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Neuro Aid: A Machine Learning Approach To Parkinson's Disease Detection In Early Stages

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Abstract: Neuro Aid is a groundbreaking machine learning solutions to early detection of Parkinson's disease, which is tackling an urgent healthcare need for millions of people around the world. If not diagnosed until symptoms such as a slight tremor in one hand and stiffness in the body appear, then Parkinson's gradually worsens over time. Though a predictive analytics system has been developed which merges the concepts of K-means clustering, Decision Trees and Support Vector Machines (SVM) to provide insights on patient information, there is a need to improve the accuracy of the prediction. In this context, the use of Random Forest classification method is proposed, looking into an expectation to achieve more than 90% accuracy. In addition to these sophisticated classification methods, there are also ways to de-noise data and models to make them more stable and effective. Next to these sophisticated classification methods, there are also ways to de-noise data and models to assure their stability and efficacy. By normalizing the values of each feature using MinMaxScaler, you can reduce the impact of scale differences among the features, which results in a more balanced contribution from each feature. The Parkinson's framework seeks to obtain a minimal error rate by combining advanced machine learning methodologies to make it more useful in research and clinical practice. The combined effectiveness of this approach not only fosters progress in Parkinson's research and knowledge but also highlights the potential impact of machine learning on solving intricate healthcare problems.

Keywords: Fraud Detection, Gmail Security, Email Fraud, Spam Detection, Phishing Emails ,Cybersecurity.

1. Introduction

The brain is the central hub of the body's functions and injuries to it have a negative impact on the health of a body. Parkinson's disease or PD is an abnormal brain degenerative disorder that mainly targets the central nervous system. PD patients are likely to face physical and emotional problems that can be a strain on their wellbeing. PD is primarily seen in the elderly, but affects all ages. Non-motor symptoms of PD include motor symptoms, and while motor may seem more troublesome to patients than non-motor symptoms, these non-motor symptoms can be a very wide spectrum. This is due to cell loss in the brain and is a factor of the difficulty of diagnosis and treatment in PD [1]. The diagnosis of PD from other disorders like essential and normal aging can be difficult, particularly at the initial stages. Correct grouping is essential to provide proper treatment strategies for the patients needed. The cause of PD is still not clear, possibly because of numerous risk factors such as genetic factors and environmental factors. The enormous impact of PD on the lives of millions around the globe emphasizes the necessity to find effective prediction and management strategies. Although much research has been conducted, there is no known cure for PD, making the need for predictive modeling for early detection and intervention even more critical. The ability to predict the onset and progression of PD using machine learning methods holds great promise for valuable insights in optimizing patient care and outcomes [2]. The ability to leverage cutting-edge algorithms and comprehensive datasets can enable proactive management strategies, which can enhance the lives of people living with PD. This introduction introduces a new domain of raising alarms and awareness relating to a new technology, deep fake evaluation by applying deep learning, which is still in its early development stages. The following sections explore some of the key techniques, developments, and challenges of deepfake detection, as it seeks to protect the authenticity of digital media in an age of high-quality AI generated fakes.

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2. Literature Survey

Aditi Govindu and Sushila Palwe in 2022 published a study called Early detection of Parkinson's disease using machine learning which can be considered a significant study highlighting the use of machine learning techniques in telemedicine for early detection of PD. Research has been carried out on the MDVP audio data of 30 PWP and healthy people during training of 4 ML models. Comparison of results of classification by Support Vector Machine (SVM), Random Forest, K-Nearest Neighbors (KNN) and Logistic Regression models, yield Random Forest classifier as the ideal Machine Learning (ML) technique for detection of PD [3]. Random Forest classifier model has a detection accuracy of 91.83% and sensitivity of 0.95. In 2020, Wu Wang ;Junho Lee; FouziHarrou; Ying Sun published an interesting work which claimed that early detection of Parkinson's disease through deep learning and machine learning is undoubtedly crucial to decelerate the progression of the disease and give patients the chance to benefit from any disease-modifying therapy. With this in mind, it is important to have a close watch on the premotor stage for PD.

