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Prediction of Parkinson's Disease Using Deep Learning in TensorFlow

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ABSTRACT

One of the most common neurodegenerative disorders of the present age is Parkinson's Disease or Parkinsonism. To estimate its advancement in the patient, huge amounts of data are being collected and studied to draw out inferences. The types of data generally studied towards that end are vocal data, body movement data, eye movement data, handwriting and drawing patterns, etc. In this work, the use of a deep neural network has been proposed to predict the Unified Parkinson's Disease Rating Scale (UPDRS) both motor and total by studying vocal data from UCI Machine Learning Repository. Both two layered as well as three layered networks were studied, and it was found that the performance of three-layer deep neural network having 10, 20, 10 neurons in different layers was found to be the best with an accuracy of 97% and 99.62% for motor UPDRS and total UPDRS, respectively. The other three parameters, MSE, MAE, and RMSE, also showed improvement in the three layered model as compared to the two layered model.

KEYWORDS

Deep Neural Network, Keras, Parkinson's Disease, TensorFlow, UPDRS, Vocal Data

INTRODUCTION

Parkinson's Disease is the second most common neurological disorder after Alzheimer's (Post et al., 2007; Pringsheim et al., 2014) Globally more than 7 to 10 million people are estimated to be suffering from Parkinson's Disease (PD). Although the disease in itself is not fatal, but it affects the quality of life of the suffering person drastically, even leading to a comparatively shorter expectancy of life than their healthy counterparts.

The degradation in quality of life is judged by the difficulties faced by the people in carrying out day to day activities, for example holding a pen straight in hand for some time, walking without trembling, etc. Major symptoms that appear in PD are: an involuntary shaking or tremor in the body, slowed down movement of limbs called bradykinesia, difficulties in sitting and standing, loss of balance, stiffness of muscles, drooping face, speech impairment, difficulty in writing and drawing,

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eventual loss of control over finger movement, unstable posture, etc (Jankovic, 2008; Marusiak et al., 2010; Moore et al., 2007).

Even though a lot of research has been conducted on PD since decades, the primary cause behind the disorder in many cases is not known. However, in 1961, a strong link between the levels of neurotransmitter dopamine in the brain and PD was deciphered. Death of neurons and lack of their regeneration in the basal ganglia portion of the brain leads to a decrease in the dopamine level which is diagnosed in a vast number of PD cases. Hence the treatment of dopaminergic therapies is used to slow down the advancement of the disease. Complete recovery is never guaranteed though.

Deep Learning for PD Prediction

In the present age, when Artificial Intelligence is changing the status quo in every aspect of our lives, its subdomain of Machine Learning including Deep Learning is making strides in the healthcare sector as well. Methods like Support Vector Machines, Naive Bayes, Random Forests, Artificial Neural Networks, etc. are being excessively used in the prediction of diseases such as various cancers, diabetes, neurological disorders from medical data (Chen et al., 2019; Fathi et al., 2020; Narayan & Dwivedy, 2021). A lot of research is also being done to predict PD from various sorts of data collected from the patients, and good results achieved, generally from Deep Neural Networks like Convolutional Neural Networks. Over the years the tool that has been trusted the most for assessing PD is the Unified Parkinson's Disease Rating Scale (UPDRS) endorsed by Movement Disorder Society (MDS) (Disease, 2003; Evers et al., 2019). The scale consists of four parts that in combination assess the development and severity of all the 65 major characteristics of the disorder, on a total score of 0 to 260 i.e. 0 to 4 on each characteristic. The upcoming literature review section is filled with many examples of classification of subjects as suffering or non-suffering from PD, by using ML or DL techniques. A substantial amount of data is available in repositories over the internet, which is generally being used to create models that can classify the subjects into suffering or normal. Our study however, takes a different approach and uses voice data of PD patients to predict the UPDRS values which can be used further for prediction of disease severity.

RELATED WORK

Various data mining techniques have been used by researchers for prediction of Parkinson's Disease on different types of data. Even though a varied variety of datasets have been used to conduct the studies but a look at the huge amount of literature available over the internet clearly suggests the preference of scientists to validate their results on Acoustic or Voice data collected from patients as well as control individuals. During the course of this study, a similar pattern has been found wherein lots of results are available for Speech data, some of which have been included. Even though the type of data used is similar in many cases, but the studies conducted and the results obtained vary significantly, from a 9 layered CNN used by (Gunduz, 2019) with the best accuracy of 86.9% and various ML algorithms employed for the task by (Wroge et al., 2018) to an 18 layered ResNet showing a massive accuracy of more than 91%, voice data has yielded very distinguishable results. Other methods applied include a mobile application - based CNN called DeepVoice by (Zhang et al., 2018), Adaptive Grey Wolf Optimization Algorithm compared to six traditional Machine Learning models in (Xiong & Lu, 2020) and SVM, stacked AutoEncoder and Softmax Classifier by (Karan et al., 2020). Also, (Al-Fatlawi et al., 2016) uses a Deep Belief Network to carry out the same exercise with an overall accuracy of 94%. Apart from using only voice to detect PD, a few instances were found where multimodal data like voice in combination with other features were used. (Wan et al., 2018) proposed methods that worked on combination of voice and movement data collected via smartphones whereas (Taleb et al., 2019) used a database of handwritings, voice recordings, eye movements of patients to formulate CNN and CNN_BLSTM towards the end of PD detection.