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# Diagnosis of Parkinson's Disorder through Speech Data using Machine Learning Algorithms

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***Abstract: Parkinson's disease is a neurodegenerative disorder that affects millions of people around the globe. Detecting Parkinson's disease at an earlier stage could help to better diagnose the disease. Machine learning provides potentially large opportunities for computer-aided identification and diagnosis that could minimize unavoidable health care errors and inherent clinical uncertainty, provide guidance, and improve decision-making. In this paper, we explore the feature extraction and prediction algorithms used to predict Parkinson's disease and provide a comprehensive comparison of these algorithms.***

***Keywords: Parkinson's disease, PD, datasets, SVM, KNN, Genetic Algorithm, UPDRS.***

## I. INTRODUCTION

Parkinson's disease is a neurological dysfunction of the central nervous system that affects the physical movements of the body. The motor system is the series of central and peripheral nervous system structures that support motor, i.e. movement functions. Skeletal muscle and neural tissue connections may include peripheral structures. PD is caused by the loss of nerve cells in the brain, known as substantial nigra, which releases a chemical known as dopamine. Dopamine serves as a messenger to regulate and organize body movements between the brain and nervous system parts. If the nerve cells are destroyed or damaged, dopamine will diminish in the brain, causing slow and abnormal movements.Worldwide, over millions of people affected by PD. The occurrence of Parkinson's disease increases exponentially, but it is estimated that 4% of people with PD have been diagnosed before 50 years of age. In Men, the chance of Parkinson's disease is 1.5 times greater than in women. Usually, the symptoms appear slowly. Screams, slow motion (bradykinesia), muscle rigidity, weakened equilibrium and stability,

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motor function impairment, voice improvements, changes in writing are some of the main symptoms.Machine learning provides almost enormous potential for computer-aided detection and diagnosis that could minimize unavoidable errors and latent clinical uncertainty in healthcare, provide feedback and speed up decision-making. Voice information [1-3], gait patterns [4-5], force monitoring data [6], single-photon emission computed tomography (SPECT) scan data [7] and odor
recognition data have been used to solve the problem of PD identification via machine learning techniques.

A speech dataset can be used accurately to determine whether or not a person suffering from Parkinson's disease [8-10] [16-17]. Factors such as voice pitch, jitter, and frequency can be used to distinguish PD patients from normal persons. Considering different attributes, supervised and unsupervised training methods are used to assess the person on a generic measurable scale. In this paper, we explore different types of machine learning models applied to speech datasets to analyze and predict the symptoms of Parkinson's disease. predict the symptoms of Parkinson's disease.

## II. METHODOLOGY FOR VOICE FEATURE EXTRACTION

Mohammad Shahbakhi et al. suggested a new algorithm based on voice analysis to diagnose PD [8]. The first step is to select the optimized characteristics of all extracted characters using a genetic algorithm (GA). The genetic algorithm is an efficient heuristic algorithm focused on the choice of human and genetic ideas for evolution. It is one of the most important methods are used in the classification of data to pick optimized features. Mohammad Shahbakhi et al. used a sample of 195 continuous vowel phonations of 31 men and women, of which almost 23 were diagnosed with PD. An average of six phonations of 1 to 36 seconds was reported in each subject. Phonations were recorded at 8 cm from the lips on an IAC sound-processed booth with a head-mounted microphone (AKG C420). The speech signals have been captured with the 16-bit resolution directly to the machine with CSL 4300B (Kay Elemetrics) equipment. Betul Erdogdou Sakar et al. proposed a model [9] with a data set of 42 PD patients tracked at weekly intervals over 6 months. The PD suffered patients who were analyzed within the past five years at the preliminary beginning on the off chance that he/she had any two of the accompanying side effects: stiffness, rest tremor, without proof of different types of Parkinson's.

