Pacific Parkinson's
RESEARCH INSTITUTE

2022 IMPACT REPORT | **Transforming Care for Parkinson's Disease**

United in the Search for a Cure

The Pacific Parkinson's Research Institute (PPRI) partners with the UBC Faculty of Medicine to fund the strategic research priorities of the Pacific Parkinson's Research Centre (PPRC), a Canadian Centre for Excellence for the diagnosis and management of Parkinson's disease (PD) and related disorders. The steadfast partnership between the PPRI and PPRC is critical to discovering new knowledge and translating it to improve the quality of life for people with Parkinson's disease, their families and caregivers across British Columbia.

For more information, please visit www.pacificparkinsons.org

Project Summary

A PPRC team led by Dr. Martin McKeown, Professor of Neurology and Director of the PPRC, embarked on a five-year project to transform patient care by improving the way PD symptoms are managed through a highly personalized approach to care, including the remote monitoring of the status of the disease.

COVID-19 resulted in the curtailment of many in-person activities crucial to Dr. McKeown's research. As we emerge from the pandemic, we look back at the continued support of the PPRI and community of donors this past year and express our gratitude to you for enabling the PPRC to continue its work to advance longitudinal monitoring of Parkinson's patients. Your support has been critical to the innovative approach we take to help improve people's lives.

Thank You

For more information, please contact:

PACIFIC PARKINSON'S RESEARCH INSTITUTE

Telephone: 604.681.5031

Email: ppri@telus.net

THE UNIVERSITY OF BRITISH COLUMBIA

The Sweat App

The Sweat App seeks to leverage the potential of wearable health-tracking devices for Parkinson's patients. A patient with chronic health issues could wear an item of clothing that could monitor vital signs such as pulse rate, blood pressure and breathing patterns and report them to a healthcare provider.

The primary treatment for PD is L-dopa medication. As PD progresses, patients may experience a return of PD symptoms before the next dose of medication. This presents a paradox: in order to prevent the medication wearing off and experiencing distress, the patient must take the next dose while still feeling well, as the upcoming off episodes can be unpredictable and the medication can take up to an hour to be absorbed. Dr. McKeown examined whether or not a wearable sensor recording autonomic nervous system (ANS) activity could be used to predict when L-dopa will begin to wear off. The research subjects kept a diary of their on medication/off medication state over 24 hours while wearing an E4 wristband® sensor that recorded features of ANS dynamics including electrodermal activity, heart rate, blood volume pulse, and skin temperature. This data was used to predict when the medication began to wear off.

When Dr. McKeown used individually-specific models assessed with cross-validation, he obtained more than 90% correlation among the "off states" logged by the patients. It was found that individually-calibrated ANS dynamics can be used to assess this on/off phenomenon in people with PD taking L-dopa with greater accuracy, although more work is required to determine how much earlier the detection of wearing off can take place.

Next Steps

Dr. McKeown plans to apply for a research grant from the Parkinson Canada National Research Program in December 2022 and has prepared a draft paper for submission to MDPI Sensors Journal.

Using a Smartphone App to Monitor Motor Function

Diagnosis and monitoring of Parkinson's disease usually consists of clinical assessments of mobility, carried out by movement disorder experts, using rating scales such as the Unified Parkinson's Disease Rating Scale (UPDRS). However, these scales are partially subjective and so a patient may be rated differently when evaluated by different clinicians. In addition, clinical assessments made using the UPDRS are resource-intensive and cannot be used for daily monitoring.

To improve the accuracy and comprehensiveness of diagnosing the status of the disease, Dr. McKeown's team has developed a mobile application in collaboration with Nanyang Technological University, Singapore. The application prompts the user to perform various tasks, including finger tapping, walking, and a pinch test. To date, data from 30 healthy subjects and 50 PD cases have been recorded and analyzed using deep machine learning to select relevant features to estimate UPDRS. This capstone project has recently been finished, and the team is preparing a paper on the results.

Next Steps

Dr. McKeown and his team will validate which subset of the motor function iPhone app accurately maps to the appropriate subset of the UPDRS clinical scale.

Sleep Monitoring of Parkinson's Patients via Headband

For Parkinson's patients, sleep a critical factor as the body needs this time to repair and restore itself. The changes in the brain brought about by Parkinson's can cause sleep difficulties, and more than two-thirds of patients report disturbances in their sleep patterns.

Monitoring these symptoms continually is important to improving the quality of life for patients. We believe that the availability of a validated, user-friendly headband for sleep monitoring may play an important role in the early detection and treatment of sleep disturbances and may trigger research into therapeutic interventions for sleep disturbances in Parkinson's disease.

Dr. McKeown has found that we can accurately assess sleep if we use standard, expensive in-hospital recordings. However, if lightweight headbands and standard analysis methods are employed, the results are unusable. Recently, they have shown that advanced analysis methods allow us to extract more information from take-home headbands.

In the past year, the team has employed a two-step approach that utilized prior knowledge extracted from labeled data to cluster unlabeled data into standard sleep stages and potential emergent EEG patterns. Currently, a Biomedical Engineering PhD student is working on causal relationships between galvanic vestibular stimulation (GVS), the process of sending specific electric messages to a nerve in the ear that maintains balance using a headband, and sleep EEG neuro-markers.

Next Steps

Dr. McKeown and his team are in the process of re-factoring its GVS stimulator so it can be utilized while the patient is asleep. They are working with a BC manufacturer to develop a GVS Version 2.0.

