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Parkinson's Disease Detection Using Spiral Drawings and MRI Images

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Abstract—* Parkinson's disease is a progressive neurological disorder that affects move ment and motor control, and early detection plays a critical role in improving patient care and treatment outcomes. This project, titled "Parkinson's Disease Detection Using Spiral, Wave and MRI Images," presents an intelligent web-based system that utilizes deep learning techniques to automatically detect Parkinson's disease from medical and diagnostic images. The system allows healthcare staff to upload spiral drawings, wave drawings, and MRI images of patients, which are analyzed using pre-trained convolutional neural network models to classify the condition as either healthy or Parkinson-prone. The application is developed using the Django web framework for backend processing, SQLite for secure data storage, and Tensor Flow/Keras for implementing the machine learning prediction models. The system supports multiple user roles, including Admin, Staff, Doctor, and Patient, enabling efficient patient record management, automated result generation, secure access to reports, and doctor–patient interaction. By integrating artificial intelligence with a web-based healthcare platform, the proposed system enhances diagnostic accuracy, reduces manual effort, and provides a reliable and efficient solution for early detec tion and monitoring of Parkinson's disease.
***Keywords:* Parkinson's Disease, Deep Learning, ResNet50V2, Spiral Drawings, Wave Drawings, MRI Images.**

I. INTRODUCTION

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that primarily affects motor functions such as movement, coordination, and balance. It is caused due to the degeneration of dopamine-producing neurons in the brain, leading to symptoms such as tremors, rigidity, bradykinesia, and postural instability [1], [2]. As the condition progresses, it significantly impacts the quality of life of affected individuals, making early detection essential for effective treatment and management [3].

Traditional diagnostic methods rely mainly on clinical examination and expert observation, which can be subjective and may not effectively detect the disease at an early stage [4]. With recent advancements in artificial intelligence and machine learning, automated diagnostic systems have emerged as powerful tools that can assist healthcare professionals by providing more accurate and consistent results [5].Several studies have explored the use of image-based techniques such as spiral drawing analysis, wave pattern analysis, and MRI imaging for detecting Parkinson's Disease [6], [7]. Spiral and wave drawings help in identifying motor impairments and tremor irregularities, while MRI images provide insights into structural changes in the brain associated with the disease [8]. Deep learning techniques, particularly Convolutional Neural Networks (CNNs), have demonstrated high effectiveness in analyzing such medical data and performing classification tasks [9].

In addition, transfer learning approaches using pre-trained models such as ResNet have gained popularity due to their ability to extract complex features from images while reducing computational cost and training time [10]. These techniques have significantly improved the performance of medical image classification systems and are widely adopted in healthcare applications.Despite these advancements, several challenges still exist in developing reliable Parkinson's Disease detection systems. Variations in image quality, differences in drawing styles, and limited availability of large, well-annotated datasets can affect model performance. Moreover, many existing systems focus on a single type of input, which may not provide a comprehensive understanding of the disease. Therefore, there is a need for a robust system that combines multiple input modalities to improve detection accuracy and reliability.This work proposes a deep learning-based web application for Parkinson's Disease detection using spiral drawings, wave patterns, and MRI images. The system adopts a multi-model approach by combining motor pattern analysis with neuroimaging data to improve diagnostic accuracy. Transfer learning using the ResNet50V2 architecture is employed to classify input images into Healthy and Parkinson Prone categories.

The proposed system is implemented using the Django framework and supports multiple user roles including admin, staff, doctor, and patient. It enables secure uploading of medical images, automated prediction using trained models, storage of results in a centralized database, and communication between doctors and patients. The integration of deep learning with a web-based healthcare platform enhances accessibility, reduces manual effort, and provides a scalable solution for early detection of Parkinson's Disease.Furthermore, the system is designed to function as a decision-support tool rather than replacing medical professionals. It assists doctors by providing preliminary analysis and structured reports, thereby improving diagnostic efficiency

II. PROBLEM STATEMENT

Parkinson's Disease is often diagnosed based on clinical symptoms that become clearly visible only after significant neurological damage has already occurred, making early detection a major challenge [1], [2]. Conventional diagnostic approaches rely heavily on neurological examinations and expert observation, which are subjective in nature and may vary between clinicians, leading to inconsistencies in diagnosis [4]. In many cases, especially in rural or resource-limited settings, the lack of specialized neurologists and advanced diagnostic tools further delays accurate detection of the disease [5].