An innovative deep-learning technique is introduced to early uncover whether an individual is affected with PD or not based on premotor features. In this study, we have focused on several signs that have been hypothesized to indicate the onset of PD, such astheRapid Eye Movement and the loss of olfaction as well as cerebrospinal fluid parameters and dopaminergic imaging parameters. When comparing to average detection performance for the ten relatively small data sets of 183 healthy subjects and 401 PD patients in early stages [4], the performance of the proposed deep learning model is better than that of 12 of those machine learning and ensemble learning methods, with the highest performance of 96.45% accuracy. Besides detecting the PD, we also provide the feature importance on the PD detection process based on the Boosting method. Various research papers related to Parkinson's Detection using various Machine Learning algorithm (MLA) were considered in the year 2022 to create an efficient method for the discovery of Parkinson's Disease (PD) [5]. People living with Parkinson's Disease (PWP) suffer from movement problems as well as communication problems, which makes it difficult to forget to make a trip to get medications and to follow up with them. Successful identification of the onset of Parkinson's in time enable people to live a normal life.

With the rising elderly population worldwide, the concern of early, remote detection, and accurate diagnosis of Parkinson's disease (PD) has drawn attention. The various technique of MLA has been implemented in this paper, and observed that the suggested model has better efficiency and high precision. Here, the research has been carried out on the biological voice data of 31 individuals among which 23 suffered from PD. The potential outcomes of the paper is based on the detection accuracy using six different classifiers of ML. Support Vector Machine, Decision Tree, Logistic Regression, Random Forest, Gradient Boost and XG Boost all have an accuracy output of 85%.

Based on the above results we propose that clinical decision making should be supported by introducing machine learning techniques to improve the accuracy and systemization of the diagnosis of Parkinson's disease. Recent studies conducted by Saeddin Kalash; Mohamad Ajaj; Nadine Abbas; Sirine Taleb in 2023 found that the use of evolving eHealth technologies including wearable technology and telemedicine is growing significantly in detecting Parkinson's Disease [7]. This improvement has the potential to change the early detection and treatment of a disease like Parkinson Disease (PD). A PD is a progressive disease of the central nervous system that impacts how an individual moves and can impact the ability to control their basic motor movements; often the first symptom of PD is hand trembling due to loss of dopamine producing neurons in the brain. There is no single diagnostic test that confirms the diagnosis of PD, yet it is very important to catch it early. In our work purpose, we will refer to a diagnostic tool for the application of PD diagnosis in the early stages based on spiral and wave patterns from human hand drawing. In this paper, we employ two deep-learning models: Inception V3 and Xception models to predict the risk of PD determined by pattern of drawings.

The models were trained using over 4500 images of the data augmentation. An accuracy rate of 94% and this translates into the lives of millions affected by this troublesome condition being improved. A recent study by Factor SA, McDonald WM, and Goldstein FC[5] examined the role of neurotransmitters in development of PD psychosis in 2017. Psychotic symptoms frequently occur in Parkinson's disease (PD), and are thought to have a predictable course of progression from minor to more severe hallucination and delusions [8], which represents a poor prognosis. Based on the proposed classification of the system, however, there are several types of PD psychosis, each associated with different characteristics of the neurotransmitter problem (dopamine, serotonin, acetylcholine) as well as varied responses to treatment and prognosis. Understanding these subtypes could lead the way into therapies tailored to specific types, providing a deviation from the one size fits all approach taken so far. This classification should be further tested in the future to determine its usefulness in tailoring treatment for PD psychosis. We hope to define the three PD psychosis subtypes according to neurotransmitter dysfunction, to highlight the varied nature of psychotic

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symptoms seen in PD and to direct more precise therapeutic interventions [8]. In sept 2008 Martinez-Martin P, Arroyo S, Rojo-Abuin JM, Rodriguez-Blazquez C, Frades B, de Pedro Cuesta J conducted a Longitudinal Parkinson's Disease Patient Study Burden, perceived health status, and mood among caregivers of Parkinson's disease patients. This study was conducted to outline the characteristics of people with Parkinson's disease (PD) and to explore the relationships between these characteristics, perceived health and mood, as well as caregiver burden. The purpose of this study was to provide a description of characteristics of people with Parkinson's disease (PD) and to assess the relationship between these characteristics, caregiver burden, perceived health and mood.

