

Early stage prediction of Parkinson's disease using Deep Neural Networks

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Abstract - Parkinson's disease (PD) is a long-term chronic disorder of the central nervous system that mainly affects the motor system. It disturbs the nerve cells in the brain that produce dopamine. The symptoms of Parkinson's disease includes muscle rigidity, tremors and changes in speech.

The objective of the survey is to analyze and predict the Parkinson's disease in early stages. As the symptoms worsen, it may deteriorate the motor and non-motor system of the patients. Thus, it is important to predict the Parkinson's disease at the early stages. The proposed system concentrates on improving the Parkinson's disease diagnosis with impressive experimental results using Artificial Neural Networks (ANN), Deep Neural Networks (DNN) and Support Vector Machine (SVM).

Key Words: **Parkinson's disease, Deep Neural Networks, Artificial Neural Networks, Prediction**

1. INTRODUCTION

Parkinson's disease (PD) is a disorder of the nervous system. It is prevalent throughout the world and mainly affects the patients above 60 years. It is a neurodegenerative disorder that affects predominately dopamine producing neurons in a specific area of the brain called substantia nigra. This leads to a reduction in a chemical called dopamine in the brain. Dopamine plays a vital role in the coordination of movement. It acts as a chemical messenger for transmitting signals within the brain. Due to the loss of these cells, patients suffer from movement disorder. [1] People with Parkinson's disease also lose the nerve endings that produce norepinephrine, the main chemical messenger of the sympathetic nervous system, which controls many automatic functions of the body such as heart rate and blood pressure. The four primary symptoms of PD are tremor, or trembling in hands, arms, legs, jaw and face; rigidity or stiffness of the limbs and trunk; slowness of movement; and postural instability, or impaired balance and coordination. PD is both chronic, meaning it persists over a long period of time, and progressive, meaning its symptoms grow worse over time. Although some people become severely disabled, others experience only minor motor disruptions. Tremor is the major symptom for some individuals, while for others tremor is only a minor complaint and other symptoms are more troublesome. [2] It is currently not possible to predict which symptoms will affect an individual, and the intensity of the symptoms also varies from person to person. In addition to these motor-related symptoms, non-motor symptoms such as cognitive impairment, mood and behavioral problems, sleep disorders, and constipation can

significantly impair quality of life and require careful symptom-based treatment. Some non-motor symptoms such as hyposmia (reduced ability to detect odors), REM sleep-behavior disorder and constipation typically precede the motor symptoms by several years. Other non-motor symptoms such as cognitive impairment commonly appear after the onset of motor symptoms. Currently available PD medications do offer valuable symptomatic relief, but as PD progresses, their use is often associated with significant and sometimes intolerable side effects. For example, levodopa, one of the most effective treatments for PD can normalize motor function for years but later cause involuntary muscle movements known as dyskinesia and dystonia (sustained muscle contractions). [4] In addition, people in the mid to late stages of PD often experience a wearing-off of the beneficial effects of PD drugs and a re-emergence of motor and non-motor symptoms before their next scheduled dose. In more advanced PD, drug-resistant motor symptoms (e.g., postural instability, freezing of gait, loss of balance, frequent falls), behavioral changes (impulse control disorders, hallucinations, and psychosis), and often dementia are leading causes of impairment. [3]

Parkinson's signs and symptoms may include:

Tremor: A tremor, or shaking, usually begins in a limb, often your hand or fingers. Patient may a rub your thumb and forefinger back-and-forth, known as a pill-rolling tremor. Patient's hand may tremor when it's at rest.

Slowed movement (bradykinesia): Over time, Parkinson's disease may slow your movement, making simple tasks difficult and time-consuming. Patient's steps may become shorter when you walk. It may be difficult to get out of a chair. Patient may drag one's feet as they try to walk.

Rigid muscles: Muscle stiffness may occur in any part of your body. The stiff muscles can be painful and limit the patient's range of motion.

Impaired posture and balance. Patient's posture may become stooped, or may have balance problems as a result of Parkinson's disease.

Loss of automatic movements: Patient may have a decreased ability to perform unconscious movements, including blinking, smiling or swinging your arms when they walk. **Speech changes.** They may speak softly, quickly, slur or hesitate before talking. Patient's speech may be more of a monotone rather than with the usual inflections.

Writing changes: It may become hard to write, and writing may appear small. The disease has no permanent cure; however, the symptoms can be treated with medications. [5]

2. LITERATURE SURVEY

Different researches have used various features and data in order to predict the Parkinson's disease.