Some simple frequency measurements, different amplitude varying measures, harmonic-to-noise ratios, signal fractal scaling exponent, nonlinear dynamic complexity analysis, and pitch entropy are included in the feature setThe Parkinson's (UPDRS) threshold is first determined in the differential grouping. They use a two-stage approach in their model. Firstly, they determine the optimum UPDRS threshold value, which can be distinguished by the vocal function with the lowest possible error rate. Such functions are provided for Support of Vector Machinery (SVM), Extreme Learning Machines (ELM) and k-classifiers (K-NN) is used for each of the binary classification problems solved by various UPDRS values. They also take into consideration the metric of the Matthew Correlation Coefficient (MCC) to determine the maximum predictable threshold value of UPDRS. Finally, simulation and clustering of the main components are conducted in order to find the desired threshold values. The significance of the human vocal characteristics is later quantified using Mutual Information (MI) with the discrete UPDRS ranking. Therefore, the vocal characteristics that change dramatically concerning the degree of motor system disorders as determined by UPDRS have been defined for PD detection.Timothy J. Wroge et al. [10] suggested a system where the human voice was captured and the raw audio is actively removed with the Voice Activation Detection (VAD) algorithm [11] to isolate and eliminate background noise from the audio until feeding into the feature extraction algorithm. Methods derived from the 2013 Audio-Visual Emotion Recognition Challenge (AVEC) [12] are used for preliminary audio analysis and the Minimum Redundancy Maximum Relevance (mRMR) [13] method is applied to these 2013 AVEC audio features. After that, the cleaned audio is transmitted through two separate extraction algorithms before entering the system models. Then, the raw audio is transferred to the Geneva Minimalistic Acoustic Parameter Set (GeMaps) algorithm [14] for extracting the features using an open smile toolkit [15] before it is sent to machine learning patterns. The GeMaps feature algorithm extracted lower-level characteristics, including loudness, pitch, shimmer, jitter, and harmonic-to-noise ratio.Satyabrata Aich et al. have implemented a model [16] which helps to classify Parkinson affected people from normal people based on voice datasets. The model's database contains speech samples for 31 individuals, 23 of whom have been diagnosed with PD. For data reduction and function collection, they have used two algorithms. First, they have used Primary Component analysis (PCA) which reduces the space dimension in order to visualize the data in a small dimensional space. They also used feature sets based on the genetic algorithm (GA) to pick features.

R. Arefi Shirvan et al [17] proposed a method for detecting PD using the Genetic Algorithm and KNN Classification Method. They collected voice signal samples of healthy people and Parkinson affected people and they extracted various features such as Fo (Hz), Jitter (%), Flo (HZ), Jitter (ABS), Shimmer, Fhi (Hz), Jitter (RAP), Shimmer (APQ5) and Harmonics-to-Noise Ratio (HNR) from the voice signals. Later, using the genetic algorithm, they extracted the optimized features which mainly affect the process of classification of data.

Table 1 shows the features extracted from the voice signal for PD prediction. The common features which are extracted and used for the disease prediction are Jitter, Shimmer, Frequency.

**Table- I: Features Extracted from speech signals for Parkinson Disease Prediction**

| References | Feature extraction Algorithm | Features extracted | Common Features |
|---|---|---|---|
| [13] | Genetic Algorithm | Jitter (RAP), Fho (Hz), shimmer (APQ5) and Fhi (Hz). | Jitter, Shimmer, Frequency |
| [14] | They performed Principal component analysis visualization, Clustering analysis and Binary classification using SVM, ELM and KNN to obtain UPDRS threshold | Shimmer, Jitter: DDP, Shimmer: APQ5 and Shimmer(dB), | |
| [15] | Using an open-source tool called OpenSmile they have extracted AVEC and GeMaps features. | pitch, jitter, shimmer, loudness | |
| [21] | Principal Component Analysis (PCA), Genetic Algorithm | Extracted 10 features | |
| [22] | Genetic Algorithm | Jitter (%), Fo (Hz), Jitter (RAP), Shimmer, Fhi (Hz), Shimmer (APQ5) Flo (HZ), HNR and Jitter (ABS). | |

