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A Review on Parkinson's Disease Diagnosis using Machine Learning Techniques

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***Abstract*— Parkinson disease is a neurodegenerative disorder that affects nervous system and the root cause of it is falling rates of dopamine levels in the forebrain. It is a chronic degenerative disease with progressive illness, which means it develops new symptoms over time[20]. This happens with progressive neuronal loss in the substantia nigra of brain. People with PD cannot do their works as a normal human. Though clinical assessments considered ample amount of data that include various features, sometimes it is hard to decide whether a person is suffering from PD or not based on the type of data, feature selection methods help to solve this issue. Various methods are developed, proposed, and analyzed to detect the Parkinson disease, given the required data. This paper is a survey of predicting Parkinson disease using machine learning algorithms, various new technologies applied, and their accuracies achieved.**

***Keywords*— *PD (*Parkinson Disease), dopamine, SVM (Support Vector Machine), KNN (K Nearest Neighbor), ANN (Artificial Neural Network).**

1. INTRODUCTION

Parkinson disease mainly effects central nervous system and is observed to be affected on many people globally. Most of the people suffering with PD are observed to be physically and emotionally draining. They even feel depressed, trouble concentrating on things, painful spasms etc. PD has a large spectrum of clinical features ranging from motor to nonmotor symptoms. Some of the motor symptoms are hypophonic speech, rigidity, resting tremor. Non-motor symptoms are as hallucinations, depression, constipation, sleeping disorders, cognitive impairment, and impulse control disorders. Non motor symptoms show sickness than motor symptoms [1,3]. Most of the cases, physicians find it difficult to envisage whether a given patient is already affected by the disease or is expected to develop the Parkinson's disease[7]. To conquer this, development of some computing model must be done that evaluates and summarizes the data of a given patient and predicts with adequate accuracy where he/she will have development of PD. Most of the PD patients are observed with symptoms called voice impairment which is known as dysphonia. There are several measures related to dysphonia, out of which voice related problem can be used to assess the patients at various stages[14].
This paper is a survey of prediction of PD using Machine learning and Deep learning techniques that generated good models and potency of those algorithms in terms of accuracies achieved, also about different methodologies applied.

2. LITERATURE SURVEY

2.1 Importance of Voice data:

Speech or voice data is assumed to be 90% helpful to diagnose a person for identifying presence of disease. In general, Person with PD suffer from speech problems, which can be categorized into two: hypophonia and dysarthria. Hypophonia indicates very soft and weak voice from a person and dysarthria indicate slow speech or voice , that can hardly be understood at one time and this causes because of damage to central nervous system. So, most of the clinicians who treat PD patients observe dysarthria and try to rehabilitate with specific treatments to improvise vocal intensity.

2.2 Survey carried out for the diagnosis of PD with different algorithms and approaches:

Several strategies are recorded for early detection of PD based on the different ML techniques. But accuracy in detection and classifying within the time is very important or else, it causes development of more symptoms. There are different kinds of data, brain MRI images, Voice data, posture images, senor captured data, handwritten data, using which we can predict whether person is having PD or not. Out of all those , speech or voice data helps in identifying PD accurately.
Eduardo Tolosa et al proposed a twofold fully automatic approach with 3D images has shown promising results in their experimentation [4].

Max A. Little et al presented a new dysphonia measure, pitch period entropy (PPE) and used a kernel support vector machine and has achieved classification accuracy of 91%[10].

RAINER SCHO¨ NWEILER et al identified a different approach which used voice analysis with ANN and got good results but observed that cost-effectiveness remains to be a challenge[5].

Marius Ene et al suggested NN based approach with three types of internal methods and discriminated persons having PD with healthy persons[7].

DAVID GIL A, MAGNUS JOHNSON B found that with a smaller number of neurons at hidden layer both training set and test sets performed poorly. With higher number of neurons, the training set performed well with high risk of

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over fitting. The ideal solution for this layer was found to be 13 neurons[8].

Ipsita Bhattacharya et al identified the ROC curve variation and identified that values of TP and FP rates show changes while increase in the CV folds[13].

Freddie Åström et al proposed unique approach of parallel neural networks and then outcome of each neural network is assessed by using a rule-based system for the decision. During the training process, data that is not yet learned of each neural network is collected and applied in the training set of the later neural network. This helped to increase prediction accuracy[14].

Athanasios Tsanas et al developed a novel algorithm based on speech signals but it's questionable as most of the features are not considered here, only 10 features are used[15].

Hui-Ling Chen et al proposed FKNN centered system using a 10-fold cross validation method[17].

Mohammad S Islam et al has compared various ML techniques based on their performance accuracies in determining whether person is having PD or not and mentioned that new classifier may be built to get better accuracies[18].

Bo Penga et al suggested Computer Aided Analysis with image data and used BrainLab software for processing the images and calculate thickness of the cortex, volume of gray matter, and surface area of the cortex on each region of interest (ROI). Use of Multilevel ROI-based features improved the classification performance[19].

