Parkinson's Disease Detection using Machine Learning on DaTScan image

Sindhuja Boda[1], Rajyalaxmi Gadusu[2], Deepika Mallupally[3], Akhila Shyamala[4], Heena Begum[5]
Department of Computer Science and Engineering
(Gokaraju Rangaraju Institute of Engineering and Technology)
Hyderabad, India
Email: sindhuboda777@gmail.com, rajyalaxmigadusu@gmail.com, deepikamallupally@gmail.com, akhilashyamala90@gmail.com, ayesha.h33n4@gmail.com.

Abstract— ***Parkinson's disease is a chronic, progressive neurodegenerative disorder caused by the gradual damage of dopamine-producing neurons in the substantia nigra. It poses certain burdens on individuals suffering from it. As the advancement of medical diagnostics continues, newer methods of detection through machine learning analyze different modalities of medical data such as speech patterns, gait analysis, electroencephalography signals, and advanced imaging technologies. Among these latest methods, DaTScan is one of the most effective tools. This type of SPECT (Single-Photon Emission Computed Tomography) imaging will allow detailed views of the dopamine transporter activity in the brain, providing crucial information for the definite diagnosis of Parkinson's Disease. Our project aims to create an innovative web-based platform that utilizes DaTScan images together with advanced machine learning techniques to transform the way Parkinson's is detected. Through this platform, individuals seeking to determine whether they have Parkinson's Disease will be able to easily upload their DaTScan images, which will then be analyzed by state-of-the-art algorithms skilled to pick out dopamine transporter irregularities suggestive of the disease. This system guarantees quick and precise diagnoses, which detail the number of stages the condition has reached (5 stages), and will have complete visual reports to be viewed and downloaded to aid decision-making clinically through Expert connect.By developing this very wide, friendly, and scalable platform, we are trying to make advanced tools available much more widely for the detection of Parkinson's so that people can reach early diagnosis and have better results for patients via seamless clinical integration.***

Keywords—Parkinson's Disease, DaTScan, Dopamine, Diagnosis, Stages, Expert Connectivity, and Dopamine Transporter

INTRODUCTION

Parkinson's Disease is often referred to as a chronic and progressive degenerative disorder, characterized by a gradual degeneration of the dopamine-producing neurons located in the substantia nigra. With the involvement of several motor and non-motor symptoms, consisting of tremors, rigidity, bradykinesia, and cognitive impairment, the quality of life is severely hampered for its patients. Timely intervention during the early phases would also be crucial to effective disease management. Conventional diagnostic procedures, mainly based on clinical evaluations and symptom identification, do not hold an adequate measure of accuracy, especially in their earlier stages.

Recent improvements in medical imaging and artificial intelligence (AI) are seen as promising avenues to improve accuracy levels with regard to the diagnosis. Among the various techniques, the dopamine transporter scan (DaTScan) is a highly specialized single photon emission computed tomography (SPECT) imaging modality that affords visualization of dopamine transporter activity in the brain. Manual interpretation of DaTScan images has long been a drudgery subject to personal bias, thus prompting the need for an automated solution that serves as a fast and robust analysis technique.

This research provides a software-support user-friendly web-based concept to aid physicians in the early detection and discrimination of Parkinson's disease. The system integrates machine learning techniques with DaTScan image processing, thus ensuring speedy and accurate diagnosis. In addition to automated image analysis, the proposed platform has other capabilities, including disease stage classification, patient history tracking, expert consultation, and risk modification recommendations. The proposed system aims to enhance intervention through early diagnosis and incorporation into clinical workflow by increasing the efficiency, accessibility, and reliability of such diagnoses.

This paper describes the methodological approaches and experimental results proposed by the above-mentioned study, showing that it could be benefited for detecting stages of Parkinson's Disease and rendering assistance for medical professionals. Furthermore, it explores the ability programs of AI-pushed diagnostic equipment in neurology, emphasizing their function in improving medical decision-making and enhancing affected person care.

