Monitoring Parkinson's Disease Progression Using Behavioural Inferences, Mobile Devices and Web Technologies

Interaction Analysis and Modelling Lab

University of Manchester

WWW'16 Conference. PhD Symposium

Julio Vega

Supervisors: Simon Harper, Caroline Jay & Markel Vigo

Parkinson's Disease (PD)

- Chronic neurodegenerative disease
- 1 in 500 people have Parkinson's
- PD has motor and non-motor symptoms
- PD progression is not linear and varies among individuals

PD traditional assessment

It's not suitable for continuous monitoring

- Short & sporadic ¹
- Clinical expertise needed ²
- Resource consuming ³
- Uncomfortable for patients ⁴
- *Symptoms vary during the day* ⁵

¹ Sung M., 2005. ² Piro N.E., 2014; Tsanas A., 2011. ³ Findley L., 2003. ⁴ Goetz C. G., 2008. ⁵ Pepa L., 2014; Hintermuller C. 2015.

Alternative assessment approaches

- Paper & electronic diaries
- Electronic surveys
- *Technology-supported:*

¹

Personal

Environmental

Surveillance

¹ Wearables and/or smartphones measuring mostly tremor, slow movement, activities of daily living, gait and voice features.

Main research question

Can PD be monitored via human behaviour inferred from smartphone collected data?

My approach

Measure PD progression using proxies derived from heterogeneous data and human behaviour

- Longitudinal
- Non-disruptive
- Non-intrusive
- Naturalistic
- Multi-source
- Macro-scale

Methodology

Progress to date

We are carrying out a one-year monitoring study

Pilot study

Collected 29 data sources from two participants during three months

- Inertial data (accelerometer, gyro, rotation...)
- Communication data (calls, sms, bluetooth, wifi)
- Spatial data (GPS, cell towers, time zone, GIS)
- Environmental data (weather, light, barometer, noise)
- Web & Interaction data (used apps & websites, touch gestures, keyboard types)

Data analysis

Hypothetical Proxies

- A. Typing patterns
- B. Phone usage
- C. Going up/down stairs
- D. Indoors routine
- E. Motor activities
- F. Social patterns

Profile of Living

- 1. Individual baseline
- 2. Fluctuation measurement

Proxies

A proxy has metrics. Metrics are of two types

→ Direct

◆ Directly quantifiable. Single-source

→ Latent

◆ Need a tailored scale. Multi-source

For example

Proxy	Direct Metrics	Latent Metrics
Typing patterns	Typing episodes (length, frequency) Duration of halts between typing events Typing duration for different word lengths	Typing context (location, time)
Phone usage patterns	Frequency of phone use Visited websites Touch gestures metrics (e.g. taps on target)	Start of morning routine Phone usage context (location, noise, time) Website content analysis
Going up/down stairs	Frequency of episodes Duration of episodes Speed of episodes	Episodes' context (time of the day, week...)
Social patterns	Communication (calls and sms) Applications used (whatsapp, email) Location (commonly visited places)	Time spent at work/home Weekly routine Individuals around participants

Options for quantifying latent metrics

- Regularity patterns
- Text mining techniques
- Bayesian and entropy based techniques
- Eigenvectors-like techniques
- Fuzzy logic
- Scanpath analysis from eye tracking

Profile of Living

* For illustrative purposes only

The proxy's metrics evolution is quantified using a PoL

Evaluation

Monthly (adaptative) scoring of PD using different clinical scales

- MDS-UPDRS (**motor & non-motor** aspects of PD, widely use in research)
- Montreal **Cognitive** Assessment scale (MoCA)
- Geriatric **Depression** scale
- **Activities** of Daily Living scale
- **Tech** skills scale
- Self-reported evaluation of symptoms' impact in **daily routine**

Future work

- Recruit more participants for the study
- Collect more data during the next 11 months
- Pick one proxy and explore its metrics
- Evaluate the proxy using PD clinical scales

Interesting questions in my research

- How can touch interaction data be analysed to find a PD proxy?
- How to quantify latent metrics? (no labelled data)
- How to measure the PoL's baseline? Dynamically, statically?
- Are there any opportunities to leverage any new proxies?
- What is the best time granularity/behavioural abstraction for data analysis?
- What is the best frequency for ground truth observations?

Thank you

**Monitoring Parkinson's Disease Progression Using Behavioural Inferences,
Mobile Devices and Web Technologies**

Interaction Analysis and Modelling Lab

Julio Vega
julio.vega@manchester.ac.uk