IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⸾ Peer-reviewed & Refereed journal ⸾ Vol. 11, Issue 3, March 2024

DOI: 10.17148/IARJSET.2024.11315

Detecting Parkinson's Disease Through Voice Analysis

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Abstract: Parkinson's disease (PD) is a neurodegenerative condition generated by the dysfunction of brain cells and their inability to produce dopamine, an organic chemical responsible for controlling a person's movement. Diagnosis involves many physical and psychological tests and specialist examinations of the patient's nervous system, which causes several issues. The PD Speech data-set used in this experiment exhibits huge dimensionality with comparatively less data-points. Random Forest classifier is used to classify individuals as either PD or healthy control (HC). The proposed system offers a non-invasive, cost-effective, and accessible approach to PD diagnosis, potentially improving healthcare outcomes and patient quality of life. This method extracts a set of features from a recording of the person's voice. Then machine-learning (ML) methods are used to analyse and diagnose the recorded voice to distinguish Parkinson's cases. This project aims to promote the integration of voice analysis into routine clinical practice for early PD detection and intervention.

Keywords: Parkinson's Disease, Machine Learning, Audio Analysis, Random Forest, Diagnosis.

I. INTRODUCTION

Parkinson's disease (PD) is a neurological condition that worsens with time and is typified by a variety of motor and non-motor symptoms, such as bradykinesia, postural instability, stiffness, and tremors. With 6.1 million people expected to be afflicted worldwide, Parkinson's disease (PD) is a serious public health concern since it causes severe impairment and lowers quality of life for both patients and caretakers. Timely intervention and effective therapy of Parkinson's disease (PD) depend on an early diagnosis. However, because early symptoms are mild and there are no reliable biomarkers, diagnosing Parkinson's disease (PD) in its early stages remains a clinical problem. Conventional diagnostic methods mostly depend on clinical observation and the existence of distinctive motor symptoms, which could not show up until the illness has advanced considerably. Therefore, non-invasive and sensitive biomarkers that can help with early PD detection are desperately needed in order to enable prompt management and better patient outcomes.

Voice analysis has been a viable method for PD identification in recent years. The human voice contains a wealth of information regarding prosody, articulation, and voice quality, all of which can be affected in people with neurological conditions like Parkinson's disease. Research has indicated that people with Parkinson's disease (PD) display unique vocal traits in comparison to those in good health. These traits include variations in speech rhythm, pitch, and loudness. By utilizing developments in acoustic analysis, machine learning, and digital signal processing, scientists have created computational instruments that can identify tiny biomarkers in speech that are linked to Parkinson's disease (PD). This opens the door to the development of non-invasive and objective disease detection techniques.

II. BACKGROUND & RELATED WORK

A number of studies about the use of voice and speech data for the identification of Parkinson's disease have been published in recent years. An author proposed a model for the identification of Parkinson's disease (PD) that made use of neural networks, decision trees, regression. A comparative analysis was conducted [4]. In order to distinguish between PD patients and healthy individuals, a study employed the (LOSO) validation technique using MFCC speech recording samples and an SVM classifier [2]. A two-stage attribute selection and classification approach for PD detection is described in another study [13]. Ali used a two-dimensional simultaneous sample and feature selection strategy to propose an early predictive model for PD identification [1]. An additional author achieved 86% accuracy in PD identification using ensemble learning techniques that combined many classifiers [19]. Additionally, a few other articles have suggested models that have very good accuracy in PD detection. For example, a paper combined the use of weighted clustering and Complex Valued Artificial Neural Network (CVANN) to reach 99.5% accuracy in their suggested model. Though these experiments are highly accurate, the outcomes are biased. Small data points were present in the published data-sets used in the trials, and each subject had numerous voice recording samples [18]. Even though PD detection has been the subject of multiple published studies, further work is still required to produce models with increased efficiency, robustness, and accuracy.

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III. METHODOLOGY

With the use of machine learning and audio analysis techniques, the system model's several interrelated components are intended to enable the automated detection and diagnosis of Parkinson's disease.

