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Parkinson's Disease Detection

Guided By

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***Abstract*— Parkinson's disease (PD) is a progressive neurodegenerative disorder that affects motor functions, making early diagnosis essential for effective treatment and management. Traditional diagnostic methods rely on clinical assessments, which can be subjective and prone to delays. In this study, we propose a deep learning-based approach using Convolutional Neural Networks (CNNs) for automated detection of Parkinson's disease from medical images.**

The model is trained on an image dataset, including MRI scans, spiral drawings, and handwritten patterns, which serve as biomarkers for Parkinson's disease. The CNN architecture extracts spatial features from these images, enabling effective classification between Parkinson's and non-Parkinson's subjects. Various augmentation techniques and hyperparameter tuning strategies are employed to enhance model performance and generalization.

Experimental results demonstrate that the proposed CNN model achieves high accuracy, sensitivity, and specificity in detecting Parkinson's disease.

***Index Terms*—MRI Scans, Image Classification, Feature Extraction, Early Diagnosis, Data Augmentation, Automated Detection.**

I. INTRODUCTION

Traditional methods for diagnosing Parkinson's disease rely on clinical assessments, neurological examinations, and patient history analysis. However, these methods are subjective and may lead to misdiagnosis, particularly in the early stages when symptoms overlap with other movement disorders. Recent advancements in medical imaging and artificial intelligence (AI) have opened new possibilities for more accurate and objective diagnosis. Among AI-based techniques, deep learning—especially Convolutional Neural Networks (CNNs)—has shown great potential in medical image analysis due to its ability to automatically extract meaningful patterns and features from complex visual data.

Medical images, including MRI scans, spiral drawings, and handwriting samples, contain valuable information that can serve as biomarkers for Parkinson's disease. CNN-based models can effectively process these images, identifying subtle patterns that may not be easily detectable by human experts. This study aims to develop a CNN-based approach for Parkinson's disease detection using an image dataset. By training the deep learning model on labeled medical images, we seek to achieve an efficient, non-invasive, and highly accurate diagnostic system. This study proposes a CNN-based approach for Parkinson's disease detection using medical image datasets. The model is trained on labeled images, including MRI scans, spiral drawings, and handwriting samples, to identify patterns associated with Parkinson's disease. To enhance the model's performance, data preprocessing techniques such as normalization, augmentation, and contrast enhancement are applied. The classification performance is evaluated using key metrics, including accuracy, sensitivity, specificity, and F1-score, to determine the effectiveness of the proposed deep learning model.

Mathematical Model:
1. Problem Definition
The task is binary classification:
y=1y = 1y=1 for Parkinson's Disease (PD).
y=0y = 0y=0 for healthy individuals.
Objective:
f(X,θ)≈yf(X, \theta) \approx yf(X,θ)≈y