Involved 289 pairs of patient/caregiver at various centers. The average age of most caregivers was approximately 60 years and they were primarily female, the majority of whom were either working or homemakers. They had been attending an average four years [9]. Patients were not mostly in late disease phases, but cost of the direct treatment care were 6,350 euros annually per patient. Caregivers experienced more mood disorders and lower health-related quality of life (HRQoL) than the general population. In general, caregiver scores were poorly correlated with patient-related factors, with moderate correlation with the burden of caring. HRQoL was poorer in female caregivers, with more anxiety. More severe PD was associated with more severe caregiver burden and depression scores [10]. Emotion of caregivers was a highly significant factor in burden and health perception and patient-related factors in burden and in mood, but not health perception. Caring for someone with PD can be burdensome and can cause affective disorders, overall these can be common and are seen in caregivers and affect their burden and HRQoL.92.18%. The findings highlight the effectiveness of the proposed method, showing its ability to improve accuracy and reliability of deepfake detection systems on various datasets.

The study adds to the existing body of knowledge and provides practical strategies for combating deceptive deepfake alarms. The work is useful in terms of insights and methodologies for the current ongoing effort in deepening defences against the spread of deceptive deepfake alarms. N D. D. Joshi, H. H. Joshi, B. Y. Panchal, P. Goel and A. Ganatra have conducted a noteworthy research work titled "A Parkinson Disease Classification Using Stacking Ensemble Machine Learning Methodology" which presents a predictive telediagnosis and telemonitoring framework for the identification of Parkinson's Disease (PD) using vocal analysis technique [11]. The proposed model includes 12 machine learning algorithms which include Naive-Bayes, k-closest neighbour, Logistic Regression, multi-layer-perceptron, Decision Trees, support vector machines (Linear, Poly, and RBF) and Random Forest Classifier. These are very good models that deduce very small frequency signals for PD detection of individuals. The stack ensemble model is a model using Random Forest Classifier, Support Vector Machine, K-nearest neighbour, Extra Tree Classifier and Extreme Gradient Boost as classifiers and the loss functions are Mean Square Error and Mean Absolute Error Loss.

The validation and testing accuracy of the model is 91% and the training accuracy is 90-100%. In addition, the Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are used for improving the accuracy and to reduce the curse of dimensionality [12]. This model has the potential to make an appreciable contribution to healthcare in India, particularly in the timely detection of Parkinson's Disease, thus educating the patients about diverse aspects at an early age before there is any treatment available. An interesting study was done by Gopamsana M., M. F. Shaik, S. N. Joyes, S. R. Chandra, P. V. Rao and G. S. S. S. V. Krishna Mohan in 2023 titled "Enhancing Parkinson's

Disease Diagnosis: A Novel Ensemble Stacking Algorithm using Voice Data Analysis" which proposes the use of an Ensemble Stacking Algorithm to improve the accuracy of Parkinson's disease (PD) identification using voice data. Previous techniques were useless with regard to early PD detection, whereas this technique takes advantage of vocal difficulties that 90% of PD patients are experiencing. The technique is better than existing ones, as it can be applied to create models that are a kind of combination of various classifiers and select the most accurate among them [13]. Interestingly, the dataset here contains different voice based metrics, obtained from different institutions, which allows to highly accurately (96.61%) predict PD. In this paper, we reviewed the practical value of the traditional and nonstandard measures to discriminate healthy subjects from people with Parkinson's disease (PD) in the detection of dysphonia, and carried out an important study published in 2009 by M. A. Little, P. E. McSharry, E. J. Hunter, J. Spielman and L. O. Ramig on the subject of" Suitability of Dysphonia Measurements for Telemonitoring of Parkinson's Disease". Two new measures of dysphonia pitch period entropy (PPE) is robust to many uncontrollable confounding effects such as noisy acoustic environments and normal healthy variations in voice frequency. We collected sustained phonations from 31 people, 23 with PD.

Then we selected a set of ten measures (with small cross correlation) and conducted an exhaustive search on all combinations of these measures to identify four measures that, together, can achieve a perfect performance of 91.4% in classification overall (with a kernel support vector machine). In conclusion, we find that nonstandard methods in combination with traditional harmonics to-

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noise ratios are best able to separate healthy from PD subjects [14]. The methods chosen are nonstandard, but are fairly invariant to many variables in the acoustic environment and in individual subjects and are therefore well suited to telemonitoring applications.