Developing a Smart Camera for Disease Monitoring

The vision of this research program is to develop a novel, privacy-compliant, smart camera system that can identify and classify symptoms of PD solely from video recordings in clinical and home settings. Patients are assessed usually once per year at a clinic visit, and therapeutic decisions are made on this short “snapshot” of time. This assessment in the clinic may not accurately represent how they are doing in the comfort of their own home; patients may be tired or anxious in a clinical setting. Therefore, there is great interest worldwide for monitoring people with Parkinson’s between visits with wearable sensors that longitudinally measure their movement and the severity of their symptoms. However, patient-worn sensors currently available have many disadvantages. They require patients remembering to wear their sensors during the day and removing them at night, or during bathing, etc. Furthermore, there is the challenge of automatically sifting through the enormous amount of data produced by the sensors to produce actionable information for the treating physician.

Dr. McKeown believes that developing a monitoring tool that leverages the technology in smart cameras can measure body movement, simplify movement monitoring, and improve the quality of data. To preserve patients’ anonymity, their movement is immediately converted into 3D positions of the patient’s anatomical landmarks – a “stick figure” - with identifiable information neither stored nor transmitted. The team offers discussions to allow patients, their families and health care professionals to express their views, ideas and concerns regarding the monitoring tool for in-home use.

To rely solely on video recordings, the artificial intelligence (AI) system needs to be “trained”. In this first stage, patients wear sensors while completing movements captured by the video camera. With enough examples, the computer “learns” the sensor information from the video recordings alone, meaning that the sensors are eventually unnecessary.

To date, 50 participants with idiopathic PD, 50 healthy controls and 20 health care professionals (HCP) who provide care for individuals with PD have been recruited to participate in the study. Dr. McKeown’s team collects video recordings and sensor data from participants while they perform a set of activities and standardized tests to assess their mobility expressions. During a “facial visit”, video recordings of the participants’ facial movements are made while they view images and videos on a computer screen. Deep AI learning is applied to the facial images to infer the facial surface.

Currently, Dr. McKeown’s team is implementing additional mobility visits to monitor changes in symptoms while being off medication and then repeating tasks as the PD medications start to take effect. They are also working on video-based 3D hand pose estimation to capture the status of the patients’ hands during a UPDRS finger tapping task.

In addition, the team is conducting further work on reconstructing a 3D skeleton of PD patients from video while walking. This model is used to estimate gait parameters such as step length and cadence, which are used to quantify Parkinson's disease motor severity.

Next Steps

Dr. McKeown and his team are in the process of installing a booth in the clinic in order to collect further mobility data when patients come in for their clinic visits.

Duodopa Infusion

While developing a smart camera to monitor PD symptoms, Dr. McKeown is expanding its functionality by including an automatic assessment PD patients' motor performance while they are determining the dose of PD medication Duodopa that has the fewest side effects, in a process known as titration. It requires frequent assessments of motor performance and as adjusting the titration rate is a delicate undertaking, there are frequent over- and under-corrections that prolong the process significantly.

With the improvements in automatic recognition in video recordings allowing for detection of fine details, e.g. intelligently zooming in on the patient's hand, the near-continuous assessment of disease performance is now a reality. Dr. McKeown aims to determine if the data captured of automatic motor functions corresponds to titration, and if a precise model of predicting motor responses according to titration adjustment can be created. The team will assess all patients that consent to have video recordings over a 2-yr period of Duodopa titration.

Next Steps

A letter of intent for this project has been sent to biotech company Abbvie, and on allocation of funds, a Postdoc Fellow with a Control Engineering background will be hired to lead the study.

The Canadian Collective for Video-based Deep Federated Learning for PD

The goal of this major collaboration is to complement the Canadian Open Parkinson Network (C-OPN) with deep federated learning (DFL) – a machine learning technique that trains an algorithm using data samples that are siloed across several devices or servers – to develop models to transform the management of PD.

Machine learning relies on large amounts of data, typically more than one centre can collect on its own, but privacy is paramount when utilizing data where the patient is identifiable. This requirement is necessary but hinders the development of advanced algorithms that demand large quantities of information. Video data can circumvent some of these issues – for example, blurring or pixelating the patient's face – but this may impact the diagnosis of PD, as a symptom of PD in some patients may include hypomimia, or reduced facial expression.

A proposed solution is to use DFL, which allows all project collaborators to leverage the finger tap, hand movement and hand tremor data sets available while allowing individual centres to maintain strict control over access to them. Dr. McKeown will work with the following participating centres:

- Movement Disorders program at the University of Calgary (Dr. Davide Martino)
- The Movement Disorders Program, University of Alberta (Dr. Richard Camicioli)
- The Movement Disorders Centre at the Toronto Western Hospital, University of Toronto. (Dr. Lorraine Kalia)
- The Parkinson Research Consortium at the University of Ottawa (Dr. David Grimes)
- The McGill Parkinson Program at the Montreal Neurological Institute and Hospital (MNI/H) and the Montreal General Hospital (Dr. Edward Fon)

Governing this data will leverage the current C-OPN's Executive, Scientific, Coordinator and Clinical Investigators Committee, but Dr. McKeown and his collaborators will establish an independent Director, National Manager and Review Committee.

Next Steps

Dr. McKeown and the project group have drafted and submitted a research plan to Brain Canada, a national non-profit that enables and supports paradigm-changing brain research in Canada.

Thank You

The UBC Faculty of Medicine, Dr. McKeown and the PPRC are sincerely grateful for your transformational support, which will drive breakthroughs in diagnosing and managing the debilitating symptoms of Parkinson's disease. Your ongoing generosity has positioned us at the forefront of Parkinson's disease study, and together we can change the future for patients, their families and communities.

Dr. Martin McKeown