A. Data Collection and Preparation

Based on characteristics taken from audio recordings of speech samples, the suggested approach uses machine learning algorithms—more especially, the Random Forest classifier—to categorize people as either Parkinson's disease patients or healthy controls. The main feature representation that is utilized is Mel-Frequency Cepstral Coefficients (MFCCs), which captures the distinctive qualities of speech signals that are pertinent to Parkinson's illness. The three primary parts of the system are prediction, model training, and feature extraction. Utilizing the librosa library, feature extraction entails calculating MFCCs from audio files. Then, using a dataset that includes acoustic features and matching labels (PD or HC), the Random Forest classifier is trained. After training, the model can accurately diagnose new audio samples, giving medical professionals a useful tool for Parkinson's disease early detection and diagnosis.

Dataset description:
The local conditions will be described first in the dataset description, followed by a description of the recording process.

Recording Procedure:
We utilized a smartphone to capture the footage. We utilized a Recording App to record the voice on the device. This indicates that the voice recording feature uses the smartphone's on- and off-hook signals to start speech recordings while operating independently in the background on the recording device. As a result of capturing the microphone signal directly rather than using the compressed stream from the GSM ("Global System for Mobile Communications"), we obtain high-quality recordings with an audio CD quality sample rate of 44.1 kHz and bit depth of 16 bits. The familiar WAVE file format (.wav) is used to write the raw, uncompressed material straight to the smartphone's external storage (SD card). We used the following workflow to perform a voice recording:

- Ask the participant to relax a bit
- Ask the participant to read out “The North Wind and the Sun”
- Depending on the constitution of the participant either ask to read out “Tech. Engin. Computer applications in geography snippet”
- Start a spontaneous dialog with the participant, the test executor starts asking random questions about places of interest, local traffic, or personal interests if acceptable.

Appendix:
North Wind and the Sun (Orthodox Version): "A traveller wearing a warm cloak arrived while the North Wind and the Sun were debating which was stronger. They decided that the traveller should be deemed stronger than the other if they were the first to force him to remove his cloak. The traveller folded his cloak about him more tightly as the North Wind blew as hard as he could, until finally the North Wind gave up trying. The traveller removed his cloak right away as the Sun began to shine warmly. As a result, the North Wind had to acknowledge that the Sun was the more powerful of the two.

BNC - Technical Engineer. Snippet of computer applications in geography

"[...] This is because the degree of incoming radiation scattering decreases as the atmospheric path length increases since there is less scattering of blue light. Because more sunlight reaches the observer's eye directly, the sun looks whiter and less orange-coloured as altitude climbs. This phenomenon is caused by the same phenomenon. A schematic picture of the visible spectrum electromagnetic energy's journey from the sun to Earth and back is shown in Figure 5.7. The energy is directed towards a sensor that is installed on an orbiting spacecraft. The pathways of waves that correspond to energy that is susceptible to scattering, or has shorter wavelengths, are depicted as they move from the sun to Earth. Although some of the energy has been dispersed throughout the atmosphere and has never reached the ground at all, it seems to the sensor that all of the energy has been reflected from point P on the ground. [...]”

B. Feature Extraction

When evaluating audio data for tasks like speech recognition or classification, feature extraction is an essential first step. The code that is provided uses Mel-Frequency Cepstral Coefficients (MFCCs) for feature extraction. MFCCs are frequently employed in audio processing applications to depict an audio signal's spectrum properties. For audio processing, the librosa library is used, which provides useful functions for feature extraction. To load the audio data from the given file path, use the librosa load function. The MFCCs are calculated by the librosa.

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Feature mfcc function after the audio data has been loaded. The number of MFCC coefficients to extract is specified by the n_mfcc option, which is normally set to 13. Using the mean function along the designated axis, the mean of the coefficients is determined following the computation of the MFCCs. The final mean as representative features, MFCCs extract important information from the audio. Subsequent processing, such model training or classification, makes use of these attributes.

C. Model Training

In the machine learning process, a model learns relationships and patterns from the data it is given during the model training phase. Because a Random Forest classifier is good at handling high-dimensional data, it is used for model training in the code that is provided. The training data is comprised of labels designating the class (e.g., Parkinson's disease or healthy control) and features that have been retrieved from audio files. The train_test_split function from scikit-learn is used to divide the training data into training and testing sets. It is possible to instantiate the Random Forest Classifier class from scikit-learn by passing in parameters like the number of estimators and random state. The classifier is trained using the training data by using the fit method on the model object. The testing set is used to evaluate the model's performance once it has been trained. Scikit-learn routines like accuracy_score is used to calculate performance metrics like accuracy. The joblib.dump function is then used to save the trained model to a file for later deployment or use.