A. Tsanas, M. A. Little, C. Fox and L. O. Ramig carried out an outstanding research paper on "Objective Automatic Assessment of Rehabilitative Speech Treatment in Parkinson's Disease" in 2014. This research is an evaluation of a computer program, LSVT Companion, that could be used by Parkinson's disease (PD) patients alone to assist them in their speech rehabilitation process. The study is designed to mimic the evaluation of voice acceptability made by speech experts which takes place during face-to-face sessions of treatment [15]. Thirty nine phonation characteristics (dysphonia measures) are chosen for each phonation by applying robust feature selection. The study's accuracy is approximately 90% in distinguishing acceptable 聲 from sound, and unacceptable sound from noise. In addition, the methodology is proposed to be a tool used by speech experts to evaluate phonations as a decision support system.

3. Related Work

3.1. Proposed Work

In this regard, the Proposed system seeks to address these limitations of the existing Parkinson's disease detection solution, with a slightly more advanced approach using state-of-the-art machine learning algorithms. We use the much-loved Random Forest classification algorithm, which is widely-used to overcome the overfitting and to deal with the complex dataset. Compared to the previous model, Random Forest has a promising way to achieve better predictive performance with potential accuracy rates of 90%. A proper preparation of the data is achieved with the MinMaxScaler approach on which feature values are appropriately normalized to a fixed range, in order to ensure proper convergence and effectiveness of the model. In addition, we split the data set into separate training and testing sets using the train_test_split function, to test the performance and robustness of our model. This can be used to comprehensively assess how well the model applies to novel inputs [16]. These cutting-edge technologies are used in this suggested algorithm to provide a more reliable and precise diagnosis of Parkinson's disease—possibly resulting in earlier diagnosis and intervention plans than is currently possible.

3.2. System Architecture

The architecture of the system of analyzing the Parkinson's disease data is shown in the given figure. The first step is to extract features from the disease data and then, the extracted features are pre-processed. The pre-processed data is then divided into training set and testing set. The three sampling schemes that are mentioned are: Random oversampling, Under sampling, SMOTE. The model is trained using the training data and the aforementioned trained model is obtained. This trained model is then tested to generate the final model answer, probably with the test set. The diagram represents an overview of end-to-end pipeline for developing a machine learning model analyzing Parkinson's disease data, including main steps involved.

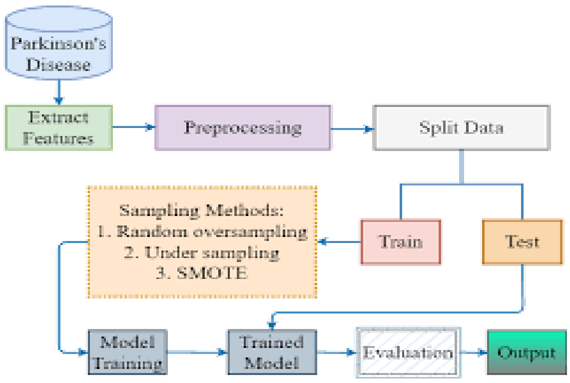

Fig.1 Architectural Overview

Extract Features: This includes detecting certain patterns or features in pre-processed data that are known to be related to PD. Each feature might be a tremor frequency, gait variability, speech characteristics or brain activity pattern. The informative features extracted from the input data try to recognize the underlying PD related patterns, thus allowing the subsequent part of the architecture (e.g. classification or diagnosis) to perform a proper discrimination between PD patients and healthy subjects.

Preprocessing: Preprocessing constitutes an important first phase in any Parkinson's Disease detection system architecture since it is important to prepare and “clean” the data before it is used in subsequent processing or analysis. It improves the quality of the data, decreases the noise and derives features of interest to the next steps of analysis and Modeling, making them more robust and accurate.

Split Data: The "Split Data" step is the one in which the data set is partitioned into smaller data sets for training, validation, and testing. This "Split Data" step divides the data set into smaller parts to train, validate, and test the machine learning model with nonoverlapping data for each of these steps. In this way, it will be possible to properly evaluate the performance of the model and maintain the generalisation to unseen data, which is important to achieve reliable detection of Parkinson's disease.

Training Set: The most of the data set (usually about 70-80%) is dedicated to the training set. This part of the data is used for training the machine learning

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model. During this stage, the model identifies the patterns and relationships among the data.

Test Set: The remainder of the data set (about 10-15%) is kept aside to make up the test set. This is used to test the model trained by this set. It offers objectively details concerning the capacity to generalise to new unseen data.