XXX: Input MRI image.
θ\thetaθ: CNN model parameters.
yyy: Predicted class.
2. Data Representation
Grayscale MRI images:
X∈Rm×nX \in \mathbb{R}^{m \times n}X∈Rm×n
RGB images:
X∈Rm×n×3X \in \mathbb{R}^{m \times n \times 3}X∈Rm×n×3
Where mmm and nnn are image dimensions.
3. CNN Architecture
A. Convolution Layer
Applies a filter WWW of size k×kk \times kk×k:
Zi,jl=∑p=0k−1∑q=0k−1Wp,ql⋅Xi+p,j+ql−1+blZ_{i,j}^{l} = \sum_{p=0}^{k-1} \sum_{q=0}^{k-1} W_{p,q}^{l} \cdot X_{i+p, j+q}^{l-1} + b^{l}Zi,jl=p=0∑k−1q=0∑k−1Wp,ql⋅Xi+p,j+ql−1+bl
B. Activation (ReLU)
Ai,jl=max⁡(0,Zi,jl)A_{i,j}^{l} = \max(0, Z_{i,j}^{l})Ai,jl=max(0,Zi,jl)
Pooling (Max Pooling)
Pi,jl=max⁡(A2i,2jl,A2i+1,2jl,A2i,2j+1l,A2i+1,2j+1l)P_{i,j}^{l} = \max \left(A_{2i, 2j}^{l}, A_{2i+1, 2j}^{l}, A_{2i, 2j+1}^{l}, A_{2i+1, 2j+1}^{l} \right)Pi,jl=max(A2i,2jl,A2i+1,2jl,A2i,2j+1l,A2i+1,2j+1l)
4. Fully Connected Layer and Classification
A. Flattening Layer
Flattens 2D feature maps into 1D vector:
F=Flatten(P)F = \text{Flatten}(P)F=Flatten(P)
B. Dense Layer
h=W(L)⋅F+b(L)h = W^{(L)} \cdot F + b^{(L)}h=W(L)⋅F+b(L)
C. Output Layer (Sigmoid for Binary Classification)
y^=σ(h)=11+e−h\hat{y} = \sigma(h) = \frac{1}{1 + e^{-h}}y^=σ(h)=1+e−h1
Final Prediction:
y={1,if y^≥0.50,if y^<0.5y = \begin{cases} 1, & \text{if } \hat{y} \geq 0.5 \\ 0, & \text{if } \hat{y} < 0.5 \end{cases}y={1,0,if y^≥0.5if y^<0.5
5. Loss Function
Binary Cross-Entropy Loss:
L(y,y^)=−1N∑i=1N[yilog⁡y^i+(1−yi)log⁡(1−y^i)]L(y, \hat{y}) = -\frac{1}{N} \sum_{i=1}^{N} \left[y_i \log \hat{y}_i + (1 - y_i) \log (1 - \hat{y}_i) \right]L(y,y^)=−N1i=1∑N[yilogy^i+(1−yi)log(1−y^i)]
6. Optimization
Gradient Descent (or Adam):
θt+1=θt−α∇θL(y,y^)\theta_{t+1} = \theta_t - \alpha \nabla_\theta L(y, \hat{y})θt+1=θt−α∇θL(y,y^)
Where:
α\alphaα: Learning rate.
∇θ\nabla_\theta∇θ: Gradient of loss w.r.t. model parameters.

II. RELATED WORK

In recent years, the application of deep learning techniques for the detection of Parkinson’s disease has gained significant attention due to their potential to improve diagnostic accuracy and efficiency. Various studies have explored the use of medical images, to detect Parkinson’s disease using machine learning and deep learning models. This section provides an overview of existing research in Parkinson’s disease detection, highlighting different methods, datasets, and performance metrics. Traditional methods for Parkinson’s disease detection primarily rely on clinical observations, patient history, and neurological examinations. However, these approaches are often subjective, time-consuming, and prone to human error.

Additionally, MRI-based methods have been used to study brain abnormalities in Parkinson’s patients, but these techniques are expensive and not widely accessible. Recent advancements in deep learning have revolutionized Parkinson’s disease detection by automating feature extraction and enhancing model accuracy. CNNs have been widely applied in various medical image analysis tasks due to their ability to extract spatial features from input images.

III. LITERATURE SURVEY

PDD-ET: Parkinson's Disease Detection Using ML Ensemble Techniques and Customized Big Dataset (2023)

Chatterjee and Kumar focus on leveraging ensemble methodologies in machine learning to enhance early-stage detection of Parkinson's disease (PD), particularly in its premotor phase. Their proposed model, PDD-ET, aims to provide a precise and reliable detection framework. The authors highlight the importance of dataset diversity and the integration of additional clinical variables to optimize the performance of ensemble techniques, advocating for a more comprehensive approach to data in PD detection.

Parkinson's Disease Detection Using a Novel Weighted Ensemble of CNN Models (2023)
Rai and Bajpai introduce an innovative ensemble learning-based model that utilizes a weighted ensemble of Convolutional Neural Networks (CNNs) to improve diagnostic accuracy in detecting Parkinson's disease. This study emphasizes the need for efficient and robust diagnostic models. The proposed method incorporates diverse feature extraction from figure-drawing task images, making it a literacy-independent, cost-effective, and time-efficient solution. The integration of multiple data sources is presented as a key factor in enhancing the model's effectiveness.

Parkinson's Disease Detection Using Machine Learning (2022)
This study applies Logistic Regression (LR) to identify patterns in data related to Parkinson's disease. It highlights the ability of machine learning models to uncover insights not easily discernible by humans. The authors stress that the quality and availability of data are critical for effective detection.

Parkinson's Disease Prediction Using Machine Learning Algorithm (2022)
Utilizing Convolutional Neural Networks (CNN), this research emphasizes the importance of early detection for improving patient outcomes. The study underscores that the accuracy of predictions is heavily reliant on the quality and quantity of available data, advocating for robust data collection methods.