The authors Zahari Abu Bakar, Nooritawati Md Tahir and Ihsan M Yassin present the Classification of Parkinson's disease based on Multilayer Perceptron Neural Network. In this paper the algorithms used were Levenberg Marquardt and Scaled Conjugate Gradient. The advantage of this model is while the LM algorithm showed accuracy of 97% for training data and 92% accuracy for test data, SCG algorithm showed accuracy of 79% and 78% respectively. The disadvantage is that the above-mentioned accuracy was obtained only for certain number of hidden units that is, in LM algorithm when the number of hidden layers were 25 the aforementioned accuracy was obtained and for SCG the count was hidden layers was 10 for the accuracy obtained.[1]

The authors Sonu S.R, Ravi Ranjan, Vivek Prakash, Saritha.K, in their paper Prediction of Parkinson's Disease using Data Mining, have used Decision tree and Logistic Regression for data of voice recordings of the patients. This model gives a 100% accuracy in decision tree and a 90% accuracy in logistic regression when no feature was selected. However when features such as voice jitter, voice frequency etc. were selected, the prediction only provided a varying accuracy in the range of 84% to 92% for decision tree. [5]

The authors Aarushi Agarwal, Spriha Chandrayan and Sitanshu S Sahu present their paper Prediction of Parkinson's Disease using Speech Signal with Extreme Learning Machine. In this paper the analysis is performed on the voice sample of the patients. The dataset used is taken from the UCI repository and the model yielded 81.55% and this system proved to be more accurate than neural network and support vector machine. [2]

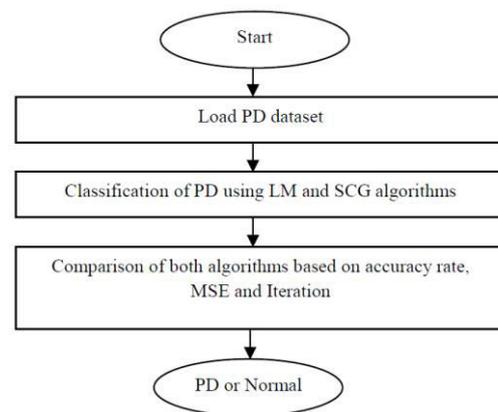
The authors Oana Geman and Luliana Chiuchisan, present the Deep Brain Stimulation efficiency and Parkinson's disease stage prediction using Markov's Models. This model has helped in the stage prediction of Parkinson's and using Deep Brain Simulation procedure that part of the brain which is responsible for the tremors is electrically simulated which relieves it. But, this method is minimally invasive and expensive therefore not suitable for all population groups and these symptoms come back with time as there is no permanent solution. [3]

The authors Mrugali Bhat, Sharvari Inamdar, Devyani Kulkarni, Gauri Kulkarni and Revati Shriram, present the paper Parkinson's disease Prediction based on Hand Tremor Analysis. In this paper the analysis is performed using accelerometer as a sensor for measuring the frequency of tremors caused. The proposed system is non-invasive and reliable for the prediction of Parkinson's disease. But, the prognosis was only based on the tremors that were caused as a symptom of Parkinson's. So, these predictions can be inaccurate for those patients who experience these tremors in later stages of the disease. [4]

3. METHODOLOGY

Parkinson's is a disease with no cure therefore, efforts are made to detect this disease in its initial stage so that necessary medications can be given to the patients to minimize the effects of its symptoms.

The authors Zahari Abu Bakar, Nooritawati Md Tahir and Ihsan M Yassin in their paper have used Multilayer Perceptrons neural network with two different algorithms for the classification. They have trained LM algorithm and SCG algorithm with Parkinson's disease dataset and then their accuracies, iteration and MSE are compared to find which algorithm gives maximum correct classification. The below flow diagram describes the various stages followed in the classification. [1]

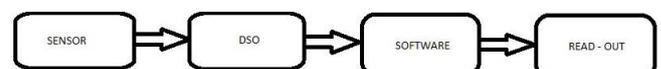


Overall block diagram of PD classification using MLPs with LM and SCG algorithms. [1]

The authors Aarushi Agarwal, Spriha Chandrayan and Sitanshu S Sahu in their paper have used Extreme Learning machine with the use of speech samples from the patients. These speech samples are then used for feature extraction and then categorized into six features which are used for the classification technique. [2]

The authors Oana Geman and Luliana Chiuchisan in their paper present the classification using Markov's model. The main aspect of this process is that given the present state, the future states are independent of the past. This process considers the transition matrix therefore, for Parkinson's disease, the evolution of patient's health status is used for the same. [3]

The authors Mrugali Bhat, Sharvari Inamdar, Devyani Kulkarni, Gauri Kulkarni and Revati Shriram have described in their paper the four main components used for the classification of the Parkinson's disease. They use sensors for the analysis of the hand tremors in the patients whose tremors lie in between the range 3Hz-8Hz. Then these tremors are then converted to digital signal which are stored as .csv file and then MATLAB programming is used to build the system. [4]



Basic Block Diagram of the proposed system. [4]

The authors Sonu S.R, Ravi Ranjan, Vivek Prakash, Saritha K in their paper have used data mining techniques for the classification of patients of Parkinson's disease. The voice recording samples of the patients are used to train system using the CART algorithm. This is done by converting the patient's voice into attributes like jitter, frequency etc. using PRAAT script. [5]

4. CONCLUSION

From the above discussions we are able to conclude that though many algorithms and models have been implemented most of them have given minimum accuracy in the prediction of the disease. Therefore, in the proposed system we build three models for which the comparison is done to find which model provides the best result. The model providing the most accurate results can then be used by hospitals, organizations etc. for the prediction of Parkinson's disease.

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