Random oversampling: is one of the techniques used in machine learning to solve the problem of class imbalance. Class imbalance is a problem when one class (Parkinson's disease positive or "1") is much smaller than the other class (Parkinson's disease negative or "0"). Random oversampling could be used when we want to fit the test set that is used for training the model with a balanced representation of both classes to get more accurate and robust classification when considering Parkinson's disease detection.

Under sampling: If the number of samples of majority class (without Parkinson's Disease) samples is reduced to match with the minority class (Parkinson's Disease) then it is called under sampling. This is performed to make up the date set less skewed towards the more prevalent class so that the model isn't skewed towards predicting the major class.

SMOTE: SMOTE is an acronym for Synthetic Minority Over-sampling Technique, a sampling technique adopted in machine learning for dealing with class imbalance problems wherein the one class (minority class) is visible in lesser quantity in the data as compared to the other class (majority class). This class imbalance problem is a common problem in any number of practical applications such as medical data like detecting Parkinson's Disease.

Model Training: Selection of an appropriate model followed by training with the pre-processed data. While training, the model takes the pattern and relationships from the data that are related to Parkinson's Disease. This is generally whether or not the loss function is improved, which is the gap between the 20 predictions the model made and the actual values in the training data. This function, called loss function, is minimized with optimization techniques like gradient descent and the model parameters are adjusted at each iteration.

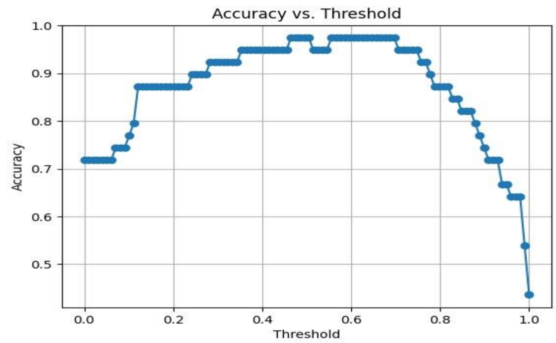
Trained Model: The trained model is, therefore, a prediction tool, which might help health care providers to better identify and manage Parkinson's.

Evaluation: In regards to Parkinson's Disease (PD) identification, the term "evaluation" would commonly be used to describe the reviewing process of a diagnostic or screening tool used to determine if a person has PD or is progressing through the disease.

4. Results

Accuracy: Test's correct ability to distinguish patient and healthy cases. To determine the "accuracy" of a test we need to determine the percentage of true positive and true negative results from all cases tested. In math terms, this can be expressed as:

Accuracy = TP + TN /TP + TN + FP + FN.



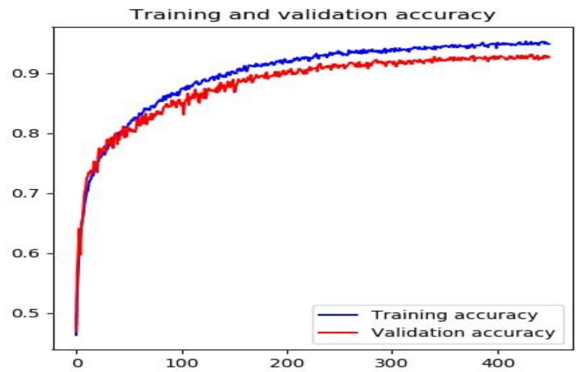
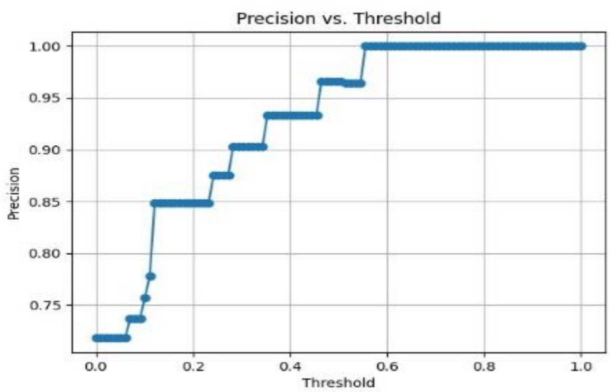


Fig. 2 Accuracy vs Threshold comparison graph

Fig 4 Training and validation accuracy

Precision: Ratio of correctly classified instances or samples that are listed as positive. Thus, the formula to calculate the precision is given by:

Precision = True positives/ (True positives + False positives) = TP/(TP + FP)