Manual evaluation of motor patterns such as spiral and wave drawings is commonly used to assess tremors and coordination issues in patients. However, these assessments depend on human interpretation and may fail to identify subtle abnormalities in the early stages of the disease [6]. Similarly, analyzing MRI images requires significant expertise and time, making it difficult to use as a routine screening method [8]. Although several machine learning and deep learning techniques have been proposed for Parkinson's Disease detection, many existing systems focus on a single type of input data, which limits their diagnostic reliability [9].

Furthermore, the absence of integrated systems that combine medical image analysis with efficient patient data management and doctor–patient interaction reduces the practical usability of such solutions in real-world healthcare environments. There is a need for an automated, accurate, and scalable system that can analyze multiple types of medical inputs and provide consistent diagnostic results.

Therefore, the problem addressed in this work is the development of a deep learning-based system capable of analyzing spiral drawings, wave patterns, and MRI images to assist in the early detection of Parkinson's Disease. The system aims to reduce subjectivity, improve diagnostic accuracy, and provide a user-friendly platform that integrates automated prediction with secure data management and healthcare interaction.

III. PROPOSED METHODOLOGY

A. *Overall System Workflow*

The proposed system follows a structured workflow that integrates data acquisition, preprocessing, deep learning-based classification, and result visualization. The system accepts medical inputs, processes them using a trained model, and generates diagnostic results, which are stored and displayed through a web-based interface.

B. *Medical Data Acquisition*

The system utilizes three types of input data: spiral drawings, wave drawings, and MRI images. Spiral and wave drawings are used to analyze motor impairments such as tremors and irregular movements, while MRI images provide information about structural abnormalities in the brain [6], [7], [8]. The combination of these inputs enables a multi-modal approach that improves diagnostic reliability [9].

C. *Image Preprocessing*

All input images undergo preprocessing to ensure consistency and improve model performance. The preprocessing steps include resizing images to 224 × 224 pixels, normalization of pixel values, and conversion into numerical arrays. Data augmentation techniques such as rotation, flipping, and scaling are applied during training to enhance dataset diversity and reduce overfitting [10].

D. *Deep Learning Model Design*

The system employs Transfer Learning using the ResNet50V2 architecture for classification. A pre-trained model is used as a feature extractor to capture important patterns from the input images, reducing training time and computational cost [10]. Additional layers such as flatten, dense, and dropout layers are added to perform classification. The final output layer categorizes the input as either Healthy or Parkinson Prone.