Parkinson Disease Detection Using Various Machine Learning Algorithms (2022)
This paper compares multiple algorithms, including Support Vector Machine (SVM), Random Forest (RF), and K-Nearest Neighbors (KNN). It notes that different algorithms exhibit varying strengths in detection tasks. A significant challenge mentioned is the computational intensity required for training and optimizing these models.

Early Detection of Parkinson's Disease Using Deep Learning and Machine Learning (2020)
Focusing on Long Short-Term Memory (LSTM) networks, this study argues that early detection can slow disease progression and improve patients' quality of life. The authors highlight the need for large, high-quality labeled datasets to effectively train deep learning models.

Parkinson's Disease Classification Using Machine Learning Algorithms: Performance Analysis and Comparison (2022)
This research analyzes the performance of several machine learning algorithms, including SVM, RF, Decision Trees (DT), Naive Bayes (NB), and KNN. The findings emphasize that accurate classification is essential for timely medical interventions, reiterating that model effectiveness is closely tied to the quality of training data.

IV. OBJECTIVES

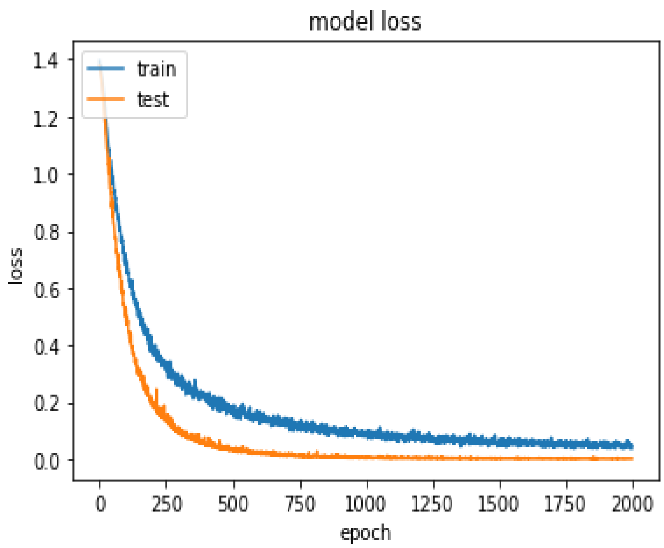
Implement a Convolutional Neural Network (CNN) to classify medical images patterns associated with Parkinson's disease. Optimize the CNN architecture to enhance feature extraction and classification accuracy. Apply image preprocessing techniques such as contrast enhancement, noise reduction, and edge detection to improve input quality. Assess model performance using metrics such as accuracy, precision, recall, F1-score, and AUC-ROC curve analysis. To develop an efficient and accurate deep learning-based model for the early detection of Parkinson's disease using image datasets.

