



Early Detection of Parkinson's Disease Using Image Processing and Machine Learning

Yamuna V¹, Monisha S², Namratha V³, Shalini K⁴, Vandana S⁵

¹Assistant Professor/CSE, Sri Sairam College of Engineering, Bangalore – 560126, 3, 4, 5.
Final Year/CSE, Sri Sairam College of Engineering, Bangalore - 560126

ABSTRACT

Parkinson's disease (PD) is a progressive neurodegenerative disorder affecting millions globally. Early detection is crucial for timely intervention and improved patient outcomes. Conventional diagnostic methods rely on clinical assessments and neurological examinations, which may not detect subtle early-stage changes. The integration of image processing techniques and machine learning (ML) algorithms has demonstrated promising results in early PD detection. Image processing extracts valuable information from medical imaging modalities such as MRI, PET, and SPECT, revealing structural and functional brain changes associated with PD prior to the manifestation of clinical symptoms. Advanced algorithms enhance image quality, segment regions of interest, and extract relevant features indicative of early PD signs. ML algorithms analyze these features and identify patterns distinguishing healthy individuals from those with early-stage PD. Supervised learning techniques such as SVM, random forests, and deep neural networks can classify new cases, while unsupervised learning methods assist in identifying PD patient subgroups. This combined approach offers advantages including objective and quantitative measures of brain changes, detection of subtle alterations, and integration of multiple information sources to improve diagnostic accuracy. Recent studies have demonstrated the potential of this approach in detecting early-stage PD, analyzing MRI scans to identify brain atrophy patterns and applying deep learning to PET images to detect abnormal dopamine metabolism. These advancements contribute to earlier diagnosis, disease progression monitoring, and treatment efficacy evaluation, presenting significant potential for revolutionizing early PD detection and management.

1 Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disorder affecting millions of individuals globally. Early detection of PD is critical for timely intervention and enhanced patient outcomes. Conventional diagnostic methods primarily rely on clinical assessments and neurological examinations, which may not detect subtle changes in the disease's early stages. In recent years, the integration of image processing techniques and machine learning (ML) algorithms has demonstrated promising results in the early detection of PD. Image processing can reveal structural and functional changes in the brain associated with PD, even before the onset of clinical symptoms. Through the application of advanced image processing algorithms, researchers can enhance image quality, segment regions of interest, and extract relevant features that may indicate early signs of PD. Machine learning algorithms play a crucial role



in analysing the extracted features and identifying patterns that distinguish between healthy individuals and those with early-stage PD. Supervised learning techniques, such as support vector machines (SVM), random forests, and deep neural networks, can be trained on large datasets of labelled images to accurately classify new cases. Unsupervised learning methods, such as clustering algorithms, can assist in identifying subgroups within PD patients, potentially leading to more personalized treatment approaches. The combination of image processing and ML offers several advantages in early PD detection. Firstly, it provides objective and quantitative measures of brain changes, reducing reliance on subjective clinical assessments. Secondly, these techniques can detect subtle alterations in brain structure and function that may not be visible to the human eye. Thirdly, ML algorithms can integrate multiple sources of information, including imaging data, clinical records, and genetic markers, to improve diagnostic accuracy. Recent studies have demonstrated the potential of this approach in detecting PD at early stages. For instance, researchers have utilized ML algorithms to analyse MRI scans and identify patterns of brain atrophy associated with PD^[1]. Others have applied deep learning techniques to PET images to detect abnormal dopamine metabolism, a hallmark of PD^[2]. These advancements not only contribute to earlier diagnosis but also aid in monitoring disease progression and evaluating treatment efficacy. As research in this field continues to progress, the integration of image processing and ML techniques holds significant promise for revolutionizing the early detection and management of Parkinson's disease, ultimately improving the quality of life for affected individual.

