Parkinson's Disease Detection Using Speech Analysis.

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***Abstract*—A neurological condition that affects millions of individuals worldwide is Parkinson's disease. It's critical to recognize early for the best possible care and handling of this illness. Speech analysis has become a viable method for diagnosing Parkinson's disease in recent years. This paper delineates the research focused on the identification of disease through speech analysis. The study involved collecting speech samples from individuals diagnosed with Parkinson's disease as well as those who are in good health. A variety of machine learning techniques were then used to analyze the speech data. Our findings suggest that speech characteristics including pitch, jitter, and shimmer can be highly helpful in distinguishing between healthy and affected patients. Parkinson's illness is diagnosed using algorithms such as decision trees and support vector machines. The principal aim of this study is to diagnose Parkinson's disease and ascertain the optimal machine learning algorithm by contrasting the accuracy rates of several approaches.**

***Index Terms*—Parkinson's disease, Decision tree, Support vector machine, machine learning algorithms**

I. INTRODUCTION

Parkinson's disease is a persistent neurodegenerative disorder that impacts speech, motor functions, and cognitive abilities. The disease, characterized by the gradual loss of dopaminergic neurons in the brain, manifests symptoms such as bradykinesia, rigidity, and tremors. Detecting Parkinson's disease early is crucial for successful management and treatment strategies. Nevertheless, Parkinson's disease can be difficult to diagnose, and there isn't a reliable test for the condition as of yet. The present diagnostic process frequently entails a neurologist's clinical evaluation in addition to the use of invasive and expensive imaging methods like PET and MRI scans. Speaking requires the synchronization of multiple muscles, including those involved in breathing, phonation, and articulation. It is a difficult motor effort. These muscles can be impacted by Parkinson's disease, which can alter speech patterns and provide diagnostic information.

This paper outlines the research focused on utilizing speech analysis for the identification of Parkinson's disease. The study aims to assess the viability of speech analysis as an affordable and non-invasive method for early detection of Parkinson's disease. Speech samples were obtained from both individuals without the condition and those diagnosed with Parkinson's disease, and various machine learning techniques were applied for analysis. The findings of this research hold the potential to contribute to the development of a speech-based diagnostic tool, aiding medical professionals in the timely identification and treatment of PD.

In ML technology, the decision tree algorithm is one of the most often used algorithms [1]. The decision tree method is straightforward to use and comprehend. To begin a decision tree's procedure, the best partitioner the tree's root is selected from among the qualities that can be classified. The algorithm keeps growing the tree until it reaches a leaf node.

Support vector machine technology is another powerful approach in machine learning [2]. The Support Vector Machine Algorithm first displays each data item as a point in an n-dimensional space. It next creates dividing lines, or hyperplanes, to split the data into two groups and displays them.

A popular machine learning technique called Random Forest [3] chooses attributes iteratively in order to construct trees. Its strength is in ensemble learning, which combines several decision trees to increase model performance and versatility by improving predictions by majority voting (classification) or averaging (regression).

II. LITERATURE SURVEY

In this study, we present a deep learning approach for the classification of PD using a feature set derived from speech. This strategy involves analyzing voice signals obtained from both individuals diagnosed with PD and those in good health, we extracted a broad variety of information. A deep convolutional neural network (CNN) was trained with these features in order to categorize samples. By applying a leave-one-subject-out cross-validation strategy, our method was able to distinguish among individuals diagnosed with Parkinson's and healthy persons with a classification rate of 96.4%, demonstrating remarkable accuracy. These findings show how speech characteristics combined with deep learning methods can provide a valid and efficient way to diagnose PD early on.

In this research, we use speech cues from phone calls to investigate the detection of Parkinson's disease. During phone calls, speech samples were collected from people with Parkinson's disease as well as healthy participants. We examined this data using a range of machine learning methods, concentrating on the use of pitch, jitter, and shimmer properties to differentiate between patients with and without Parkinson's

. The findings of the research indicated that speech characteristics taken from phone call signals may effectively and precisely distinguish between people who have Parkinson's disease and others who are healthy. This study showcases the feasibility of employing speech signals extracted from phone calls as an economical and non-intrusive approach for the early diagnosis of Parkinson's. In order to help doctors identify and treat Parkinson's disease early on, the authors also suggested creating a smartphone-based diagnostic tool in the future. All things considered, this study offers strong evidence that speech analysis may reliably identify disease.