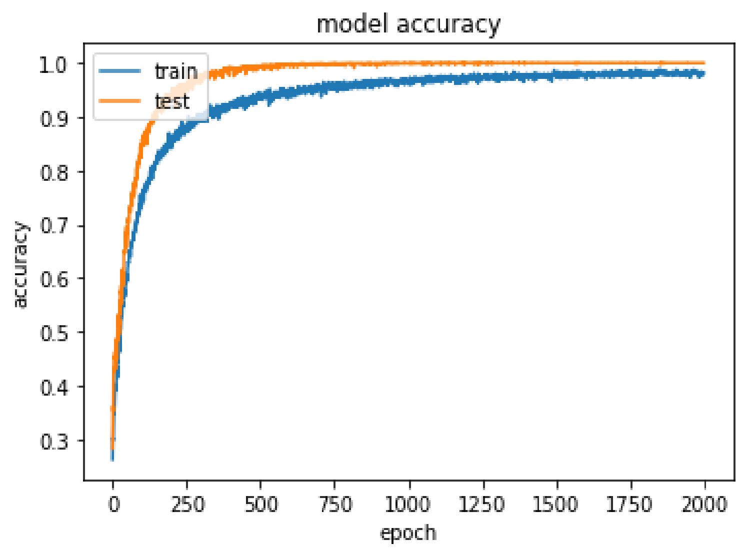
V. METHODOLOGY

Deep learning-based approach using Convolutional Neural Networks (CNNs) for the detection of Parkinson's disease from image datasets. The methodology consists of several key stages, including data collection, preprocessing, model development, training, evaluation, and deployment.
Grayscale Conversion: Converts images to a single-channel format for computational efficiency.
Normalization: Scales pixel values to the range [0,1] to improve CNN performance.
Noise Reduction: Applies Gaussian and median filters to remove unwanted noise.
Input Layer: Takes preprocessed images of a fixed size (e.g., 128×128 pixels).
Convolutional Layers: Extract spatial features using multiple filters (kernels) with ReLU activation functions.
Batch Normalization: Normalizes activations to speed up training and improve generalization.
Pooling Layers: Uses MaxPooling to reduce feature map dimensions and computational cost.
Dropout Layers: Prevents overfitting by randomly deactivating neurons during training.
Fully Connected Layers: Processes extracted features and maps them to output classes.
Softmax Output Layer: Provides the final classification probability between Parkinson's and Healthy classes.

VI. RESULTS

The performance of the proposed CNN-based Parkinson's disease detection model was evaluated using a set of key metrics, including accuracy, precision, recall, F1-score, and AUC-ROC curves. The results demonstrate the model's effectiveness in detecting Parkinson's disease from image datasets. Above 90% accuracy indicates the model's ability to correctly classify Parkinson's and non-Parkinson's stage cases.