## III. PREDICTION MODELS

In [8] the Support Vector Machine (SVM) for the Gaussian kernel function is used after the optimized features were removed. It is a two-layered neural network using a hidden layer of radial units and a single output neuron. The way to build that network is organized and its parameters are learned. The test samples are classified with 94.50 percent precision per 4 optimized features, as well as 93.66% per seven optimized features and 94.22% per nine optimized features: jitter (RAP), Fhi (Hz), shimmer (APQ5) and Fho (Hz) provide the best grading accuracy.In the case of [9], samples of patients that have a UPDRS score above that threshold are removed,

and a new dataset of samples whose UPDRS score is lower than this threshold, consisting of PD patient environments, and of eight healthy subjects is used for analysis. The analysis assesses the efficacy of speech characteristics
in discrimination between early PD suffered patients and healthy people with classifiers ELM, k-NN, and SVM, as well as shows the accuracy and Matthew Correlation Coefficient (MCC) of each classifier for various parameter values and types of kernels.In [10], 90 percent practice and 10 percent of research were separated following the implementation of the extraction algorithm. The dataset is presented to various models such as Random Forest, Artificial Neural Network, Decision Tree Classifier, Gradient Boosted Classifier, Extra Tree Classifier, and SVM. Among these Gradient Boosted Decision Tree provided the best classification accuracy of about 86%.In [16], the various classifications have been used: C4.5, Bagging Cart, PART, BoostedC5.0, RPART, Random Wood and SVM. All classifications are non-linear decision-making tree-based classification with the exception of SVM. SVM is the most popular method of linear grading. Throughout grouping, it uses different kernel functions. They used the kernel function radial base in this paper. They compared performance measures such as specificity, precision, positive predictive value (PPV), sensitivity and negative predictive value (npv) following a different classification approach. For GA-based feature sets, SVM classifiers offer maximum reliability of 97.57%.The below flow diagram shows the flow chart of the system for PD prediction.

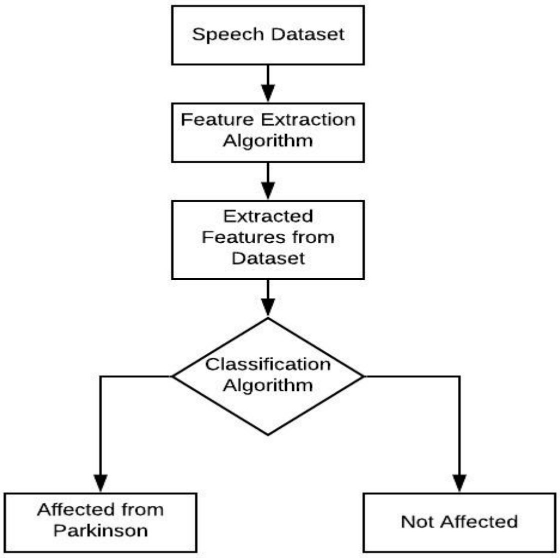


**Figure 1 System design for PD prediction**

In [17] the information classification is performed using the KNN classification system after the introduction of the genetic algorithm. The highest percentage of precision achieved is 98.2 per 9 optimized features. The 9 features showing the greatest accuracy include Fhi (Hz), Jitter(percent), Flo (HZ), Jitter (ABS), Shimmer, Fo (Hz), Jitter (RAP), Shimmer (APQ5) and HNR. Also, a 93.7 percent accuracy per four optimized features, with a 94.8 percent accuracy per seven optimized features is obtained.

## IV. RESULT ANALYSIS

The comparison of different Parkinson's speech prediction classification algorithms is shown in Figure 2. Various algorithms for machine learning have been used in the prediction of Parkinson's disease. In the KNN classifier [17], 9 tailored characteristics are usable at the maximum level of accuracy for Parkinson's disease prediction. The SVM classifier provides 97.5 percent accuracy and has the nearest performance to KNN [17]. Figure 2 shows the comparison of the exactness of the various algorithms.

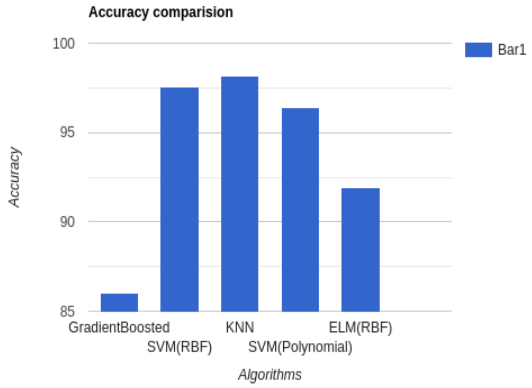


**Figure 2 Accuracy Comparison**

## V. CONCLUSION

A genetic algorithm is the most common method used to extract voice signal characteristics. For analysis, the common features considered are jittering, shimmering and voice signal frequency. Various algorithms for machine learning have been used in the prediction of Parkinson's disease. The range of prediction accuracy from applied algorithms lies between 85% and 95%, which demonstrates that machine learning algorithms can be used to predict Parkinson's disease by analyzing voice signals.

