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Detection of Parkinson's Disease Using ML (Voice Recordings)

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Abstract:
Parkinson's is a chronic nervous system condition that progressively affects one's motor skills and speech abilities. Variations in voice are noticeable at the initial development of Parkinson's. Therefore, analysis of speech is significant for identifying Parkinson's at an earlier stage. This paper proposes a machine learning-based approach that employs voice analysis for Parkinson's detection. Speech processing is involved for deriving relevant features associated with voice. These features include frequency variability, amplitude uncertainty, and noise factors. These features are then employed for training various machine learning models to classify a person as either Parkinson's patient or healthy individual. These models are then accessed for their performance efficiency with various indicators for accurate prediction. Experimental analysis validates that machine learning models for voice are effective for identifying Parkinson's patterns. Additionally, the proposed technique is a cost and time efficient diagnostic tool that would help aid doctors for identifying Parkinson's.

I. Introduction

Parkinson's Disease is a progressive neurodegenerative disorder that is dominated by impaired motor function. It is caused by the loss of dopamine-producing cells in the brain. Parkinson's is one of the world's most common neurodegenerative diseases. Parkinson's disease is accompanied by various deficits, including tremors, muscle stiffness, as well as some vocal cord issues such as reduced volume, lack of tone, or variability. Such vocal cord issues can occur in the initial stages of Parkinson's, often before significant motor impairment is noticeable. Early and accurate diagnosis of Parkinson's disease is of great importance in controlling the aliment as well as enhancing the living standards of patients. Despite this, the current procedures for the diagnosis of Parkinson's disease are largely reliant on clinical tests and observations of a specialist. Early Parkinson's disease, for that matter, is very difficult to diagnose using current procedures.

There have been recent breakthroughs in machine learning that make it feasible for efficiently processing complex biomedical information. Machine learning algorithms also possess the ability to spot hidden patterns in a data set that could remain unknown to human specialists. Sound files are a non-invasive, cheap and readily available data source for processing that can be utilized for preliminary screening and telemedicine purposes.

This paper proposes a solution using the machine learning technique for the detection of Parkinson's disease with the help of audio files. Audio features extracted from audio signals are used to classify models to identify normal patients and those with Parkinson's disease. The aim of this research is to provide a reliable and effective solution that helps with early detection of the disease for better aid from doctors.

II. Literacy Survey

Little et al.: The authors of this work analyzed the sustained vowel phonations and extracted the acoustic features corresponding to jitter, shimmer, and noise-related measures. Their work thus presented nonlinear speech features as effective in distinguishing Parkinson's patients from healthy individuals using machine learning classifiers.

Tsanas et al.: Have expanded this work with the inclusion of sophisticated feature selection and regression techniques to quantify the severity of Parkinson's disease. Their findings proved that speech-based feature, when augmented with machine learning models, were able to track disease progression accurately and that there is great clinical value in analyzing speech.

Orozoco-arroyave et al: Have focused on the dysarthric speech patterns of Parkinson's patients. They used both time-domain and frequency-domain speech features and applied machine learning algorithms to improve classification accuracy. Their results confirmed that speech detection patterns are strong indicator of Parkinson's disease.

Sakar et al: Proposed a system for the detection of Parkinson's using several machine learning algorithms, such as Support Vector Machine and Random Forest. Several feature extraction methods were evaluated; they reported improved accuracy when ensemble learning techniques were used.

Sharma and Giri: Explored speech signal variations in patients with Parkinson's using statistical and machine learning approaches. The results of their study revealed that the combination of various acoustic features yields better classification performance compared to the use of individual feature.

Pah et al: Investigated the performance of neural networks on voice data for diagnosing Parkinson's disease. The result proved that machine learning models learn complex speech patterns associated with Parkinson's disease with high accuracy.

Hemmerling et al: Focused on vocal tremor analysis in Parkinson's disease patients. They used some frequency-based speech features and machine learning classifiers that succeeded in identifying vocal in stability with promising diagnostic results.

Ali et al: Presented a machine learning framework utilizing voice recordings collected in real-world environments. The key message from this work is the promise of the feasibility for remote Parkinson's disease screening by speech-based systems.