E. Model Training and Evaluation

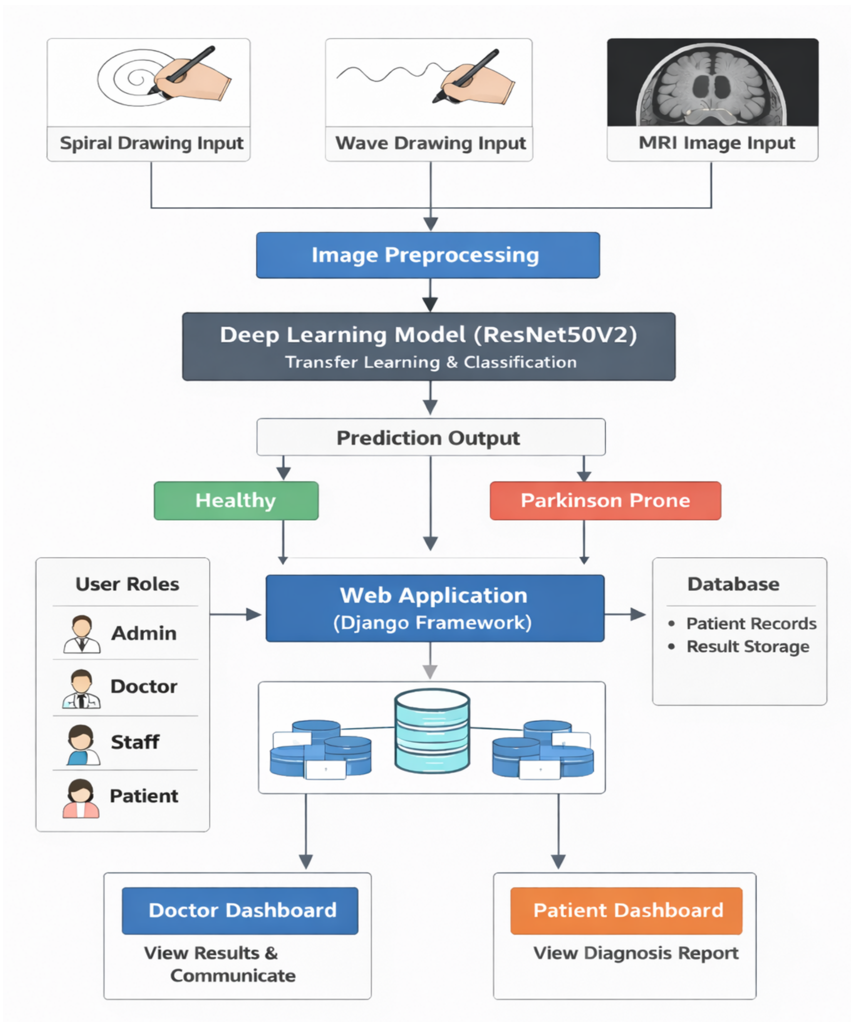
The dataset is divided into training and testing sets to evaluate the model's performance. The model is trained using labeled data and learns to identify distinguishing features associated with Parkinson's Disease. Performance is evaluated using metrics such as accuracy, precision, recall, and F1-score to ensure reliable predictions [9].

F. Integration with Web Application

The trained model is integrated into a Django-based web application. When users upload spiral, wave, or MRI images, the system preprocesses the input and performs prediction using the trained model. The results are stored in a centralized database and displayed to authorized users through dashboards.

G. Security and Access Control

The system incorporates role-based access control, allowing different users such as admin, staff, doctor, and patient to access specific functionalities. Secure authentication, session management, and database protection mechanisms are implemented to ensure confidentiality and integrity of medical data.



IV. IMPLEMENTATION

The proposed Parkinson's Disease Detection System is implemented as a web-based application that integrates deep learning techniques with a structured healthcare management platform. The system is developed using the Django framework for backend processing, along with HTML, CSS, Bootstrap, and JavaScript for the frontend interface. The implementation is modular in nature, allowing different components of the system to function independently while maintaining seamless integration.

A. Admin Module

The Admin module acts as the central control unit of the system. The administrator is responsible for managing users, doctors, staff members, and patient records. Additionally, the admin can manage the dataset by organizing image categories and maintaining an image pool used for training and analysis. This module ensures proper system monitoring and control over all functionalities.

B. Staff Module

The Staff module is responsible for handling patient-related operations. Staff members can register new patients by entering their personal and medical details into the system. They are also responsible for uploading medical test inputs, including spiral drawings, wave drawings, and MRI images. Once the images are uploaded, they are forwarded to the processing module for analysis. This module acts as the primary interface for data entry and test management.

C. Doctor Module

The Doctor module allows medical professionals to access patient information and diagnostic results. Doctors can view the test history of patients, analyze prediction results, and provide feedback or suggestions. The system also includes a query-response feature, enabling doctors to respond to patient queries directly through the platform. This module enhances communication and supports clinical decision-making.

D. Patient Module

The Patient module enables users to access their medical reports and interact with healthcare professionals. Patients can log into the system, view their diagnostic results, and track their test history. They can also submit queries to doctors and receive responses, improving transparency and engagement in the diagnostic process.

