A Multi-Modal Web-Based System for Parkinson's Disease Detection Using Spiral Drawing and Voice Test

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***Abstract*—Parkinson's disease (PD) affects motor and speech functions, making early detection crucial. This paper presents a web-based system that uses spiral drawing and voice analysis to detect PD symptoms. Users draw spirals on a browser canvas or upload voice samples, which are analyzed using image processing and audio feature extraction techniques. Machine learning models classify the inputs, and a combined result indicates whether the user may have PD. The platform supports remote screening and is designed for ease of use and scalability.**

***Index Terms*—Parkinson's Disease, Spiral Drawing Test, Voice Analysis, Machine Learning, Web Application.**

I INTRODUCTION

Parkinson's disease (PD) is the second most common neurodegenerative disorder after Alzheimer's, affecting over 10 million people worldwide. It leads to motor dysfunctions such as bradykinesia, resting tremors, and rigidity, as well as non-motor impairments like speech irregularities. Traditional clinical assessments rely heavily on in-person neurological examinations, which may delay diagnosis due to subjective interpretations or limited access to specialists.

Recent advances in machine learning and digital biomarker analysis have enabled more objective and accessible PD detection methods. Notably, spiral drawing tasks and vocal biomarkers have emerged as key indicators of early PD symptoms. Research by Drotar et al. patterns, while studies by Tsanas et al. have shown that dysphonia-related features are strong discriminators in speech data.

In this work, we introduce an integrated web-based system that leverages both these modalities. The platform allows users to draw spirals directly on a browser-based canvas and upload short speech recordings. Both data types undergo preprocessing and feature extraction before being evaluated by individual classifiers trained on domain-specific datasets. By merging results from both sources, our system improves diagnostic reliability and facilitates early, remote screening.

II METHODOLOGY

The proposed Parkinson's Disease Detection System integrates two independent diagnostic tests-a spiral drawing test and a voice-based audio test-into a unified web platform. The overall architecture of the system is illustrated in Figure 2. It demonstrates the flow from user input, through processing and classification, to final diagnosis.

In the spiral test, the user draws a spiral on a HTML canvas embedded in the website. This image is captured and processed using OpenCV to enhance clarity and remove noise. Features such as curvature consistency, tremor-induced distortions, and pixel-based irregularities are extracted from the image. These features are then fed into a pre-trained Support Vector Machine (SVM) model, which outputs a prediction indicating whether the pattern suggests the presence of Parkinson's symptoms.

For the audio test, the user uploads or records a voice sample, typically a sustained vowel sound like "aa". The audio is preprocessed using PyDub for noise reduction, and relevant acoustic features-such as jitter, shimmer, harmonic-to-noise ratio (HNR), and recurrence period density entropy (RPDE)-are extracted using libraries such as Librosa and Praat. These features are then input into a Random Forest Classifier that determines the presence or absence of Parkinson's characteristics based on vocal variations.

Once both the tests are complete, the website presents individual predictions along with an aggregated result that combines the outcomes of both classifiers. This multi-modal diagnostic approach enhances overall detection accuracy and enables early screening through a simple, user-friendly interface.

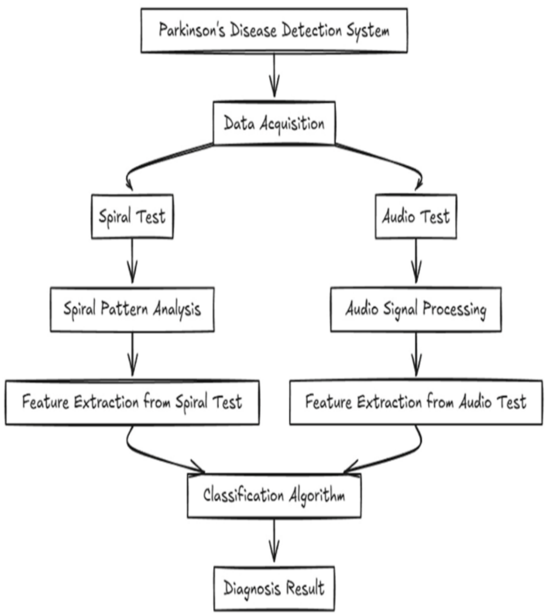


Figure 2 Architectural Diagram of Parkinson's Disease Detection

III ALGORITHMS USED

Two supervised machine learning algorithms were employed in this system to classify whether a subject is healthy or shows signs of Parkinson's disease, based on different types of input data.