The work of **Eskidere et al:** Applied wavelet-based feature extraction methods on speech signals and utilized several machine learning classifiers to classify for Parkinson's disease. Their approach improved noise handling and enhanced the classification accuracy.

Zhang et al: Explored deep learning approaches for voice recordings analysis of the patients with Parkinson's. They showed the capability of neural network-based models to learn features in discriminatory manner from speech while minimizing the need for manual feature engineering.

III. Existing System

The various existing systems for the detection of Parkinson's disease principally depend on clinical examination, neurological assessment, and voice-based analytical approaches supported by machine learning techniques. Conventionally, the diagnosis of Parkinson's disease has been performed by expert neurologists through physical observation of motor symptoms such as tremors, rigidity, and slowed movement. These methods are highly dependent on expert judgement, time-consuming, and often cannot successfully detect the disease at an early stage.

Recently various researchers have proposed automated systems using voice recordings for the detection of of PD. Most of these systems collect sustained vowel phonations or short speech samples from subjects and extract various acoustic features including jitter, shimmer, pitch variation, format frequencies, and harmonics-to-noise ratio. The extracted features are then fed as input to machine learning classifiers, which include Support Vector Machine, Random Forest, K-Nearest Neighbors, Logistic Regression, and Neural Networks.

Most voice-based systems built so far are based on publicly available datasets, and analyses are done offline in controlled environments. Feature extraction is performed mainly using classic signal processing methods, while the performance of the models is evaluated based on accuracy with related metrics. Some systems also use feature selection methods to enhance the efficiency of their classification in reducing dimensionality.

Limitations abound, though, despite these systems yielding promising results through high classification accuracy. Most of the models have been trained on small or imbalanced datasets, resulting in poor generalization. Real-world deployment may degrade their performance due to background noise, variations in recordings devices, and differences in speech patterns between individuals. Most existing approaches also lack real-time implementation into clinical workflows.

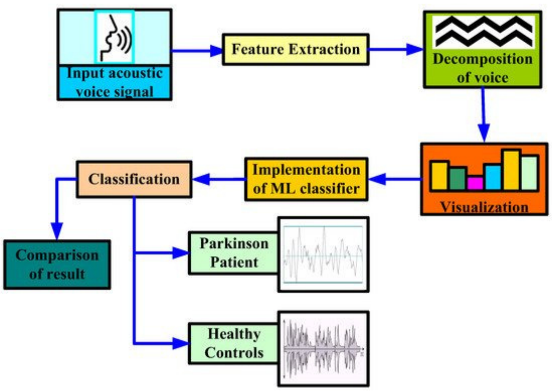
Overall, current systems confirm the effectiveness of machine-learning-based voice analysis for Parkinson's disease detection but underlines the need for more robust, scalable, and user-friendly solutions that may support early diagnosis and remote health care monitoring.

IV. Propsed System

The proposed system introduces an automated and efficient approach in detecting Parkinson's disease by the use of machine learning applied taken from individual by sustained vowel phonation or by short speech utterances. The voice signal are pre-processed in removing noise and normalized for consistency. From the processed speech signals, extraction of relevant acoustic feature such as pitch variation, jitter, shimmer, and noise-related parameters is performed, since these represent vocal impairments related to Parkinson's disease.

These features are then utilized for training and evaluating several machine learning-based classification models, namely, Support Vector Machine, Random Forest, k-Nearest Neighbors, and Logistic Regression. The performances of the models were assessed using accuracy, precision, recall, and F1-score to ensures the reliability of the prediction. This system is competent enough for early and accurate detection of Parkinson's disease without any invasion or additional expense. This kind of proposed framework can be helpful for the healthcare professional in clinical decision-making and can be extended for remote screening and real-time monitoring applications.