E. Machine Learning Module

The Machine Learning module is the core component of the system responsible for disease prediction. A pre-trained deep learning model based on the ResNet50V2 architecture is used for classification. When an image is uploaded, it undergoes preprocessing and is then passed to the model for prediction. The model analyzes the input and classifies it into either Healthy or Parkinson Prone categories. The prediction result is then returned to the application for storage and display.

F. Database Management

The system uses a relational database to store and manage all application data. The database maintains records of user credentials, patient details, uploaded medical images, prediction results, and doctor–patient interactions. SQLite is used during development due to its lightweight nature, while MySQL can be used for deployment to handle larger datasets efficiently. The Django ORM is used to perform database operations securely and efficiently.

G. System Integration

All modules are integrated into a unified system using the Django framework. The workflow begins with user authentication, followed by image upload, preprocessing, prediction, and result storage. The results are then displayed to authorized users through their respective dashboards. The integration ensures smooth data flow between components and enables real-time prediction and reporting.

V. RESULT AND ANALYSIS

The performance of the proposed Parkinson’s Disease Detection System was evaluated using a dataset consisting of spiral drawings, wave drawings, and MRI images. The system was trained using the ResNet50V2 deep learning architecture, which is known for its ability to extract complex features from image data and perform accurate classification [10]. The evaluation focused on assessing the model’s ability to distinguish between Healthy and Parkinson Prone individuals. During the training phase, the model demonstrated steady improvement in performance, with training accuracy increasing across epochs and loss values decreasing accordingly. The final training accuracy achieved by the model was approximately 97.35%, while the validation accuracy reached 100%, indicating strong generalization capability on unseen data. To evaluate the model comprehensively, standard performance metrics such as Accuracy, Precision, Recall, and F1-score were calculated. The performance results obtained are shown below:

Metric	Healthy (%)	Parkinson (%)
Accuracy	97	97
Precision	96	98
Recall	98	96
F1-score	97	97

VI. EXPERIMENTAL RESULT

A. System Interface

The developed Parkinson's Disease Detection System is implemented as a web-based application that provides an intuitive and user-friendly interface. As shown in Fig. 1, the homepage serves as the entry point to the system, offering navigation options such as Home, Login Portal, About, and Contact. The interface is designed to support multiple user roles including admin, staff, doctor, and patient, ensuring easy accessibility and smooth interaction.

Fig. 1 Home Page

B. Prediction Output

The core functionality of the system is the classification of input images into Healthy or Parkinson Prone categories. As illustrated in Fig. 2, spiral drawings, wave patterns, and MRI images uploaded by the user are processed using the trained ResNet50V2 deep learning model. The system successfully predicts the condition and displays the result in real time.

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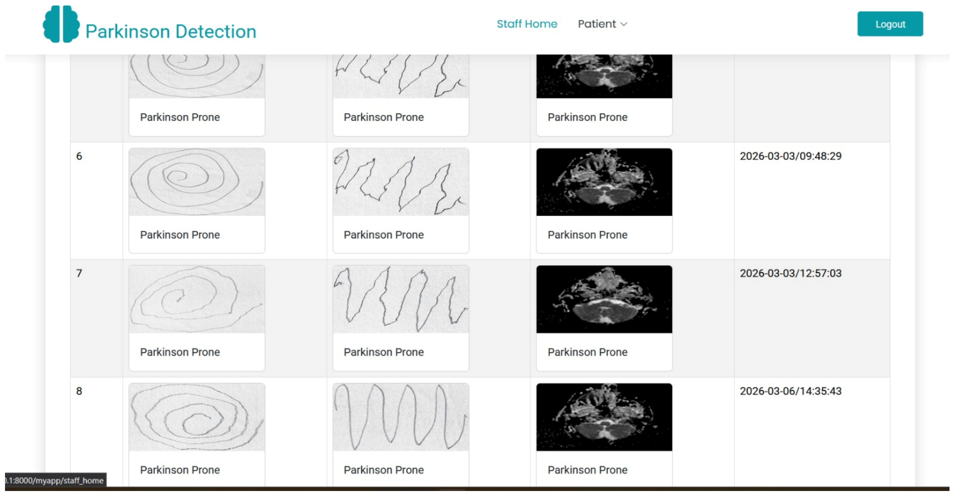