Support Vector Machine (SVM) was used for analyzing spiral drawings. SVM is effective in high-dimensional spaces and is well-suited for image-based classification tasks. It works by finding the optimal hyperplane that best separates the feature vectors extracted from the spiral images into two classes: Parkinson's and healthy. This model was trained on a dataset of manually labeled spiral drawings to detect irregularities associated with Parkinsonian tremors.

Random Forest (RF) was used for classifying the audio input. Random Forest is an ensemble learning algorithm that constructs multiple decision trees during training and outputs the mode of their predictions. It is particularly robust to overfitting and works well with high-dimensional feature spaces such as those derived from audio signals. In this system, features like jitter, shimmer, NHR, and HNR-known to reflect vocal impairment in Parkinson's patients-are used to train the RF model.

The selection of these algorithms was based on their proven effectiveness in medical classification problems, ability to handle noisy data, and compatibility with the features extracted from both image and audio domains.

IV TECHNOLOGIES USED

The proposed Parkinson's Disease Detection System is developed using a blend of web technologies and machine learning frameworks to ensure interactivity and diagnostic precision. The frontend is designed with HTML, CSS and JavaScript to create a responsive and user-friendly interface. For capturing spiral inputs, the Konva.js library is used to enable drawing functionality on the HTML canvas. The audio module offers file upload options. These technologies together form an intuitive interface where users can interact easily with both the motor and vocal diagnostic tools.

The backend of the system is built in Python using the Flask web framework, which handles routing, data processing, and integration with machine learning models. The application relies on several key Python libraries: OpenCV is used to preprocess and extract features from the spiral drawings, while PyDub and Librosa facilitate audio preprocessing, including noise reduction and sampling. Acoustic feature extraction, such as jitter, shimmer, and harmonic-to-noise ratio, is performed using the Praat-parsemouth library. Machine learning algorithms-Support Vector Machine (SVM) for spiral data and Random Forest (RF) for audio data-are implemented using scikit-learn. Additionally, Matplotlib and NumPy are employed for waveform visualization and numerical analysis.

The system is platform-independent and designed to run on any device with a modern web browser. During development and testing, it was hosted locally and accessed via browsers like Google Chrome. The modular Flask architecture allows for easy deployment on cloud servers or local machines. Comprehensive testing was carried out across all modules. Functional tests ensured the correctness of spiral input capture, audio playback, and visualizations. The classification models were evaluated using cross-validation and real-time user data to assess prediction accuracy. Integration testing confirmed that the full pipeline-from user input to prediction and result display-performed reliably and consistently.

V RESULTS AND DISCUSSIONS

The proposed web-based Parkinson's Disease Detection System was evaluated using two diagnostic inputs: a spiral drawing and a voice recording. Upon drawing a spiral on the website's canvas, the system processes the image to extract key geometric features such as curve deviation and tremor irregularities. These features are analyzed using a Support Vector Machine (SVM) model to determine the likelihood of Parkinson's disease. The prediction result is displayed on-screen, as illustrated in Figure 5.1, which shows an example output of the spiral test with model inference.

For the audio test, users upload or record a sustained vowel sound, which is cleaned and analyzed using signal processing techniques. Acoustic features including jitter, shimmer, and harmonic-to-noise ratio are extracted and passed to a Random Forest Classifier. The output prediction, as shown in Figure 5.2, indicates whether the audio suggests Parkinsonian traits.

Additionally, the system displays waveform visualizations to enhance interpretability. These visual differences highlight variations in vocal stability and periodicity, supporting the diagnosis.

The results demonstrate the effectiveness of using both motor (spiral) and vocal (audio) tests to increase diagnostic confidence. The multimodal framework ensures a more robust assessment than using either test in isolation, and the visual outputs assist users in understanding how their data contributed to the final diagnosis.