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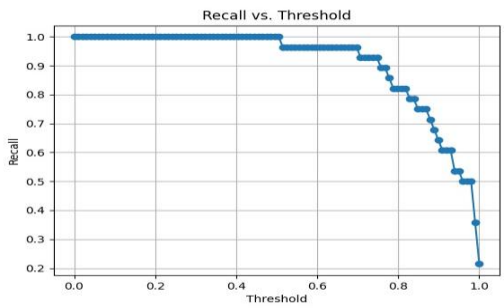


Fig.3 Precision vs Threshold comparison graph

Recall: Recall is a metric in machine learning computing to see how well a model can detect all of the instances from a specific class. It gives an indication of the completeness of a certain model in capturing instances of a certain class—it is the ratio of correctly predicted positive observations to the total number of actual positive.

Fig 6 Recall vs Threshold graph

Confusion Matrix: The confusion matrix is used to push the prediction of a machine learning model on a set of test data, and show the number of true and false instances.

The matrix shows the number of occurrences from the model on the data set.

- True positives (TP): When the model correctly predicts a positive data point.
- True negatives (TN): When the model makes an accurate prediction that the data point is negative.
- False positives (FP): is when the model incorrectly classifies a data point as positive.
- False negatives (FN): the data points that the model incorrectly predicts to be negative.

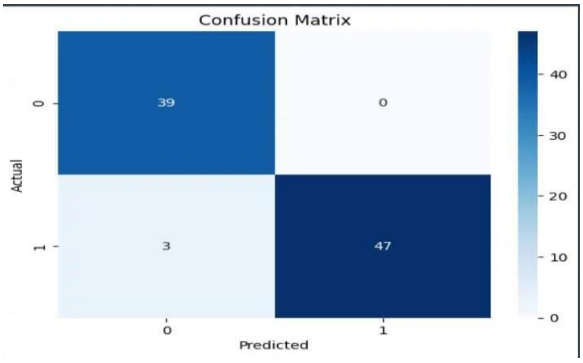


Fig.4 Confusion Matrix

Receiver Operating Characteristic(ROC) Curve: An ROC curve is a graph showing the performance of a classification model at all classification thresholds. This curve represents the plot of 2 parameters:

- True Positive Rate: The True Positive Rate is the same as Recall and is defined below:

  TPR=TP/(TP+FN)

- False Positive Rate: False Positives Rate is defined as follows:

  FPR=FP/(FP+TN)

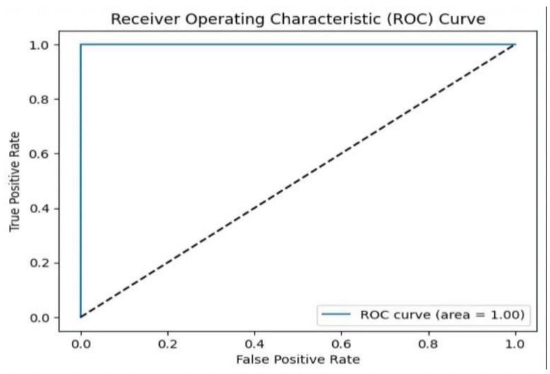
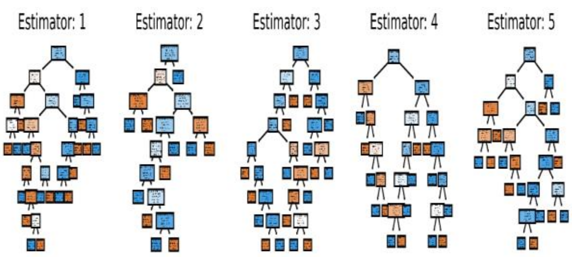


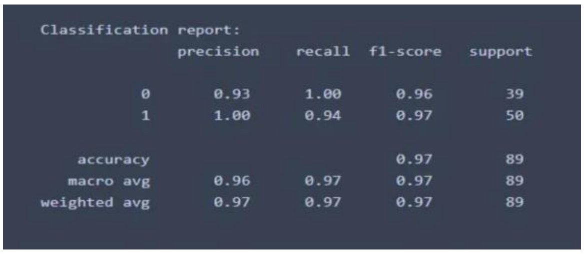
Fig. 5 ROC Curve



Random Forest classifier Estimators Trees: A random forest is a meta-estimator that trains a k number of decision-tree classifiers using k random subsets of the data around each sub-sample and then averages them to get the keeper. predictive accuracy and control over fitting.