2 Recent Works

In the recent work, the final augmented image is created by combining the original pre-processed image with a mixture image using a convex combination, where the mixing coefficient (m) is drawn from a beta distribution. The depth of augmentation, or the number of transformations applied sequentially to each image, can either be fixed (if mixture depth > 0) or randomly chosen from the set $\{1, 2, 3\}$. The severity of these transformations is also adjustable. The AugMix algorithm generates augmented versions of the input images by applying random transformations, which are then pre-processed (e.g., normalized) and combined into a 'mixture' image through a weighted sum. One of the augmentations mentioned includes randomly flipping images horizontally with a probability of 0.5 to further diversify the dataset. [3] Another recent study introduces a deep learning framework aimed at the early detection of Parkinson's disease (PD). The detection process consists of two primary stages: training and testing. In the training stage, raw data undergoes preprocessing and Standardization before being utilized to develop the deep learning model. Parameters of the model are carefully chosen to minimize the loss function during training. In the subsequent testing stage, the constructed model with the selected parameters is employed to detect PD. subsequent studies aim to enhance the dataset, where outliers were processed and missing values were addressed using the coefficient of variation to assess the relative dispersion of the data points. Additionally, the SMOTE method was employed to balance the dataset. The correlation coefficient was used to



evaluate the relationship of all features with the target variable. The RFE algorithm measured the relationship between features and the proportions of positive and negative correlations for each. To identify the most significant features, both t-SNE and PCA algorithms were utilized. Finally, the selected features were classified using five different classifiers. [5]

3 Proposed Work

The study focuses on MRI scanned image datasets of Parkinson's disease, encompassing both normal and abnormal cases. It involves preprocessing and enhancing these images to improve their quality for analysis. Tumor detection within the images is achieved through image segmentation techniques, allowing for a clear delineation of affected areas. Essential features are then extracted from the segmented images, including Gray Level Co-occurrence Matrix (GLCM) features and various geometric characteristics, resulting in a total of 16 distinct features that contribute to the understanding and diagnosis of Parkinson's disease. These GLCM features are used to extract an overview of the tumour for both normal and abnormal scanned images. The dataset obtained through this is fed into the machine using various algorithms which is trained up to two to three models. The model that yields the best and the accurate result is chosen as the final model. The model will be well trained in the processes like image segmentation, feature extraction, and GLCM techniques. Once the model is well versed with the necessary techniques, it will automatically detect the anomaly in the brain by simply studying the image that is fed into it. For different datasets, different algorithms like Decision Tree, KNN algorithm, SVM algorithm, Bayesian Learning and more are implemented, the one which yields the accurate result is chosen at the end.

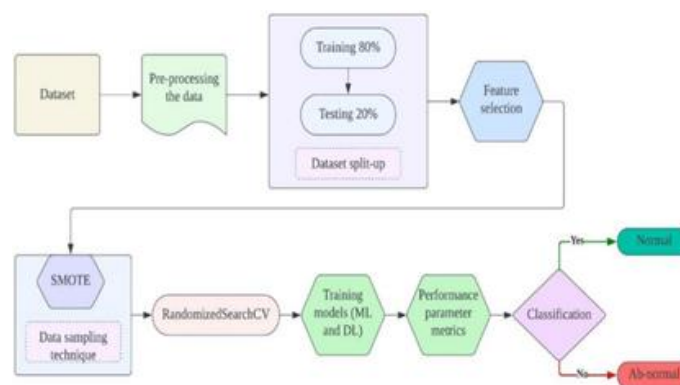


Figure 1: *Proposed block diagram*

4 Mathematical Expressions and Symbols

The study employs MRI scanned image datasets of Parkinson's disease, including both normal and abnormal cases. The initial step involves preprocessing and enhancing the images to



improve their quality, which may include techniques such as noise reduction and histogram equalization. Following this, image segmentation is performed to identify tumor or regions of interest, often utilizing algorithms like thresholding or clustering. This process can be mathematically represented by:

$$I_8(x, y) = \begin{cases} 1, & \text{if } I(x, y) \geq T \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

Where I_8 is the segmented image, I is the original image, and T is the threshold.

Essential features are extracted from the segmented images, including Gray Level Co-occurrence Matrix (GLCM) features and geometric features. GLCM features can be computed using:

$$(i, j) = \sum \delta(I(x, y), i, j) \quad (x, y) \in I \quad (2)$$

Where δ is the function indicating the pixel pair occurrence? In addition, geometric features such as area, perimeter, and shape descriptors are computed. The complete feature set includes 16 essential features that play a vital role in the classification and analysis of Parkinson's disease.

5 Results and Discussion

This study on MRI datasets related to Parkinson's disease focuses on enhancing image quality, segmentation, and feature extraction for improved analysis, particularly for tumor detection. Preprocessing techniques reduce noise and improve clarity, making MRI images more suitable for precise analysis. Image segmentation isolates potential tumor areas, clearly delineating abnormal regions. Sixteen distinct features, including GLCM-based texture attributes (contrast, correlation, energy, homogeneity) and geometric characteristics (shape, size, perimeter), are extracted to differentiate healthy and affected tissues. Analyzing these patterns aids in identifying manifestations of Parkinson's disease and supports diagnosis, especially in cases where tumors may influence disease progression or symptoms. Some of the below figures gives a comparison with the normal brain with the brain of a Parkinson patient.