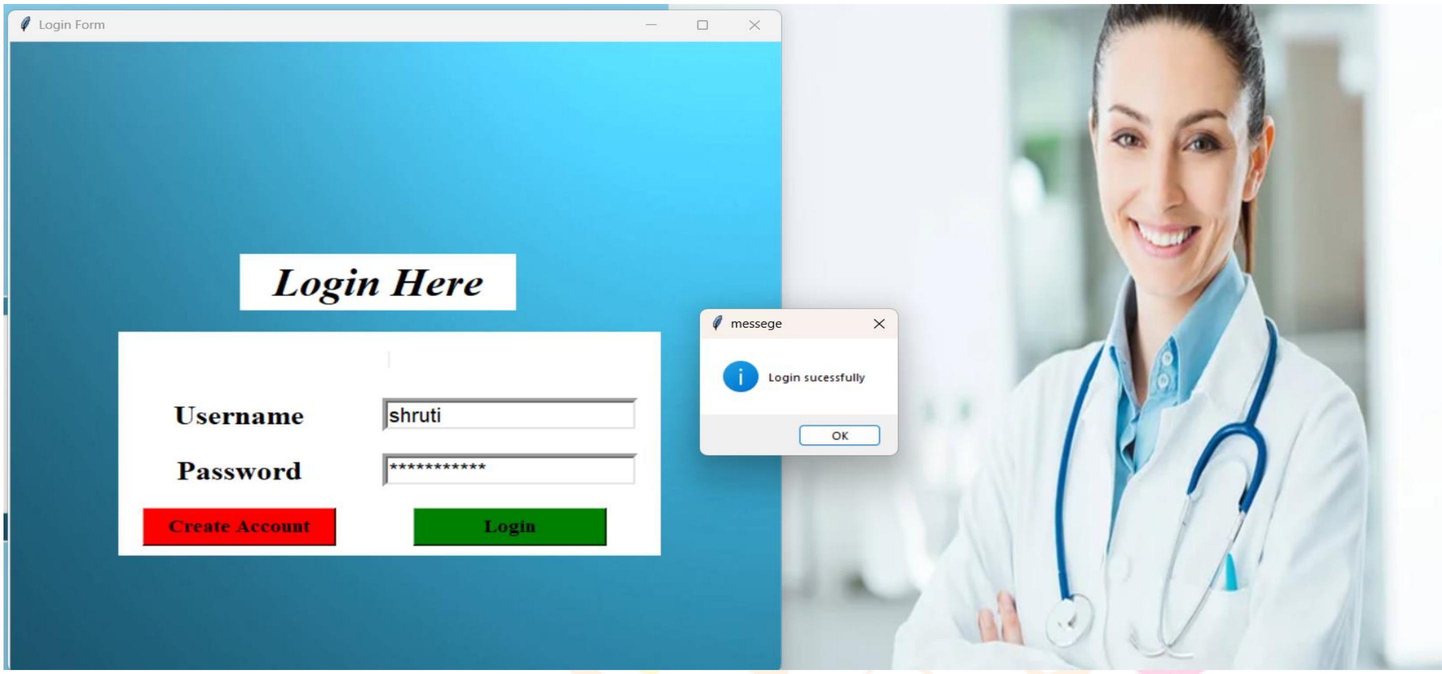


VII. Conclusion

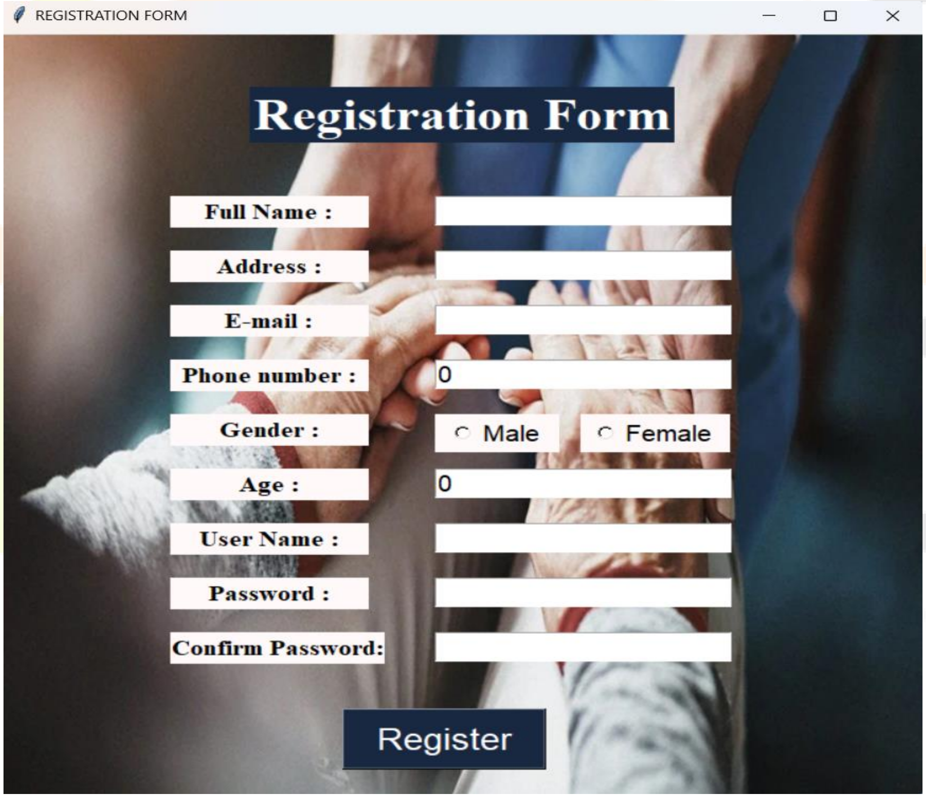
This study proposed a deep learning-based approach using Convolutional Neural Networks (CNNs) for the automated detection of Parkinson's disease from medical image datasets. The developed model successfully extracted meaningful features and classified images with high accuracy, demonstrating its potential as a non-invasive, efficient, and reliable diagnostic tool. The confusion matrix analysis further confirms the model's ability to differentiate between Parkinson's stage subjects with minimal false positives and false negatives. This work contributes to early Parkinson's disease detection, which is crucial for timely medical intervention and treatment.