Fig 9 Estimators of random forest classifier

Classification Report: This is a metric used for machine learning to demonstrate the score/accuracy of a trained classification model in terms of precision, recall, f1score and support.


Classification report:

	precision	recall	f1-score	support
0	0.93	1.00	0.96	39
1	1.00	0.94	0.97	50
accuracy			0.97	89
macro avg	0.96	0.97	0.97	89
weighted avg	0.97	0.97	0.97	89

Fig. 6 Classification Report

5. Conclusion and Future Scope

There is a potential for the use of machine learning techniques for early detection and intervention in Parkinson's disease. The use of the

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Random Forest classifier not only resulted in high accuracy in the classification process but also provided insights into the features most important for the predictive capacity of Random Forest model. From the feature importance analysis, it is found that certain voice related features play significant role in detecting patterns indicating PD. This reinforces the ability of voice as a non-invasive, economical biomarker diagnostic for screening and monitoring at risk individuals. Furthermore, the Random Forest algorithm is scalable and interpretable, allowing it to be used in real-world applications in healthcare. Because it can process large volumes of data, and make decisions easily comprehended and accounted for, it aids clinicians and researchers in grasping the reasons that underlie disease processes. The results of our model are encouraging but validation and calibration are needed to make a final conclusion about the robustness of this model for different patient size populations and data source.

The work with collaborative teams of multidisciplinary professionals from clinicians, data scientists, and experts from other specialties will be critical to improvement of model reliability and generalizability. In conclusion, our project underscores the transformative potential of machine learning in revolutionizing healthcare practices, particularly in the realm of disease diagnosis and management. To conclude, the study highlights the need to develop deeper technologies for detecting deep fakes as deep tech grows.

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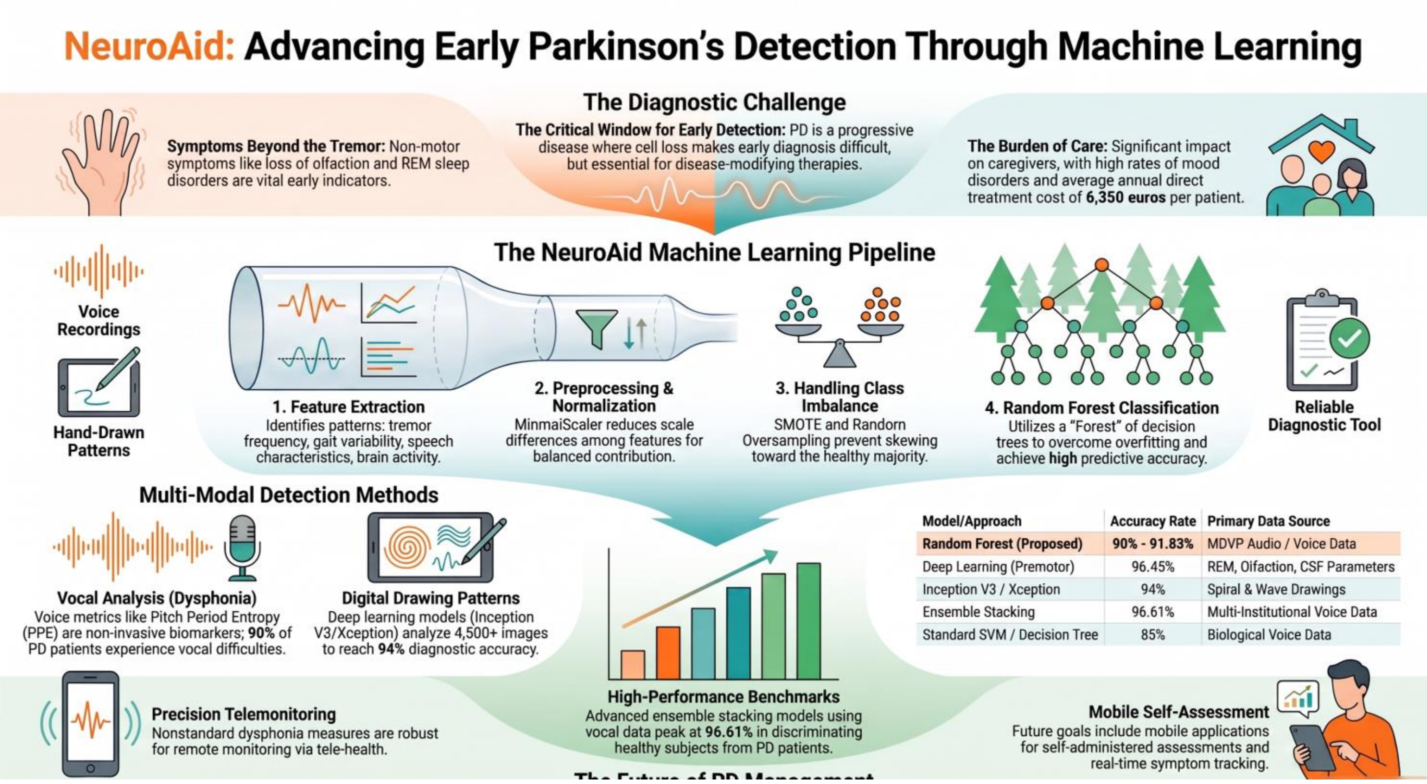