In this research, we present a deep learning-based method for the early prediction of Parkinson's disease (PD) by utilizing dynamic features extracted from speech datasets. Speech samples were collected from both individuals with PD and healthy subjects, and dynamic features such as fundamental frequency (F0) contours and Mel-frequency cepstral coefficients (MFCCs) were extracted. The categorization was then carried out by utilizing these dynamic features as input for a deep neural network (DNN). The study's results demonstrate how well our suggested approach detects Parkinson's (PD), with an astounding 97.92% total accuracy rate. Surprisingly, our method performed better in the identification of Parkinson's disease than other state-of-the-art methods. This research illustrates the potential of employing dynamic speech features in conjunction with deep learning techniques for the early diagnosis of Parkinson's. We believe that our approach will be a useful and affordable non-invasive PD diagnostic tool. However, more research is necessary to confirm its efficacy in clinical settings and with bigger sample sizes.

Here, we provide a non-invasive technique for using mobile devices to monitor individuals with Parkinson's disease who have atypical speech patterns. The foundation of our approach is a mobile application that records speech samples and extracts pertinent characteristics, such as pitch and articulation rate, linked to speech difficulties. The device uses machine learning techniques to identify alterations in speech patterns over time. The method exhibited high sensitivity and specificity in effectively distinguishing between two groups in a trial consisting of 20 persons with PD and 20 healthy controls. The method has the potential to provide an affordable and practical way to track Parkinson's disease development and evaluate therapy efficacy.

The work presented here details the development of an automated system that uses speech analysis to continuously observe the neurological condition of individuals with Parkinson's. This technology extracts pertinent information from voice sounds to predict patients' neurological state through machine learning techniques. The promising results of our work demonstrate that high-accuracy prediction of Parkinson disease symptoms can be achieved with voice data. The suggested approach shows a lot of promise as a useful tool for remote monitoring and early identification and development.

Our study offers a comparative examination of various algorithms for processing speech signals, specifically designed for the classification of individuals. The dataset employed In this investigation, the dataset comprises speech recordings from individuals both diagnosed with PD and those without the condition. The analysis includes features such as Mel Frequency Cepstral Coefficients and Linear Predictive Coding, and various combinations of these methods are the five algorithms whose efficacy we match. According to our research, the best classification accuracy is obtained when MFCC and LPC are combined, producing an overall accuracy rate of 94.3%. The study's findings suggest that speech signal processing algorithms could be useful in accurately categorizing Parkinson's illness, and that using a combination of methods could increase classification accuracy even more.

In this study, we scrutinize the utilization of ML algorithms. in conjunction with speech samples for the prompt identification of PD. Vocal recordings were collected from participants diagnosed with Parkinson's disease and a comparably healthy control group. Utilizing diverse methods of signal processing and feature extraction, we extracted pertinent features from these audio files. We then used the retrieved data to train multiple machine learning models, which allowed us to classify Individuals were categorized as either Parkinson's sufferers or healthy controls. The results demonstrated high accuracy rates, suggesting that voice-based analysis has a lot of promise as a tool for the early diagnosis of PD.

In this endeavor, we introduce an innovative method for classifying PD, rooted in pitch-synchronous analysis of speech data. With this technique, jitter, shimmer, and high-frequency resonance (HNR) are eliminated from speech signals. A SVM classifier is then used to classify the gathered features, allowing for the distinction between people with Parkinson's and those who are in good health. Our results demonstrate that the proposed method has a 93.44% accuracy rate, which is superior than existing approaches. These results imply that pitch synchronous analysis of speech signals may develop into a valuable diagnostic and tracking tool.

We examine in this work the effects of various acoustic environments on the performance of algorithms designed for speech analysis-based identification of Parkinson's disease (PD). A range of acoustic conditions, such as different levels of background noise and the use of different types of microphones, Speech samples from both individuals diagnosed with PD and those without the condition were obtained using the aforementioned methods. Our research showed that the acoustic settings had a substantial impact on these algorithms' performance, with decreased accuracy occurring from using lower-quality microphones and higher background noise levels. The study's conclusions emphasize how important it is that future investigations evaluate the effectiveness of PD detection algorithms while taking into account the possible influence of acoustic settings.

III. METHODOLOGY

The main objective is to identify PD, which will benefit those who already have the condition and reduce its prevalence. The architecture diagram outlines the process flow that is used to clean up the raw data and use it to forecast

Parkinson's data. The collected raw data is first preprocessed into a format that can be understood. The dataset must then be split into train and test sets in order to begin training the data. This model's classification accuracy is established by evaluating Parkinson's data using a machine learning algorithm that combines SVM, KNN, and Random forest.