Derya Avci and Akif Dogantekin proposed another approach using Genetic Algorithm-Wavelet Kernel-Extreme Learning and achieved good accuracy results[22].

R Prashanth identified that multimodal features can be used to predict PD in earlier stage[23].

Satyabrata Aich proposed a unique approach by using Genetic algorithm and PCA as feature selection methods and applied seven ML algorithms for classification, that saved time and productivity while doing pattern classification with two categories such as PD and not PD[25].

Leandro A. Passos compared ResNet-50 , Optimum-Path Forest (OPF) classifier with Support Vector Machines (SVM) and Bayes and achieved 96% of identification rate[37].

Deepak Gupta followed a different approach cuttlefish algorithm and used for feature selection,
different fitness functions approximations are used to improve cuttlefish algorithm and is termed as Optimized cuttlefish algorithm (OCFA).Decision tree and K-Nearest Neighbor classifiers are applied and achieved 94% of accuracy in detecting PD effected patients [36].

Salama A. Mostafa proposed
(i) Multiple Feature Evaluation Approach (MFEA) of a multi-agent system (ii) Implementation of five classification schemas which are Decision Tree, Random Forests, Neural Network, Naïve Bayes and Support Vector Machine on the Parkinson's diagnosis before and after applying their approach, and (iii)Author approach witnessed the following average rate of accuracies : Decision Tree achieved accuracy of 10.51%, Naïve Bayes shown 15.22%, Neural Network is found with 9.19%, Random Forests and SVM performed with 12.75% and 9.13% respectively.[34]

S.No	Author Name	Year	Methodology	Input data	Performances
1	Ali H. Al-Fatlawi et al	2016	Deep belief network, Restricted Boltzmann Machines ,Back propagation algorithm	Voice data	Acc: 94%
2	Marius Ene et al	2008	Probabilistic neural network (PNN)	Speech samples	Accuracies ranging between 79% and 81%
3	David Gil A, Magnus Johnson B	2009	ANNs and SVMs	Speech	90%
4	Chien-Wen Cho et al	2009	Principal component analysis with linear discriminant analysis.	Voice samples	95.49%
5	Max A. Little et al	2009	SVM	Voice recordings	classification performance of 91.4%
6	Resul Das et al	2010	Neural Networks, DMneural, Decision Tree and Regression	Speech	Score of 92.9% is achieved
7	C. Okan Sakar & Olcay Kursun	2010	SVM	Speech data	classification accuracy:92.75%
8	Zachary C.Lipton et al	2016	Long Short-Term Memory (LSTM-RNN) with forget gate, MLP	Voice data	Several accuracies are compared.
9	Ipsita Bhattacharya et al	2010	Used LibSVM for classifying along with random split of the dataset, and determine accuracy for the different kernel functions	speech	Improved average accuracy achieved.
10	Freddie Åström et al	2011	Used a different neural network to minimize the probability of outcome with error	Voice data	Total nine parallel neural networks are arranged and achieved development of 8.4%

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					for the prediction of PD compared to single network
11	Athanasios Tsanas et al	2012	Speech signal processing algorithms, RF,SVM	Voice signals	99%
12	Indrajit Mandal et al	2017	Multinomial logistic regression, rotation forest together with SVM and PCA, ANN, boosting methods	Speech	100% accuracy achieved with sparse multinomial logistic regression and linear logistic regression, observed sensitivity:0.983 and specificity: 0.996
13	Hui-Ling Chen et al	2013	FKNN,SVM	Speech	96.07% obtained by the FKNN dependent system using a 10-fold CV method
14	Tarigoppula V.S Sriram et al	2013	SVM,KNN,NB,RF	Voice data	Random Forest shown better accuracy
15	Mohammad S Islam et al,2014	2014	SVM, Random Tree and Feedforward Back-propagation built Artificial Neural Network.	Speech	90% recognition accuracy
16	Oana Geman et al	2015	SVM,DNN	Voice data	90% accuracy achieved
17	Bo Penga et al	2015	t-test, SVM, and Minimum Redundancy and Maximum Relevance.	Speech impairment data	Proposed method used multilevel ROI-based features and is observed better classification accuracy..
18	Othman Ibrahim , Mehrbakhsh Nilashi, & Ali Ahani	2016	PCA is used for feature selection, EM, ANFIS and Support Vector Regression (SVR).	Voice data	SVM:AUC-0.9623 ANFIS:AUC-0.848
19	Hui-Ling Chen et al	2016	Extreme learning machine and kernel ELM	Speech samples	10- fold cross validation through 10 runs achieved 96.47% accuracy
20	Derya Avci and Akif Dogantekin et al	2016	Genetic Algorithm, wavelet kernel and Extreme Learning Machines(ELM).	Voice data	96.81%.
21	Thomas J. Hirschauer	2015	EPNN (Enhanced Probabilistic Neural Network	Speech	98.6 %
22	Lígia Sousa et al	2019	DNN, KNN,PCA (for optimizing feature set)	Voice samples	93.4% for the binary classification,84.7% for multiclass classification.
23	Leandro A. Passos	2018	ResNet-50 , Optimum-Path Forest (OPF) classifier	HandPD dataset, speech	96% of identification rate using speech samples.
24	Deepak Gupta	2018	Optimized cuttlefish algorithm ,Decision tree, KNN	Speech data and Handwritten data are used to evaluate the proposed model.	94%
25	Shreya Bhat	2018	Along with advanced machine learning methods, Neuroimaging modalities also used	Image data, speech, ,MRI, EEG	(Various implementations are discussed)
26	Hariharan et al	2014	Gaussian mixture with PCA and LDA. SVM classifier	Speech data	100%
27	Zhang et al	2017	Stacked autoencoders, KNN	Speech	In the range of 94-98%
28	Oung et al	2018	Classifiers used are KNN, PNN, ELM classifiers.	Motion and Speech	KNN:93.26% PNN: 95.22% ELM: 95.93%
29	Hlavnicka et al	2017	Zero-crossing rate, variance of autocorrelation function.	Speech	Accuracy: 71.30% Sensitivity: 56.70% Specificity: 80%
30	Salama A. Mostafa	2018	Decision Tree, Random Forests, Naïve Bayes, Support Vector Machine and Neural Network.	Voice data	Avg rate of improved accuracies achieved are: Decision Tree: 10.51%, Random Forests: 12.75% Naïve Bayes:15.22%, Support Vector Machine: 9.13%, Neural Network: 9.19%
31	Rainer schonweiler et al	2000	Artificial neural networks, Regression tree	Voice data	Various combinations of methods applied and achieves improved accuracies.

