Adopting Machine Learning Technology for the Classification of Parkinson's Disease

A Thesis Submitted in
Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy

By

Farhan Mohammed

In

Faculty of Engineering and Information Technology

School of Electrical and Data Engineering

UNIVERSITY OF TECHNOLOGY SYDNEY

AUSTRALIA

Submitted JANUARY, 2020

UNIVERSITY OF TECHNOLOGY SYDNEY
SCHOOL OF ELECTRICAL AND DATA ENGINEERING

The undersigned hereby certifies that he has read this thesis entitled **"Adopting Machine Learning Technology for the Classification of Parkinson's Disease"** by **Farhan Mohammed** and that in his opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy

Production Note:
Signature removed prior to publication.

. . . . . .

Prof. Xiangjian (Sean) He

Principal Supervisor

Certificate of Authorship/Originality

I, Farhan Mohammed, declare that this thesis, is submitted in fulfillment of the requirements for the award of Doctor of Philosophy, in the School of Electrical and Data Engineering, Faculty of Engineering and Information Technology here at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Trainig Program.

Production Note:

Signature: Signature removed prior to publication.

Date: 20/07/2020

ABSTRACT

Adopting Machine Learning Technology for the Classification of Parkinson's Disease

by

Farhan Mohammed

Parkinson's Disease (PD) is the second most common neuro-degenerative disorder affecting approximately 1% of the population. Major symptoms include tremor, bradykinesia and freezing of gait. The precise diagnosis of PD remains a challenge for clinicians due to the similarity of PD symptoms with other disorders. Although diagnosis is based on clinical symptoms, PD is associated with a plethora of non-motor symptoms adding to its overall disability.

Research into early diagnosis of PD has taken advantage of machine learning-based image analysis. Neuroimaging modalities, like Single Photon Emission Computed Tomography (SPECT), have shown to aid in early diagnosis of PD. SPECT images are powerful tools that depict dopaminergic deficits in brain. Dopamine transporter (DAT) loss is a crucial feature necessary for PD identification. Regular scans are identified by intense and symmetric DAT binding that appear as two "comma-shaped" regions. Any asymmetry of this shape implies an abnormal finding. This thesis proposes three machine learning approaches for the classification of PD.

Firstly, we developed a neural network that classified PD patients from healthy controls. SPECT images were used to train our network. 10-fold cross-validation was used to evaluate our network's performances. Experimental results indicated that our approach outperformed the benchmark studies.

To classify PD patients into different stages, PDStageNet was implemented which learned several features from the images and their associated stages. The affected re-

gions were enhanced using image segmentation process. Experimental results showed that the proposed approach achieved a very high accuracy in classifying PD patients into five clinical stages of PD progression.

Finally, a classification model was utilised to streamline the process of identifying PD patients for surgical treatment using only clinical data. A feature selection process was used to identify the essential features and determine if the accuracy could be improved. Two experiments were carried out to test this hypothesis. In experiment 1, the best classifier for PD classification was identified. In experiment 2, feature selection process was implemented to determine the essential features. Experimental results indicated that, with only 60% of the features, the accuracy was higher than the benchmark studies.

The significance of these studies is that we propose effective machine learning-based approaches to diagnose PD at its earlier stages, so that the management and prognosis of PD patients can be significantly improved. Given the high performance of our approaches, we believe that the early diagnosis of PD can be done, which will revolutionize PD diagnosis and management.

Acknowledgements

This research would not have been possible without the guidance and the help of many people.

First of all, I would like to thank my supervisor, Prof. Xiangjian He, for his guidance, support and encouragement in my academic career. I have learned so much from him in regards to research and academic writing. I know that Prof. Xiangjian He has always been doing his best for me and believe his knowledge, experience and vision enabled him to help me do my best in my academic career.

I would also like to express my gratitude to my co-supervisors, Dr. Yiguang Lin and Prof. Jinjun Chen. Dr. Yiguang Lin has provided me with valuable and constructive comments that helped me refine my writing skills. I believe that what I have learned from him will be a valuable asset for me in the future. In addition, their guidance, comments and suggestions during the course of my PhD research have been invaluable. Prof. Xiangjian He, Dr. Yiguang Lin and Prof. Jinjun Chen are nice and humble and have a very good reputation in our research community.

Finally, I would like to express my love and gratitude to my parents and my family. I am extremely grateful for their love, prayers and moral support to complete my PhD studies. Being a member of such a wonderful family is the most beautiful thing that happened to me. Thank you very much for everything you have done for me.

Farhan Mohammed

Author's Publications for the PhD

Book chapter

B-1. **F. Mohammed**, X. He and Y. Lin,"Applications of Machine Learning Techniques in the Diagnosis of Parkinsons Disease: Promises and Challenges," *mHeath for Belt and Road Initiative: mHealth for Parkinson's Disease*, (pending publication)

Journal Papers

J-1. **F. Mohammed**, X. He and Y. Lin, "Easy-to-use Deep Learning Model for Highly Accurate Diagnosis of Parkinson's Disease using SPECT Images," *Computerized Medical Imaging and Graphics*, (pending publication).

Conference Papers

C-1. **F. Mohammed**, X. He, Y. Lin and J. Chen, "A Novel Model for Classification of Parkinsons Disease: Accurately Identifying Patients for Surgical Therapy, *Proc. of 52nd Hawaii International Conference on System Sciences (HICSS-52)*, Hawaii, USA, January, 2019. (ERA Tier A conference)

Contents

List of Figures

List of Tables