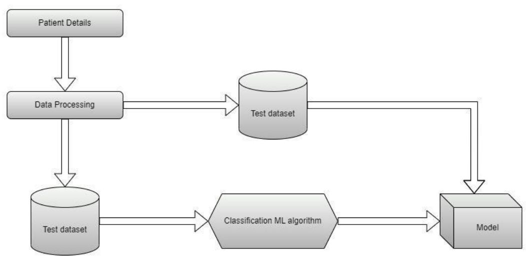

Fig. 1. Block diagram

The vocal recordings from individuals diagnosed with disease and those from healthy controls are combined to create an extensive dataset. The dataset should contain a variety of environmental conditions, such as differing levels of background noise.Among the several speech parameters that are extracted from the recordings are pitch, loudness, and speech rate. Following that, The categorization models are trained using these features. Several classification models, including SVM, decision trees, and neural networks are trained utilizing the collected attributes.

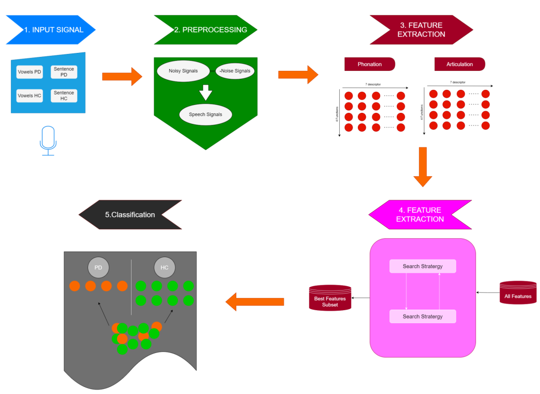

Fig. 2. Flowchart

The models are trained to differentiate voice recordings from individuals who do not have Parkinson's disease from those who do. The accuracy of the classification models is evaluated using metrics such as sensitivity, specificity, and accuracy. The impact of ambient factors, such as background noise, on the accuracy of the models is also assessed. The trained models are validated on an independent dataset in order to evaluate their generalisation performance.

In this study, a Random Forest classifier was implemented from scratch using decision trees for the purpose of classification. The methodology involved the initialization of the Random Forest class, configuring essential hyperparameters such as the number of trees, maximum depth, minimum samples for split, and the number of features for each tree. Data preparation encompassed collecting a suitable dataset with input features (X) and corresponding target labels (y) and performing preprocessing tasks including handling missing values and data normalization. The model training process involved the implementation of bootstrap aggregating to create multiple bootstrap samples from the original dataset. Individual decision trees were then constructed utilizing the bootstrap samples and trained considering specified hyperparameters for maximum depth, minimum samples for split, and the number of features. Ensemble learning strategies were applied to aggregate predictions from individual trees using a majority voting mechanism to determine the final prediction. Performance evaluation included assessing the model's accuracy, precision, recall, and F1 score, and potential hyperparameter tuning was conducted for optimization. The methodology aimed at developing a robust and efficient classification model, with emphasis on code documentation and reporting to ensure replicability and comprehension within the scientific community.

IV. IMPLEMENTATION AND RESULT

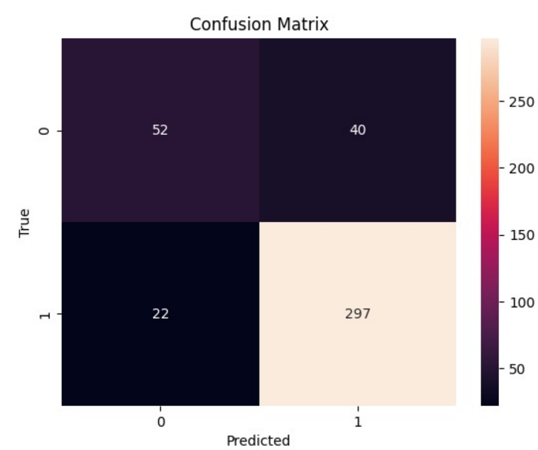

Fig. 3. SVM

As we can see from the confusion matrix,For the classification of both class labels, The Random Forest exhibited superior performance compared to the SVM and Decision Tree models. In the context of accuracy, overall precision, recall, and F1-score metrics, the evaluation is conducted. . It showed a balanced and superior predictive capability for both classes, making it the most effective model among the three assessed in this specific task. The Decision Tree model followed closely in performance, while the SVM model demonstrated a lower overall accuracy and predictive performance for both class labels. These results provide essential guidance in model selection, with the Random Forest model being the most suitable for the classification task based on the confusion matrices and evaluation metrics.