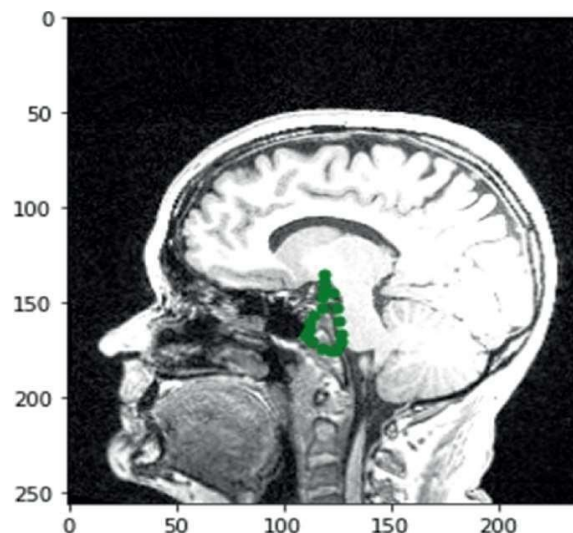




Figure 2: *MRI scan of a Parkinson patient using Deep Learning Algorithm*

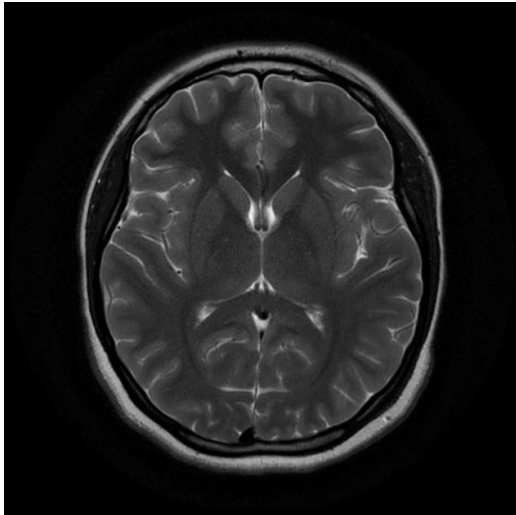


Figure 3: (a) Normal Brain

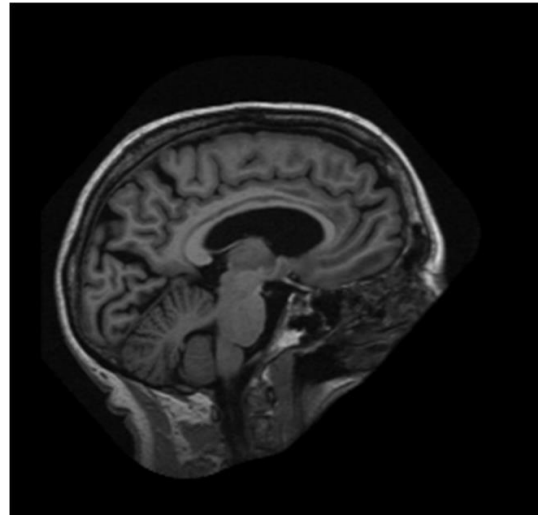


Figure 4: (b) Brain of Parkinson Patient

below figure shows the MRI scanned image of a patient using Deep Learning Algorithm: Images similar to the above MRI scanned images are provided as the input to the trained model. The model then analyses the images, perform segmentation, feature extraction operations and then classify whether the person is Parkinson affected. Hence, this method proves to be much more efficient way of prediction of Parkinson's disease than the previous ways, as the latter one may not be much efficient in detecting the disease at the early stage.

6 Conclusion

The main outcome of this work is to detect the Parkinson's disease at its earliest stage so as to reduce the death rate to some extent because the disease has no permanent cure. If detected at the earliest, the patient can save his life by undergoing suitable treatments. But the work will not always necessarily provide the accurate outcomes, as some error can occur or there can be some variations in the scans, which is the sign of other symptoms. As it is software based work, it can be used at the ease of our location, provided, the person has the scanned images with him. The work is open for further more research and additional inclusion of new technologies.

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