D. Prediction

Using a trained machine learning model to classify or forecast previously unknown data is the process of prediction. Based on auditory features, the offered code predicts the diagnosis of Parkinson's disease using the trained Random Forest classifier.

To access its training parameters, the joblib.load function loads the model from the stored file.

Consistency is ensured by extracting features from audio samples using the same technique as model training.

To get predictions for every audio clip, extracted features are fed into the trained model's forecast algorithm.

Based on the patterns it has learnt from the training set of data, the model predicts a label for each input. Class labels or numerical values that correspond to the anticipated result are commonly used to convey predictions.

The anticipated diagnosis for each audio clip is mapped to a legible format for humans, like "Parkinson's" or "Healthy". Predictions based on audio recordings offer important information on whether or not a person has Parkinson's disease.

E. Result

At last we get the result of user interface that can select our desired audio clip and process it and detect whether the individual has the disease or not.

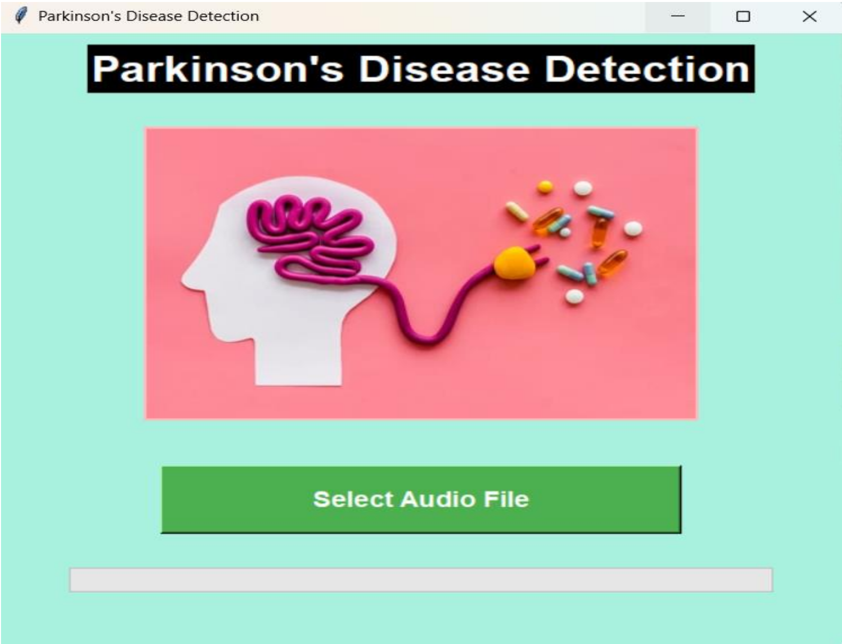

Fig. 1 User Interface

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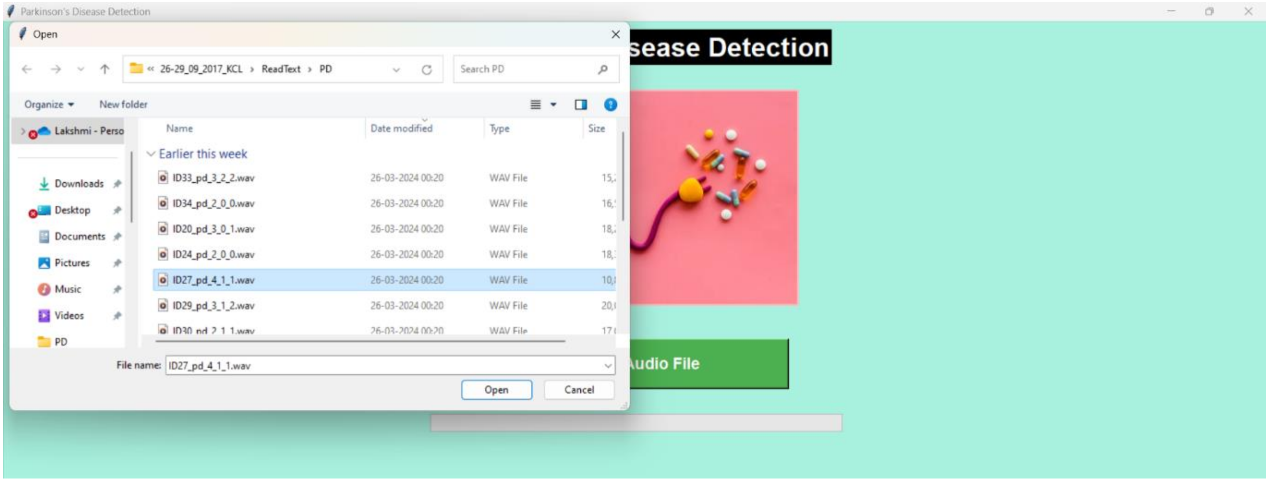