A. EXISTING SYSTEM

1) An existing system for detecting Parkinson's disease focuses on analyzing brain frequencies via Electroencephalogram (EEG) data to enable diagnosis. The EEG approach, which is conventionally for epilepsy, uses 20 electrodes attached to the patient scalp with paste or glue. The electrodes record the brain activities for a period of 20-40 minutes while the patient is at rest, occasionally opening and closing the eyes. Data of interest includes maximum, minimum, and average frequency values, jitter (frequency

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variations), and shimmer (amplitude variations). As it is nearly impossible for any human interpreter to evaluate these patterns, hence the selection of a machine-learning and deep-learning approach to mine for changes specific to Parkinson's disease. Data preprocessing, validation, and hyperparameter tuning have been used to optimize the different algorithms using basic classification, boosting, and bagging for predictive accuracy and efficiency. However, limitations arise since EEG setup is time-consuming and requires expertise, difficulties arise when patient relaxation levels determine the variations, and distinguishing Parkinson's disease from other neurological conditions with very similar brain patterns would still be a challenge, hence compromising on specificity and scalability.

$$\text{Fundamental Frequency}(Ff) = \sum fi/N \qquad (1)$$

a) EEG:Nowadays, EEG has been found as a promising tool in detecting Parkinson's disease with the help of abnormal brain waves under different frequency bands. The brain of a patient with Parkinson's disease usually shows a lowering in alpha waves (8 to 12 Hz), an increase in theta waves (4 to 8 Hz), and beta rhythm instability (13 to 30 Hz) in the motor cortex; also, there is a limited connectivity among districts in the mind, which affects neural communication. Late P300 waves (approximately 300 ms post-stimulus), a type of event-related potential, indicate cognitive decline associated with the disease. Deep learning techniques, including CNNs and LSTMs, are some machine learning models to process these EEG signals so that they can classify Parkinson's with high accuracy. EEG is a very effective method as it is non-invasive and cheap. It can be utilized in diagnosing, tracking the disease, and evaluating the responses to treatment: all making EEG an important instrument in research and clinical applications in Parkinson's disease.

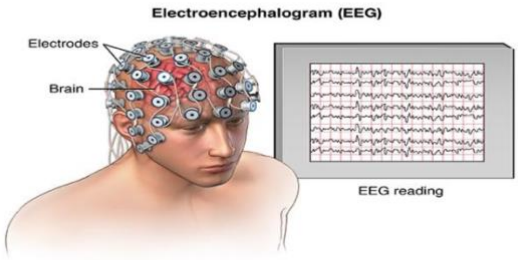

Fig. 1. Electroencephalogram Reading to Detect Parkinson's Disease.

b) Prediction Analysis:

Table 1: *Model Predictions for Sample Patients*

	Parkinson's Disease Detection		
	Feature	*Healthy Range*	*Indicative Range of PD*
1.	*Jitter(%)*	<1.0%	>1.04%
2.	*Shimmer(%)*	<3.5%	>3.81%

B. PROPOSED SYSTEM

The proposed system is designed to detect Parkinson's disease using DaTScan imaging combined with machine learning techniques.DaTScan produces high-resolution images of dopamine transporter levels in the brain, which are notably decreased in patients with Parkinson's. This uses a well-structured approach to achieve the following steps: image preprocessing, feature extraction, and classification with advanced machine learning approaches, such as Convolutional Neural Networks (CNNs). Image preprocessing serves two purposes: it enhances the quality of the image by filtering out noise, normalizing the intensity levels, and improving the contrast for easier perception of the features; and it reduces the image to a minimal form for the classification. In the feature extraction step, patterns that are symptomatic of dopamine deficiency are extracted, focusing on those regions of interest where Parkinsonian abnormalities are highlighted. The next step in the classification chain involves the application of CNNs that process the extracted features to discriminate between the Parkinsonian and the non-Parkinsonian cases with a high degree of accuracy. Aims to produce a robust and reliable diagnostic tool to assist physicians in making accurate diagnoses.

The web platform is under construction to make this technology available to the masses. The mechanism allows patients and doctors to log in safely and upload DaTScan images. After the upload, the image is processed wherein the analysis generated is of predictive nature, presenting a probability of the presence of signs of the disease in the patient. Ultimately, the platform aims to facilitate early diagnosis and assist in clinical decision-making and patient management by providing an accurate, evidence-based diagnostic tool. By automating and integrating the system with deep learning, we aim to increase efficiency in neurological assessments, leading to better patient outcomes.