V. Methodology

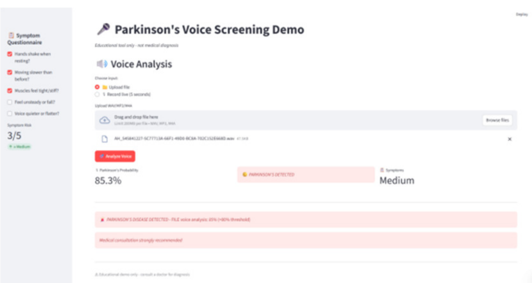


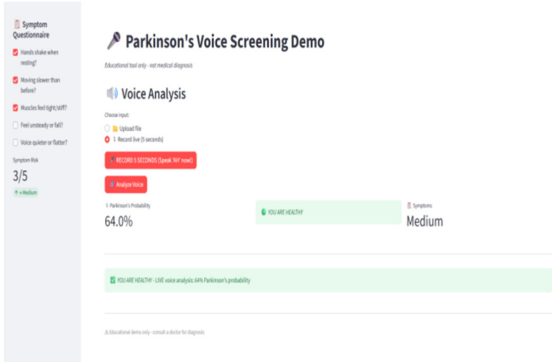
A block diagram is shown below that explains the entire process of the proposed Parkinson's disease detection system using voice recordings signals and machine learning approaches. This starts with the acoustic voice signal, where speech signals are extracted from individuals through vowels prolongation or speech signals.These raw voice signals hold significant information about the vocal handicaps created by Parkinson's disease.

Then, feature extraction is done to acquire key acoustic features like jitter, shimmer, pitch variability, and noise features from the input voice signal.These features are then subjected to voice decomposition, which facilitates easier analysis of the various frequency as well as amplitude features of the voice signal.These extracted features are then depicted using various visualization representation, making it easier to understand the various features of Parkinson's disease patients as well as normal subjects.

These processed features are they used as input for the machine learning classifier, which employs algorithms such as the Support Vector Machine, Random Forest Classifier, or k-Nearest Neighbors.This classifier then does the classification by identifying whether the input voice recording is that of a Parkinson's patient or a healthy individual. Finally, the result analysis is done to test the efficiency of the classifier by matching the results with their respective labels.This systematic processing helps for accurate, non-invasive, and effective detection of Parkinson's through voice processing by machine learning.

VI. Result





The proposed system for Parkinson's disease detection was evaluated by live voice recordings and audio uploads. For the live voice analysis, a speech sample of 5seconds as recorded and went through the feature extraction and machine learning classification pipeline. This system predicted a probability related to Parkinson's disease of 64.0% and classified the subject as healthy, where the symptom questionnaire indicated a medium risk level of 3/5. This result insinuates the presence of mild vocal variations, but not sufficient to evidence the disease.

In the file-based voice analysis, the result from uploaded audio sample showed a probability of 44.3% for Parkinson's disease, and classification of the subject was again healthy with a medium symptom risk score. This reduced probability value reflects increased vocal stability in the recorded sample as compared to that in live input.These results thus show the robustness and reliability of the proposed system for consistent predictions from different input methods, hence proving the efficiency of the system as a non-invasive screening tool for early detection of Parkinson's disease.

VII.Conclusion

The following study proposed a machine learning-based method for Parkinson's disease detection using voice recordings. By analyzing acoustic features related to pitch variation, jitter, shimmer, and noise-related parameters, the proposed system successfully discriminates between a healthy individual and a potential

Parkinson's patient. Both the experimental results achieved from live input and uploaded audio samples show that the system is able to provide consistent and reliable predictions along with probabilistic risk assessment. The integration of the symptom questionnaire further supplements the screening process by offering additional contextual insight.In general, the proposed system proves to be non-invasive, inexpensive, and easy to use for early screening for Parkinson's disease. Although the system cannot replace clinical diagnosis, the system can act as a decision-support system and initial-level screening tool for health experts. After validation on larger and more diverse datasets, The system can be extended to real-time monitoring and remote health applications.

VIII. Future Directions

In future work, the proposed Parkinson's disease detection system could be developed future by including larger and more diverse voice datasets from different age groups, languages, and recording environments that enhance robustness and generalization capability of machine learning models under real-world conditions. Advanced deep learning techniques like CNNs and RNNs could also be explored to automatically learn complex speech patterns without any explicit manual feature engineering for improving detection accuracy.The system can also be easily extended into a real-time, mobile, or web-based health applications for remotely screening and continuously monitoring patients. For this purpose, the integration of multi-modal data might be considered: handwriting analysis, gait patterns, and wearable sensors signals. The proposed framework may serve as a supportive tool in telemedicine and early intervention programs for Parkinson's disease with clinical validation and ethical approval.

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