## REFERENCES

1. Alex Frid, Edmond J. Safra, Hananel Hazan, et al. “Computational Diagnosis of Parkinson's Disease Directly from Natural Speech Using Machine Learning Techniques”, in IEEE International Conference on Software Science, Technology and Engineering, 2014.
2. Made Satria Wibawa, Hanung Adi Nugroho, Noor Akhmad Setiawan, “Performance Evaluation of Combined Feature Selection and Classification Methods in Diagnosing Parkinson Disease Based on Voice Feature”, in ICSITech, 2015.
3. HakanGunduz, “Deep learning based Parkinson’s Disease classification using vocal feature sets”, in IEEE.
4. Peng Ren, Esin Karahan, Chao Chen, Ruixue Luo, et al. “Gait Influence Diagrams in Parkinson’s Disease”, in IEEE.
5. Juliana P. Felix, Flavio H. T. Vieira, Alisson A. Cardoso, et al. “A Parkinson’s Disease Classification Method: An Approach Using Gait Dynamics and Detrended Fluctuation Analysis” in IEEE (CCECE), 2015.
6. .R. Brewer, S. Pradhan, G. Carvell, A. Delitto, “Feature selection for classification based on fine motor signs of Parkinson's disease”, in Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2009.
7. I.A. Illan, J.M. Gorrz, J. Ramirez, F. Segovia et al, “Automatic assistance to Parkinson's disease diagnosis in DATASCAN SPECT imaging”.
8. Mohammad Shahbakhi, Danial Taheri Far, et al, “Speech Analysis for Diagnosis of Parkinson’s Disease Using Genetic Algorithm and Support Vector Machine”, February 2014.

9. Betul Erdogdu Sakar, Gorkem Serbes, C., et al. "Analyzing the effectiveness of vocal features in early telediagnosis of Parkinson's disease", August 9th, 2017.
10. Timothy Wroge, Yasin Serdar Ozkanca, David C Atkins, "Parkinson's Disease Diagnosis Using Machine Learning and Voice", November 2018.
11. Xiaoling Yang, Baohua Tan, Jiehua Ding, et al, "Comparative Study on Voice Activity Detection Algorithm", International Conference on Electrical and Control Engineering, 2009.
12. M. Valstar, B. Schuller, K. Smith, F. Eyben, et al, "Avec 2013: the continuous audio/visual emotion and depression recognition challenge," in ACM international workshop on Audio/visual emotion challenge. ACM, 2013.
13. H. Peng, F. Long, and C. Ding, "Feature selection based on mutual information criteria of max-dependency, max-relevance, and min-redundancy," in IEEE Transactions on pattern analysis and machine intelligence, 2005.
14. Florian Eyben, Klaus Scherer, Bjorn Schuller, Johan Sundberg, et al, "The geneva minimalistic acoustic parameter set (gemaps) for voice research and affective computing", in IEEE Transactions on Affective Computing, 2016.
15. Florian Eyben, Martin Wollmer, et al, "Opensmile: the Munich versatile and fast open-source audio feature extractor", in 18th ACM international conference on Multimedia, 2010.
16. Satyabrata Aich, Hee-Cheol Kim, Ahmed Abdulhakim et al "A Supervised Machine Learning Approach using Different Feature Selection Techniques on Voice Datasets for Prediction of Parkinson's Disease", in ICACT Transactions on Advanced Communications Technology (TACT), May 2018
17. R. Arefi Shirvan, E. Tahami, "Voice Analysis for Detecting Parkinson's Disease Using Genetic Algorithm and KNN Classification Method", in 18th Iranian Conference on BioMedical Engineering, December 2011, Iran.


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