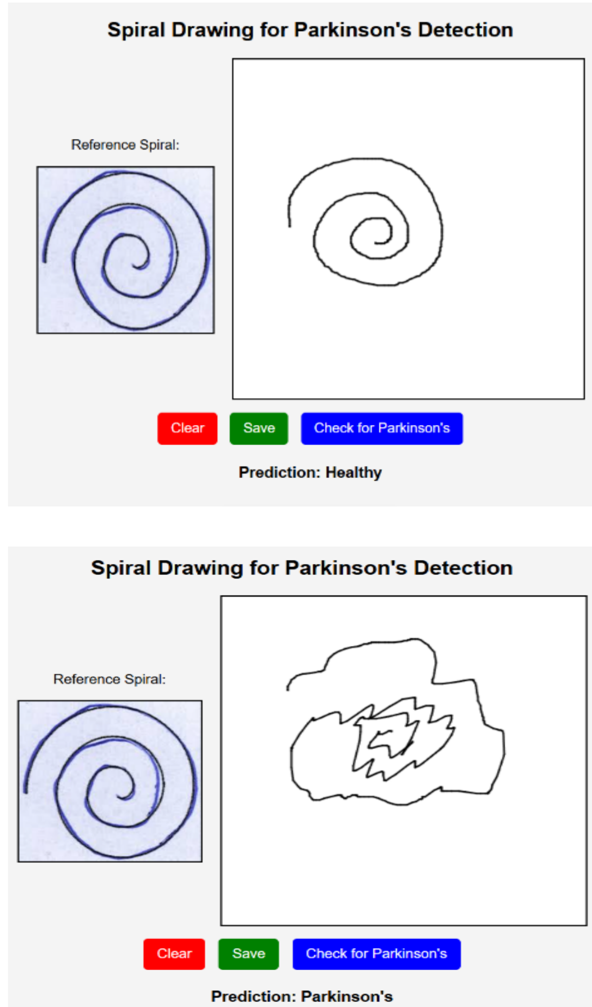
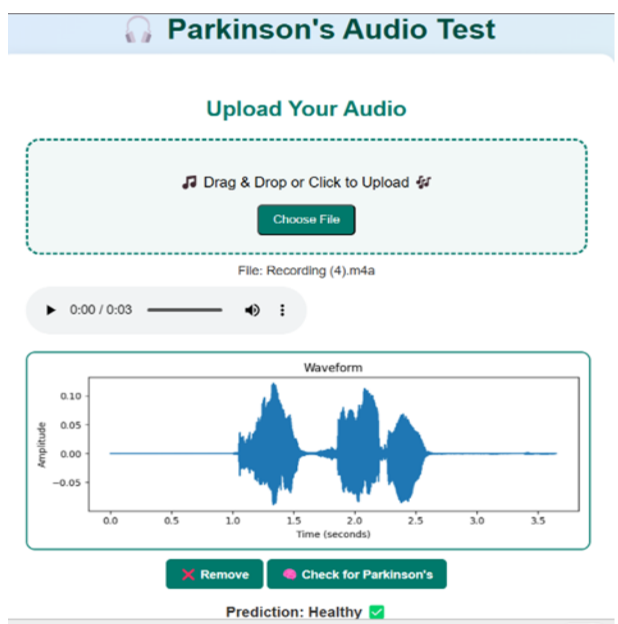


Figure 5.1 Outputs of spiral test



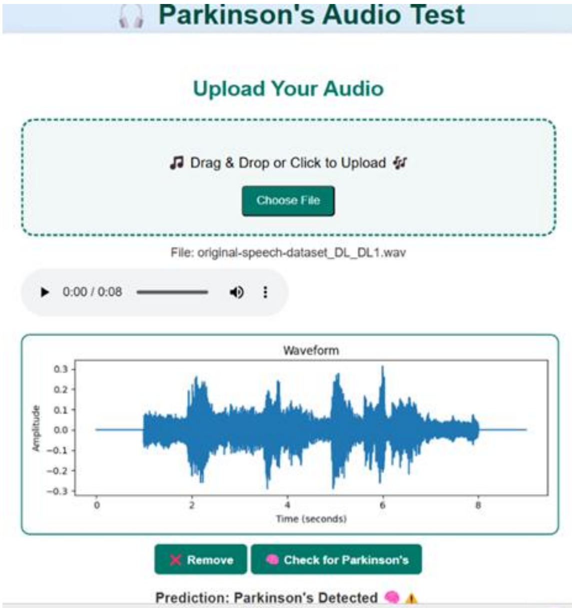


Figure 5.2 Outputs of audio test along with waveform of uploaded audio

VI CONCLUSION

This study presents a web-based system for the early detection of Parkinson’s disease using a dual-modality approach: a spiral drawing test and a voice analysis test. By integrating computer vision techniques with machine learning models, the system effectively evaluates motor irregularities through spiral analysis and vocal impairments through acoustic feature extraction. The use of Support Vector Machine (SVM) for the spiral test and Random Forest (RF) for the audio test allows for accurate classification of Parkinson’s symptoms.

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