Fig. 2 Upload the audio file

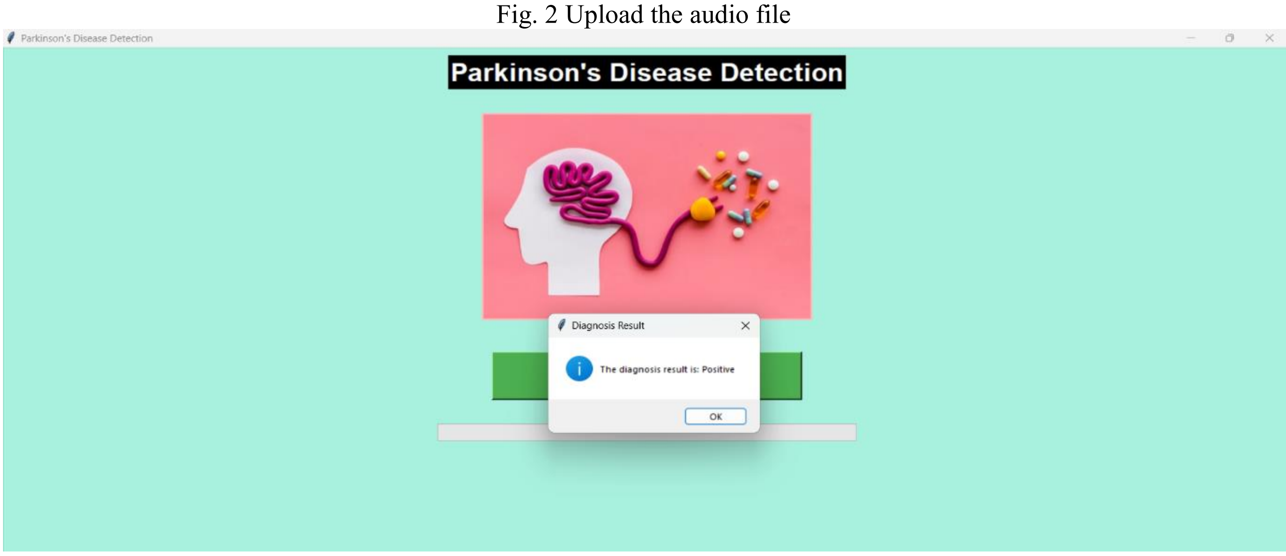

Fig. 3 Output containing diagnosis (positive)