C. MODEL TRAINING AND EVALUATION

1. Dataset Preparation

Preprocessing:

- *Normalization: Pixel intensity values normalized across the board.*
- *Resizing: All images are resized to fixed dimension (e.g., 128x128 or 224x224) to fit model input.*
- *Augmentation: Some transformations (rotation, flipping, zoom) were applied to increase data variability and reduce overfitting.*
- *Label Encoding: Images labeled as Normal, Early Stage, Moderate stage PD, Advanced Stage PD.*

2. Model Selection

Baseline Models:

- *Traditional ML: Support Vector Machine(SVM), Random Forest(RF), k-Nearest Neighbors(k-NN) with handcrafted features like HOG/SIFT.*

Deep Learning Models:

- *CNN architectures: Custom CNN, ResNet50, VGG16, EfficientNet, etc.*

- *Transfer Learning: Used pre-trained models fine-tuned on DaTScan data to improve performance with limited data.*

3. Training Process

Splitting: Dataset split into:

- *Training Set (70%)*
- *Validation Set (15%)*
- *Test Set (15%)*

Loss Function: Categorical Cross-Entropy (for multiclass classification).

D. WORKING MODEL OF PROJECT

a) Register

- *User authentication system (Email Address/Password).*
- *The new user can able to create the account before login.*

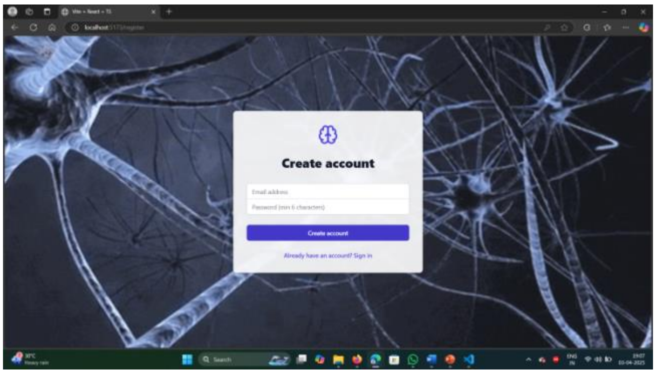

Figure.2. Register Page

b) Login

- *User can Sign in after the completion of Registration.*
- *Through these Sign in can be entered into the Dashboard of Parkinson's Disease Detection.*

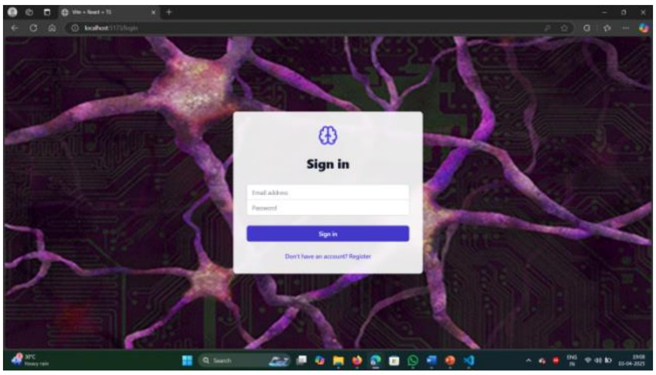

Figure.3. Login Page

c) Storage of Authentication credentials

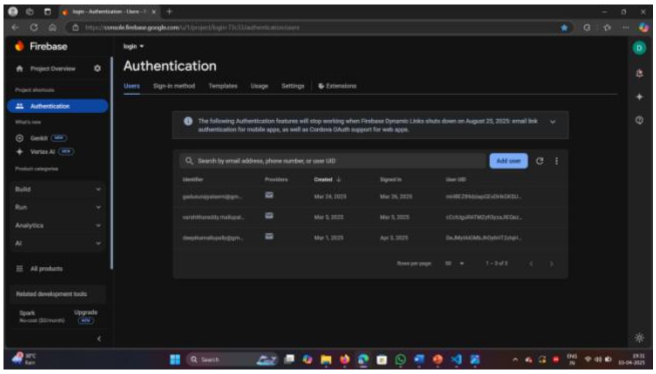

Figure.4. Storage of Credentials

d) Uploding of DaTScan

- *File upload functionality with format validation (e.g.,JPG).*

Figure.5. Upload area of DaTScan

e) Analysis Results

- *CNN-based model to analyze DaTScan images.*
- *Extracting key biomarkers indicating Parkinson's progression.*
- *Displaying results in a user-friendly manner.*