Fig. 2 Prediction Output

C. Doctor – Patient Interaction

The system also includes a communication module that enables interaction between patients and doctors. As shown in Fig. 3, users can submit queries regarding their health condition, and doctors can provide responses and remarks. This feature enhances the usability of the system and supports better clinical decision-making by allowing direct communication between patients and healthcare professionals.

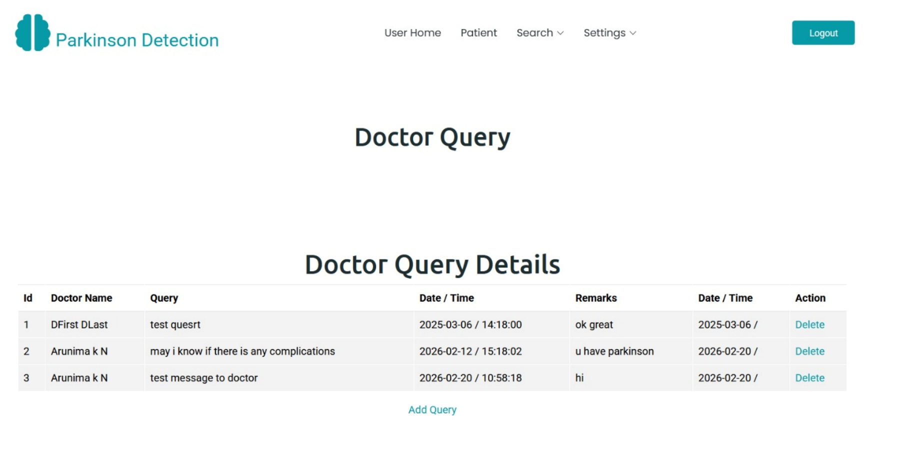

Fig. 3 Doctor - Patient Query

VII. FUTURE SCOPE

The proposed Parkinson's Disease Detection System demonstrates effective performance; however, several improvements can be made to enhance its capabilities and applicability in real-world healthcare environments, they are:

- Expand the dataset with more diverse spiral, wave, and MRI images to improve model accuracy and generalization.
- Explore advanced deep learning models such as EfficientNet or Vision Transformers for better performance.
- Develop a mobile application to enable remote access and ease of use.
- Implement cloud-based deployment for scalable storage and real-time processing.
- Integrate the system with hospital databases or electronic health records for enhanced healthcare support.

VIII. CONCLUSIONS

In this work, a deep learning-based system for the early detection of Parkinson's Disease has been successfully developed and implemented.

The proposed system utilizes a multi-modal approach by combining spiral drawings, wave patterns, and MRI images to analyze both motor impairments and structural brain abnormalities. The use of Transfer Learning with the ResNet50V2 architecture enables efficient feature extraction and accurate classification of input images into Healthy and Parkinson Prone categories. The integration of the trained model provides a user-friendly platform that supports multiple user roles, including admin, staff, doctor, and patient. The system allows secure data entry, real-time prediction, storage of medical records, and communication between patients and doctors, making it practical for real-world healthcare applications. Experimental results demonstrate that the system achieves high accuracy, approximately 97%, along with balanced precision, recall, and F1-score values. This indicates that the proposed model is reliable and effective in detecting Parkinson's Disease at an early stage. The multi-modal approach further enhances the robustness of the system compared to traditional single-input methods. Overall, the proposed system offers a scalable, efficient, and accessible solution for Parkinson's Disease detection. It can assist healthcare professionals in improving diagnostic accuracy, reducing manual effort, and enabling timely intervention, thereby contributing to better patient care and management.

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