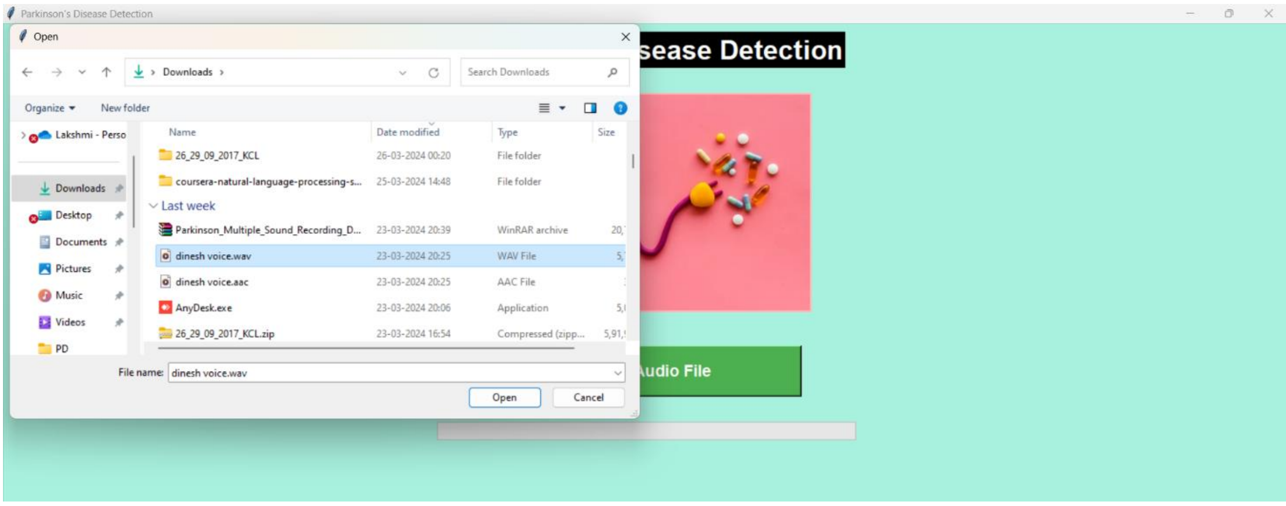

Fig.4 Upload the audio file

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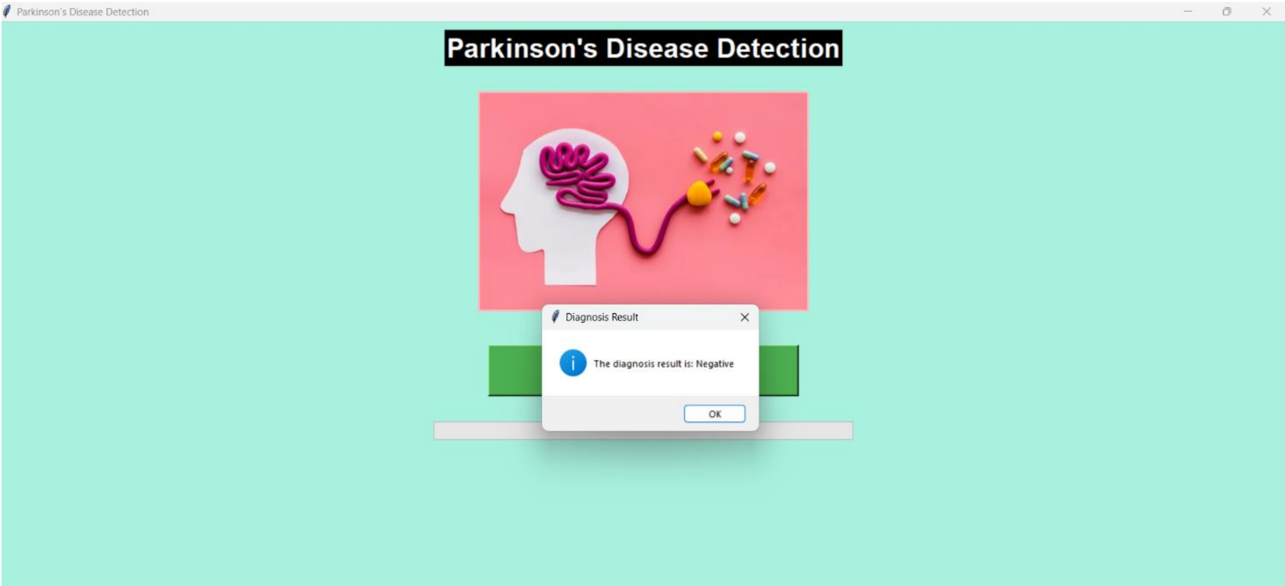

Fig. 5 Output containing diagnosis (negative)

IV. CONCLUSION

In summary, this system uses machine learning algorithms and audio analysis techniques to propose an automated method for the identification of Parkinson's disease. Through the process of feature extraction from speech recordings and Random Forest classifier training, the system is able to classify people into two groups: those with Parkinson's disease and healthy controls. The suggested approach has a number of benefits over conventional diagnostic techniques, such as accessibility, affordability, and non-invasiveness. Furthermore, a thorough study of the system's performance has confirmed its effectiveness in accurately diagnosing Parkinson's disease.

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