VIII. Result

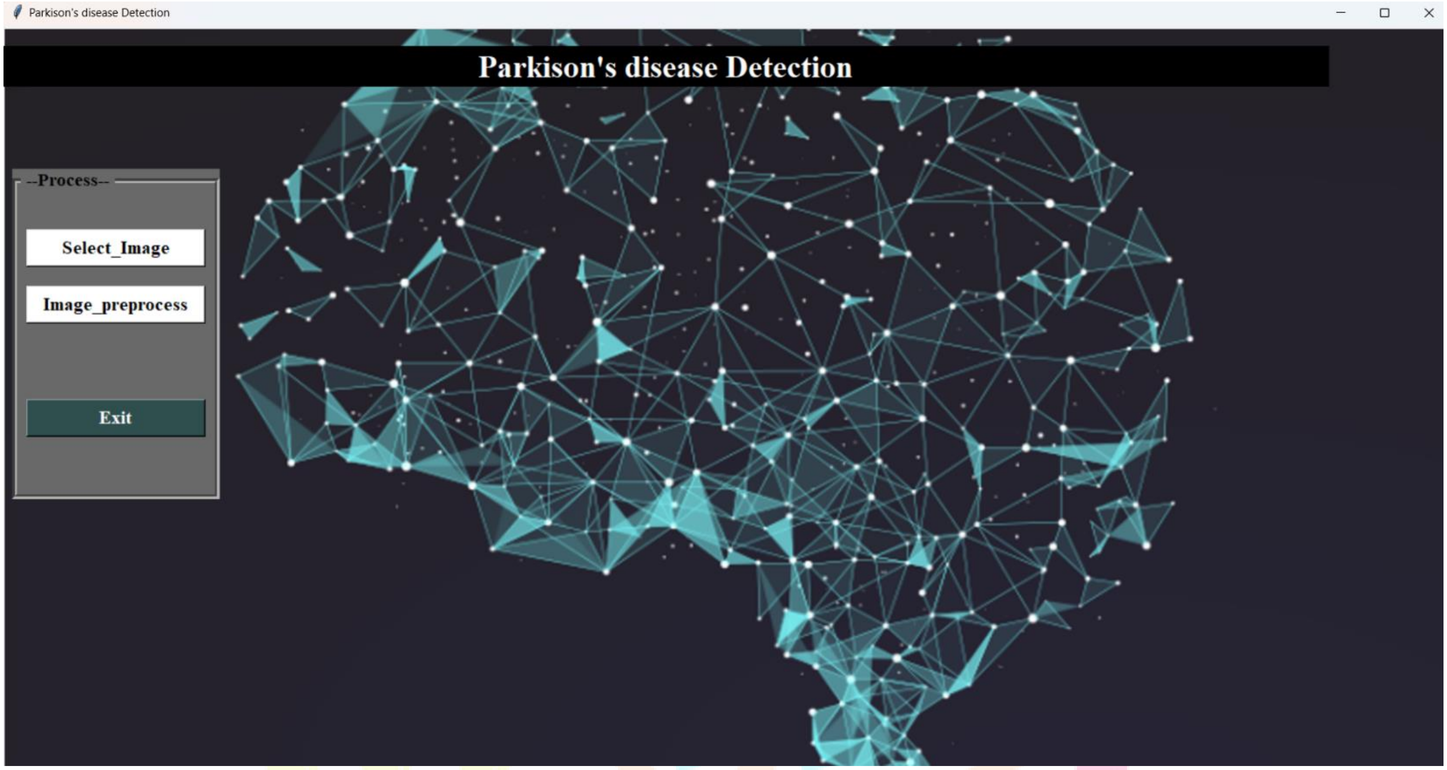
Dashboard



Registration form to sign up or create new account



Login Form