Table 1: Summary of the survey of various methodologies and their performances

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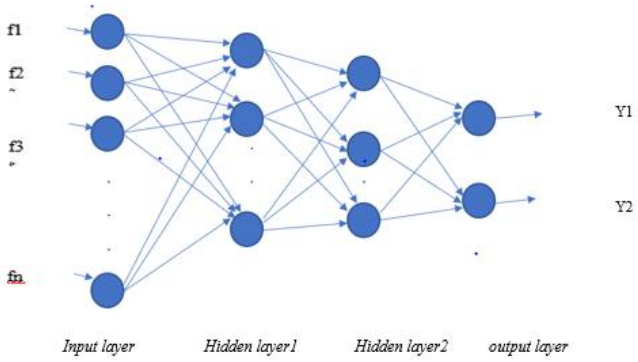
It is important to note that , out of all ML techniques, ANN and SVM classifier are used most of the proposed algorithms to aid faster and accurate the prediction.

As per the survey, we observed that most of the models used voice/speech data for efficient diagnosis of the disease and because it is preferred by most of the therapists to consider voice data as relevant feature.

3. ARCHITECTURE OF ANN

The following figure represents architecture of Artificial Neural network with an input layer, hidden layer(s) and an output layer. Number of hidden layers for each network varies from one another.



Every circle in the above network represents a neuron at which the inputs and corresponding weights are processed layer by layer.

Input Layer:

An input layer accepts large volumes of data as input to build the neural network. The data can be in the form of text, image, audio, etc. In general, the input layer contains features of the dataset, each node of input layer in the above architecture represents one feature

Hidden Layer:

Every hidden layer receives the input feature along with their weights, where weights of every feature indicates their contribution towards the decision or prediction. Hidden layer processes the data at each node by performing complex computations and helps in feature extraction. Nodes at first hidden layer receives product of input feature with its weights value and is passed as input

to next hidden layer and so on. Choosing number of hidden layers and number of nodes for every hidden layer varies with the problem as well as dataset.

Output Layer:

At output layer Processing of nodes are determined by the functions called as activation functions like tanh, sigmoid, ReLU. Depending on the kind of dataset and criteria , one can decide suitable activation function. Output layer receives the output generated by last hidden layer as input and generates an output in the desired form.

4. DISCUSSIONS

Machine Learning techniques has got prominent role as they are applied in variety of domains especially in the healthcare. Unlike traditional methods, the models generated by applying ML techniques show dynamic outputs as data is fed into it. One shall make note that significant and narrow research is needed to obtain knowledge in diagnosing the disease. Various machine learning algorithms and techniques are being proposed rapidly, out of which some are observed to be promising with the results and few demonstrated their usage in different fields. Advantage with the ML generated models is that when more data is used, the precision values gets increased and the much accuracy in predictions can be gained.

5. CONCLUSION

This paper is an effort to present broad review about Parkinson disease diagnosis system that have applied various machine learning techniques. The summary of results obtained by different researchers is made available in literature survey table , almost all the authors/researchers made great efforts to predict the Parkinson disease with novel approaches. It can be identified that maximum of all ML techniques used by various authors worked better but developing a very faster classifier using novel architecture of neural network combined with specific approach may work better. To achieve this, we try to implement artificial neural network with different number of hidden layers and number of nodes in future and compare all the accuracies.

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