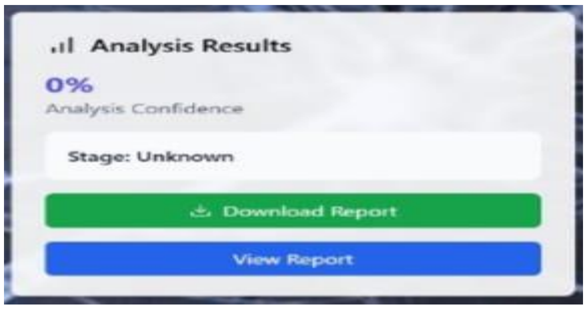

Figure.6. Analysis Part

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f) Binding Ratio

- *Calculating Striatal Binding Ratios (SBR) from DaTScan images.*
- *Comparison with threshold values for different Parkinson's stages.*
- *Graphical representation of SBR variations.*

Figure.7. Binding Ratio

g) History

- *Can able to see the history of past results.*

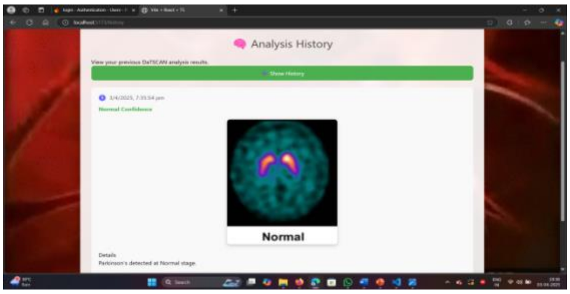

Figure.8. Previous Data

E. RESULT AND DISCUSSION

a) Prediction Outcomes

The proposed system was evaluated for its ability to detect Parkinson's disease from DaTScan images and determine the stage of progression. Upon analyzing the input scan, the system outputs a classification label (e.g., Stage 1, Stage 2, Stage 3, Stage 4, Stage 5, or Normal) along with a corresponding confidence score. A few sample outputs are shown in Table 1.

Table 2: Model Predictions for Sample Patients

patientID	*Predicted class*	*Confidence(%)*	*Diagnosis*
PID001	*No*	*95%*	*Normal*
PID002	*Stage 1*	*85%*	*Early*
PID003	*Stage 3*	*75%*	*Moderate*
PID004	*Stage 2*	*65%*	*Advanced*
PID005	*Stage 4*	*55%*	*Severe*

b) Performance Evalustion

The performance of the model was measured using standard classification metrics such as accuracy, precision, recall, and F1-score. These metrics were calculated over the test set comprising DATscan images not seen during training.

Table 3: Model Performance Metrics

METRIC	*SCORE(%)*
ACCURACY	*9.24*
PRECISION	*90.1*
RECALL	*89.7*
F1-SCORE	*89.9*
AUC-ROC	*0.945*

c) Report Generation and Recommendations

In addition to prediction, the system generates a downloadable report summarizing:

