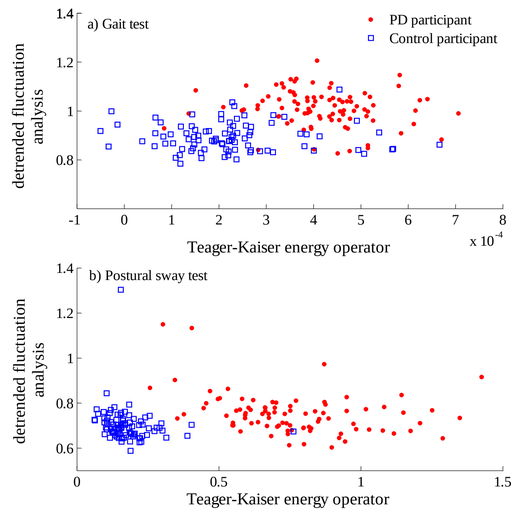
UPDRS: Unified Parkinson's Disease Rating Scale, SD: Standard Deviation, NA: Not Applicable

Data Collection

- Data for gait and postural sway tests was collected using smartphones (cost: $30 each) that ran a specialized software program developed by the team that was capable of recording tri-axial acceleration.
- For the gait test, participants were instructed to walk twenty steps forward, turn around, and return back to the starting position.
- For the posture test, participants were instructed to try and stand upright for about thirty seconds at end of the gait test.

Feature Extraction

- We derive useful features/summary measures from the data for analysis. We plot two features: Teager-Kaiser Energy Operator (TKEO) and Detrended Fluctuation Analysis (DFA).



Results

- The 20 participants performed an average of 2.53 tests (63.25% adherence) per day for an average of 31.6 days.
- To quantify classification accuracy, we use Sensitivity (*true positive rate*) – proportion of PD participants correctly identified, and Specificity (*true negative rate*) – proportion of Control participants correctly identified.

Measure	*Accuracy*
Sensitivity	98.5 ± 1.3%
Specificity	97.6 ± 1.8%

Conclusions and Future work

- Using consumer-grade smartphone accelerometers, it is possible to distinguish PD from healthy controls with high accuracy.
- Future studies could investigate monitoring and predicting the severity of PD (as quantified using UPDRS or PDQ-39) using smartphone data.

Bibliography

[1]. Joundi RA, Brittain JS, Jenkinson N, Green AL, Aziz T. Rapid tremor frequency assessment with the iPhone accelerometer. Parkinsonism Relat Disorders 2011; 17:288–290.
[2]. Abdolahi A, Scoglio N, Killoran A, Dorsey ER, Biglan KM. Potential reliability and validity of a modified version of the Unified Parkinson's Disease Rating Scale that could be administered remotely. Parkinsonism Relat Disorders 2013; 19:218–221.
[3]. Dorsey ER, Willis AW. Caring for the majority. Mov Disord 2013; 28:261–262.
[4]. Pramis J. By 2017 there will almost be as many smartphones as literate adults. In: Digital Trends. Available at: http://www.digitaltrends.com/mobile/2017-literate-adults-smartphones/#ixzz2d1dtkRDg. Accessed May 2013.