MRI Report Image can be uploaded here to predict the disease

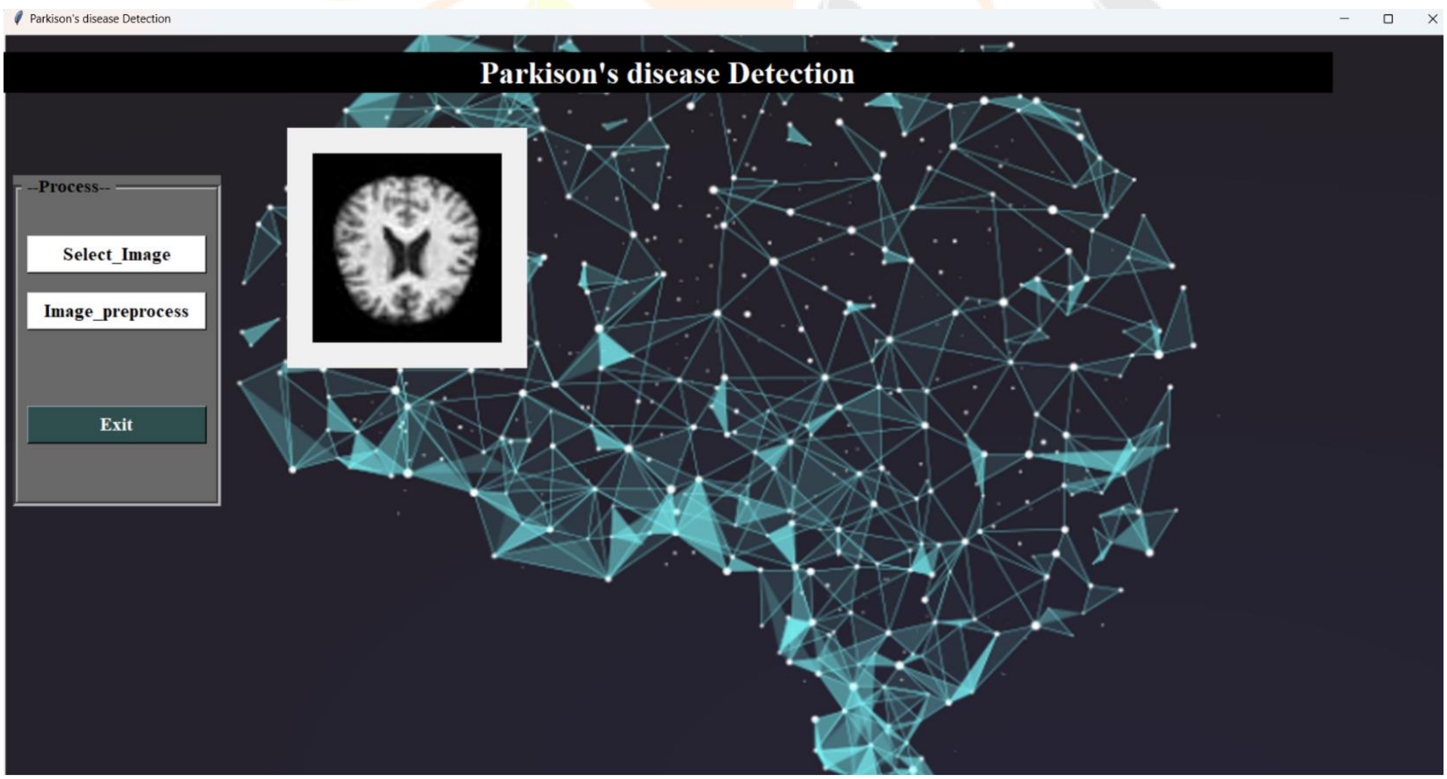
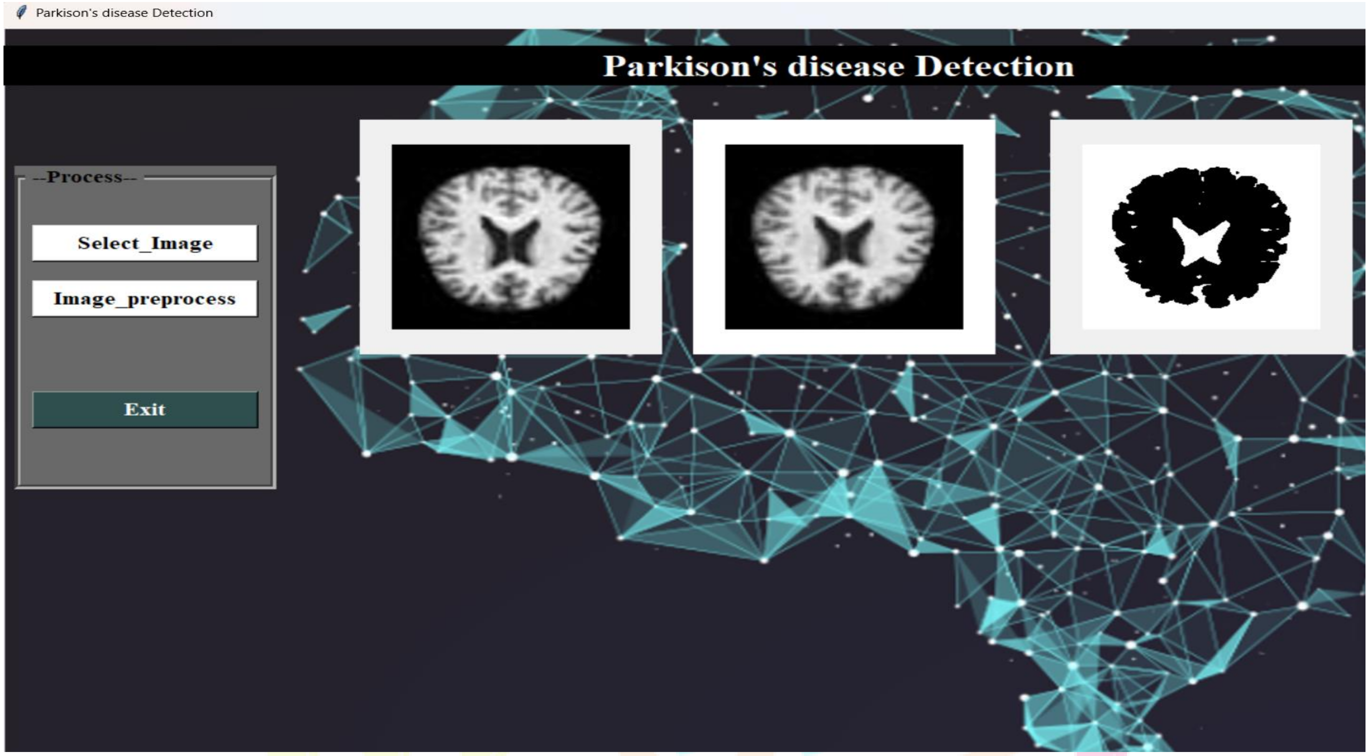