- *The patient's diagnostic result*
- *Confidence level*
- *Visualization of the scan*
- *Suggested next steps, such as consulting a neurologist or considering lifestyle interventions.*

d) Stages according to the dopamine levels

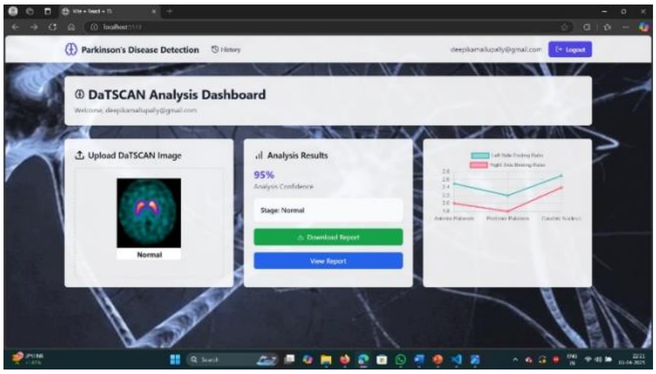

Figure.9. Normal Analysis

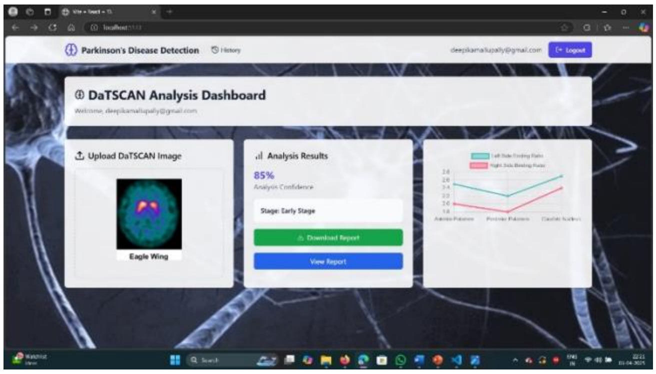

Figure.10. Early Stage Analysis

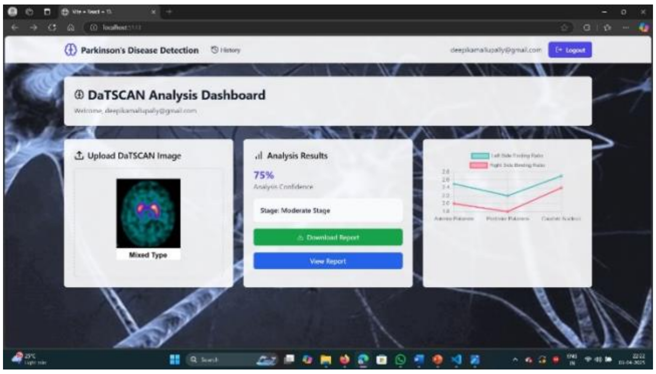

Figure.11. Moderate Stage Analysis

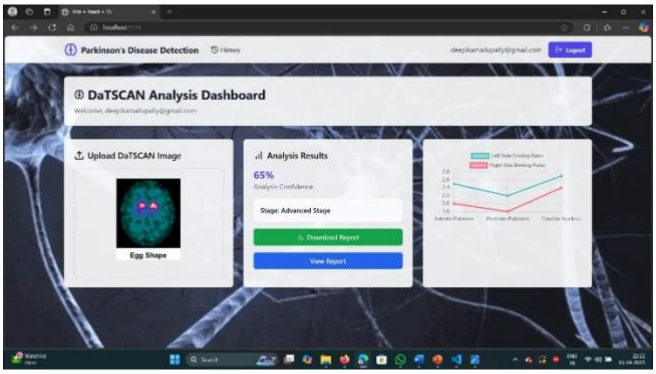

Figure.12. Advanced Stage Analysis

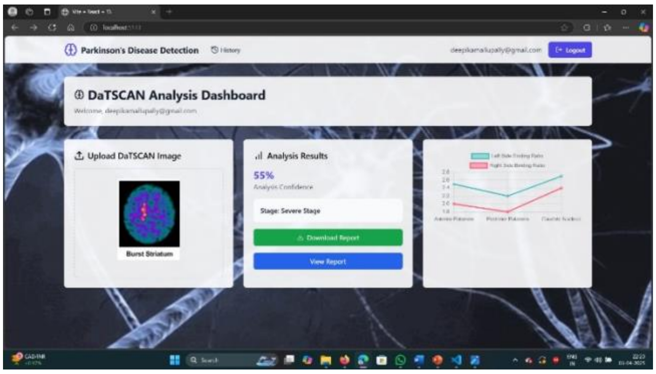

Figure.13. Severe stage Analysis

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