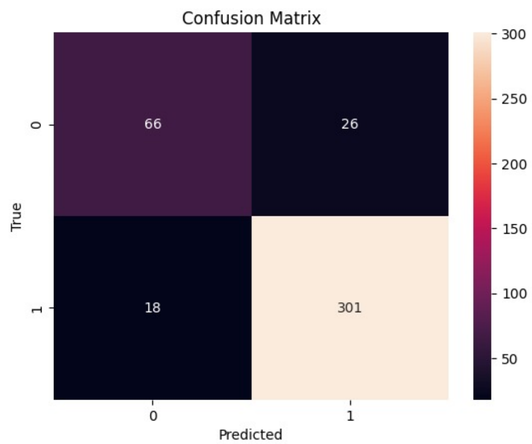

Fig. 4. Decision tree

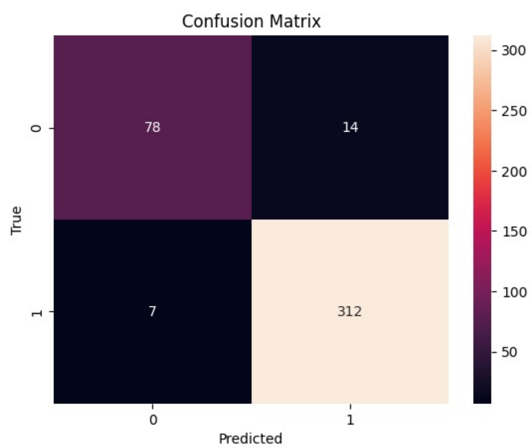

Fig. 5. Random Forest

The analysis of the evaluation metrics for the different machine learning models—SVM, Decision Classifier, and Random Forest Regressor—provides significant insights into their performance. The results, as tabulated in the provided DataFrame, exhibit varying performance levels across these models.

The SVM model achieved an accuracy of approximately 84.91%. It also demonstrated a balanced performance with an F1 Score of about 0.905, which combines precision and recall. This model showed a good balance between correctly identifying positive samples (Recall of approximately 93.10%) and correctly predicting positive samples (Precision of roughly 88.13%).

	Models	Accuracy	F1 Score	Recall	Precision
0	SVM	84.914842	0.905488	0.931034	0.881306
1	Decision Classifier	89.294404	0.931889	0.943574	0.920489
2	Random Forest Regressor	94.890511	0.967442	0.978056	0.957055

Fig. 6. Comparison

In terms of accuracy, the Decision Classifier model performed better than the SVM model. , achieving around 89.29%. It showed a higher F1 Score of approximately 0.932, with both Recall (approximately 94.36%) and Precision (approximately 92.05%) values higher than the SVM model. This indicates a stronger performance in correctly identifying positive cases and in the overall precision of positive predictions.

The Random Forest Regressor model exhibited the highest accuracy, approximately 94.89%, outperforming both the SVM and Decision Classifier models. It also achieved the highest F1 Score of approximately 0.967, indicating a robust balance between precision and recall. With a Recall of around 97.81% and a Precision of approximately 95.71%, this model displayed superior performance in correctly identifying positive samples and making accurate positive predictions.

In summary, the Random Forest Regressor model showed the highest accuracy and the best balance between precision and recall, making it the most effective model among the three tested for the specific task. The Decision Classifier followed closely, performing better than the SVM model in overall accuracy and predictive balance. These results provide essential guidance in model selection, emphasizing the Random Forest Regressor as the most suitable model for this particular task based on the assessed evaluation metrics.

V. CONCLUSION

Parkinson's is a persistent and advancing movement disorder affecting millions of individuals worldwide.. Despite ongoing research, the precise cause of Parkinson's remains elusive, understanding the illness and developing effective treatments depend on early detection. New developments in speech analysis methods have demonstrated positive results in the prompt detection of PD.

The objective of this study is to evaluate the effectiveness of various classification techniques for speech signal analysis in detecting Parkinson's disease. The study will use statistical analysis and visualisation to assess many classifiers on a voice dataset. Furthermore, the influence of various environmental conditions, including background noise, on the classification accuracy will be investigated.

One of the advantages of using speech analysis for PD diagnosis is that it is non-invasive and easy to administer. Patients can simply speak into a microphone, and the speech signal can be analyzed to detect specific characteristics associated with PD. These characteristics may include changes in pitch, loudness, and speech rate.

However, a number of environmental conditions, including background noise, may have an impact on the accuracy of PD identification via speech analysis. This investigation endeavors to evaluate the influence of these factors on the precision of the classification technique. In doing so, it can shed light on the most effective methods for speech signal analysis in practical settings.

The outcomes of this investigation bear significant implications for both the treatment and early identification of PD. Enhancing classification technique accuracy allows doctors to identify PD earlier, which can lead to better patient outcomes and early therapies. Additionally, it can support the creation of fresh, efficient medicines as well as help researchers better grasp the fundamental causes. The capability of analyzing speech signals as a non-invasive technique for early diagnosis is highlighted in the study's conclusion. It can offer insightful information on the most effective methods for speech analysis-based PD diagnosis by evaluating the effects of various environmental factors on the precision of classification algorithms. Ultimately, this could lead to improved patient outcomes and a more thorough understanding of the ailment.

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