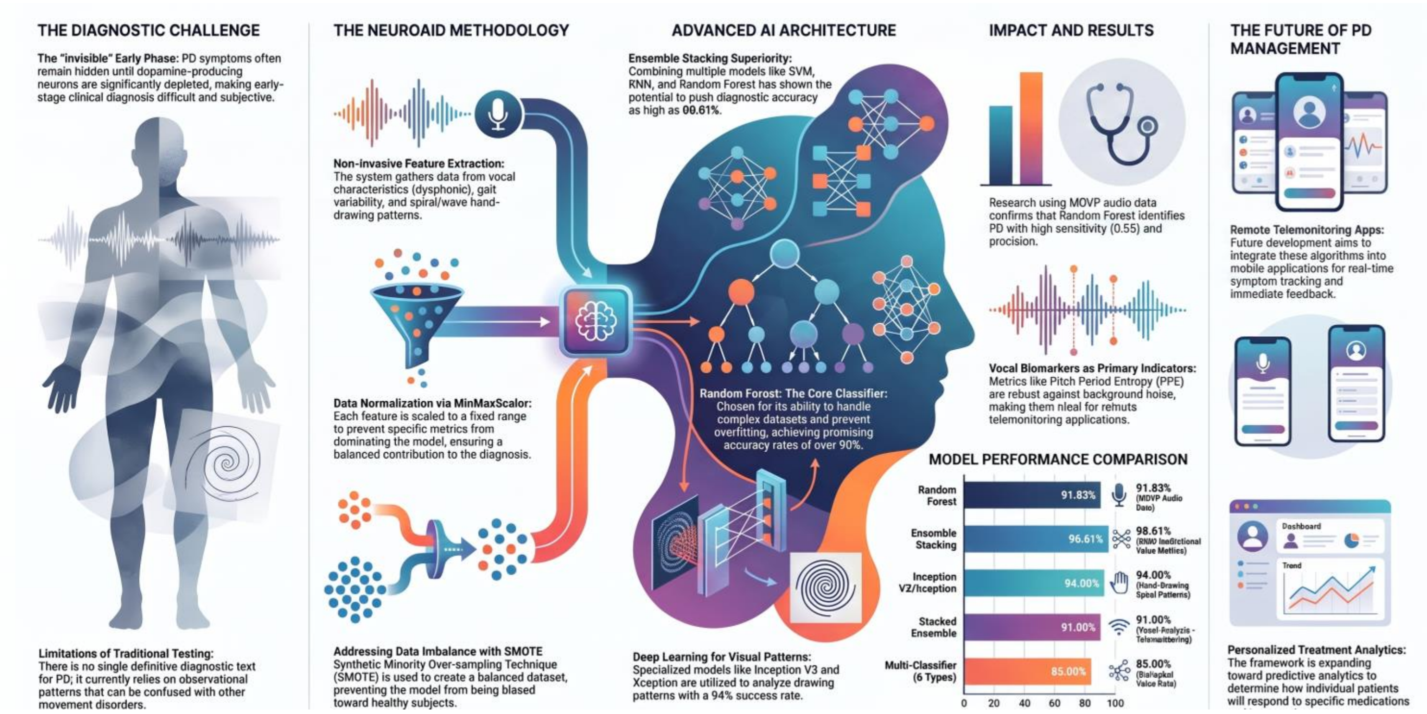

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