Monitoring Parkinson's Disease Progression using Smartphones and Behavioural Inferences

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Parkinson's Disease is a neurodegenerative disorder that affects around 1 in 350 people in the UK. Traditional Parkinson's clinical assessment can be inaccurate because symptoms vary within hours or days, but health professionals examine patients only during short sessions every six months. Furthermore, the clinical scales used in these consultations are expertise-dependant and prone to recall and cognitive biases. Consequently, doctors and patients would benefit from an objective and fine-grained way to monitor Parkinson's progression. Clinicians could tailor medications to each person's condition which in turn could enhance patients' quality of life by reducing the impact of the disease in their daily activities and stopping them from dwelling on the disease.

Previous works have used off-the-shelf sensors to assess Parkinson's symptoms. In general, these devices are objective and more precise than traditional methods. Nevertheless, most of these projects were tested under controlled conditions, were focused on motor symptoms neglecting non-motor ones, were uncomfortable to use because they needed to be attached to people's bodies, or were disruptive, asking people to perform assessments tasks periodically. These issues make it unfeasible to monitor Parkinson's over an extended period.

This is the reason we are working on a novel longitudinal, naturalistic, combinatorial, and unobtrusive methodology to monitor Parkinson's using smartphones. It is known that symptoms affect various aspects of people's daily lives; therefore, we hypothesise that if we quantify changes on people's behaviour using digital biomarkers, then we can measure Parkinson's symptom fluctuations. We define a digital biomarker as a set of metrics that quantify a human activity inferred from smartphone data (inertial, location, interaction, communication, and ambient data).

We are at the end of a 1-year monitoring study working with 11 people with Parkinson's where we have collected up to 22 data sources, 24/7, from their personal phones using an in-house version of the Aware Framework (8 iOS, 3 Android). We are following an exploratory data-driven approach to identify relevant digital biomarkers for Parkinson's progression. As such, we created a set of operational hypotheses that link one or more digital biomarkers to a feature of human behaviour affected by Parkinson's symptoms. These hypotheses are based on the inferences that we can make from smartphone data, digital biomarkers for passive monitoring used in other mental and physiological conditions, and clinical knowledge of the symptoms and the daily life consequences of Parkinson's.

More specifically, we hypothesise that the following metrics are linked to social isolation caused by depression, anxiety, apathy, and motor difficulties: time spent at home, total/max travelled distance, number of incoming/outgoing calls, and phone usage sessions at night (as a proxy to sleep interruptions). In the same way, we suspect the following metrics are linked to dexterity movement problems caused by tremor, bradykinesia, and rigidity: number of keyboard typing events, number of smartphone usage sessions, and mean/total duration of sessions.

We want to build a Profile of Living (PoL) for each participant combining the metrics mentioned above. Each PoL has a baseline of n days that is compared to a rolling window of the coming days. In this way, we want to model the rate of change of this metrics over time. To validate the PoL, we assessed the motor symptoms, quality of life, cognitive performance, and emotional condition of our participants using clinical scales. Also, we created and deployed a paper diary to record symptom fluctuations of the top 3 symptoms of each person, which we will use to evaluate daily changes. So far, time at home, call patterns, typing events, and the number of usage sessions have all shown a link to measurements of quality of life in Parkinson's. We will explore combinations of these metrics to create a stronger model that could potentially predict the progression of Parkinson's Disease.