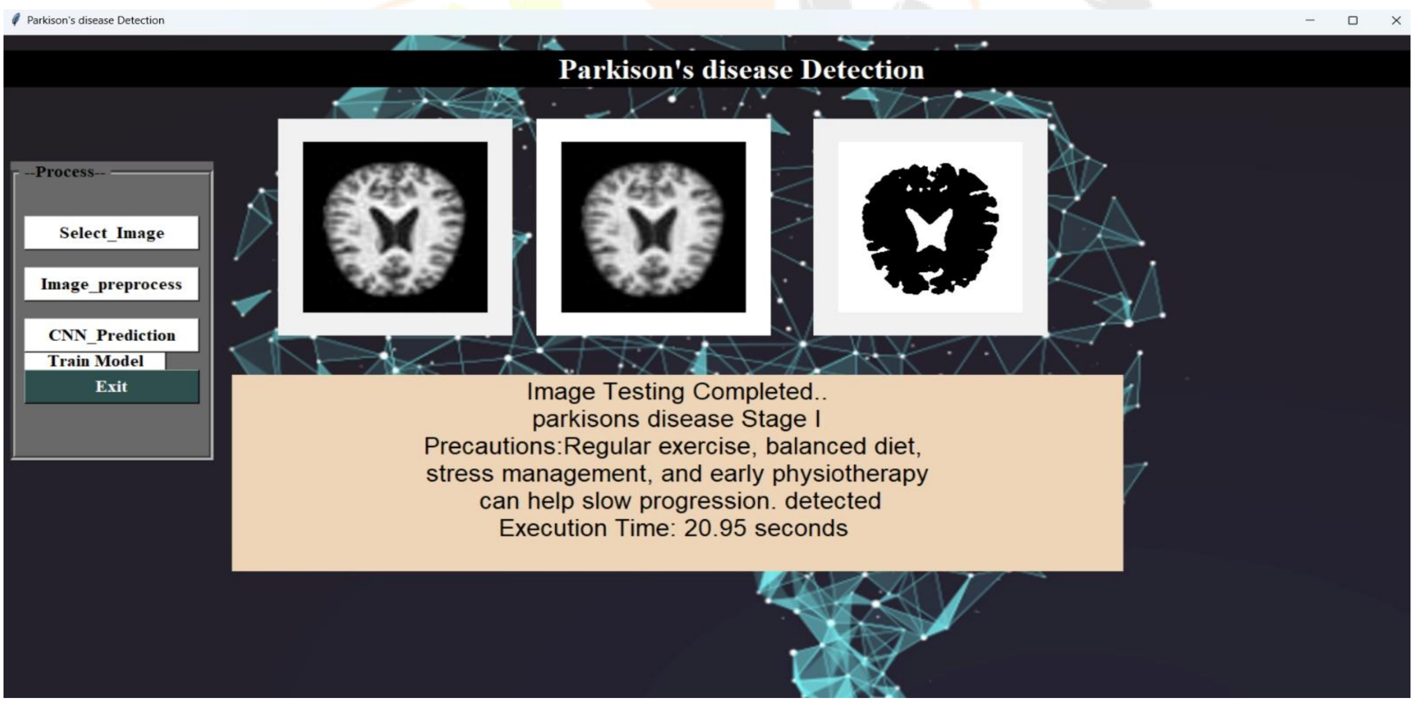


Image threshold



Final Predicton



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