**UNDERGRADUATE RESEARCH**

**TEAM-440**

**Introduction:**

Many people across worldwide suffer with Parkinson’s Disease, a neurogenerative disorder, it happens due to certain braincells produces dopamine, dopamine is a substance produced by the neurons that communicates between neurons. Parkinson’s disease results from impaired neuronal communication due to insufficient dopamine production in brain. This led to symptoms like tremors, stiff muscles, slow movements. But it doesn’t affect only on movements It can also be memory issues, trouble sleeping. In Recent developments in artificial intelligence (AI) and medical imaging have opened up new avenues for bettering the diagnosis of Parkinson's disease. A promising method for identifying minute patterns in medical photos that might point to Parkinson's disease is image-based analysis, especially when deep learning techniques are applied. Other AI-driven techniques, such as Convolutional Neural Networks (CNNs), have demonstrated promise.

Parkinson's disease is on the rise these days, particularly in the elderly. According to studies, PD affects 2-3% of those over 65. According to a United Nations estimate, neurological diseases including Parkinson's, Alzheimer's, epilepsy, and stroke affect around 1 billion people globally. Although the precise origin of Parkinson's disease (PD) is still unknown, experts think a combination of environmental and genetic factors are to blame. Each person's sickness advances at a different rate, some may have minor symptoms for years, while others may have their symptoms rapidly increase.

It might be challenging to diagnose PD. Majority of the time, physicians depend on the physical checks and patient medical records, by this sometimes the results would be delayed, for these researchers are looking for ways to diagnose PD more precisely and by using artificial intelligence it performs well. AI and DL can analyse brain scans to identify early signs of sickness, increasing the speed and accuracy of diagnosis.

Deep learning algorithms in Artificial Intelligence are especially effective at detecting patterns in a image. These algorithms can identify the minute abnormalities in the brain that are invisible to the human sight. A lot of Deep learning models like VGG16, DenseNet, and on have been used for this task. These models have shown great accuracy and performance in identifying diseases from MRI scans.

To work more effectively, these deep learning models must be improved. This includes adjusting parameters like as batchsize, learning rate. It takes a lot of time and work to do this, scientists use optimization techniques.one of these mostly used is Grey wolf optimisation which is based upon how wolves hunt in packs. GWO will increase the accuracy and functionality of deep learning models, enhancing their precision and functionality.

In this study, we combine both deep learning models with GWO to provide a more accurate method for detecting PD. For improving the performance of models like DenseNet, VGG16, DenseNet-LST, GWO was applied further. For even more better outcomes, we also provide a hybrid model that combines both InceptionV3, VGG16. This part of study will describe the preprocessing of MRI images and the methods that have been developd.

Our main contributes in this study include:

1.Data Preprocessing: This process involves in removing the unnecessary data to improve the accuracy or to enhance model performance

2.Optimized Deep learning Models: Using GWO to improve deep learning models like InceptionV3,VGG16, DenseNet, DenseNet-LSTM.

3. New hybrid model: Creating a model by combining the both VGG16 and InceptionV3

4.Performance comparison: Testing models against existing methods to make improvements.

**Related Literature Review:**

**Deep Learning for Parkinson's Disease Detection.**

As we seen lot of research has been done in last few years to improve how PD [Parkinson’s Disease] has been diagnosed using AI. A lot of studies focussing and analysing on MRI brain scans to get the PD related abnormalities. Deep learning techniques performs better than any of machine learning models it has been more accurate and most used method for classifying MRI images. So that, this particular section will explains the research using ML and DL methods to diagnose patient’s suffering with Parkinson’s Disease.

**Studies Using T1, T2 Weighted MRI Data**

Camacho[[14](https://www.sciencedirect.com/science/article/pii/S2213158223000943?via%3Dihub)] have developed a deep learning model trained for the classification of PD patients using T1-weighted MRI dataset. A total of 2,041 MRI scans which includes 1,024 PD cases and 1,017 healthy patients of the same age and gender are collected from 13 separate investigations. These images went through some of preprocessing steps like skullstripping, isotropic resampling, bias correction. By using Jacobian maps which is extracted from the deformation fields and fundamental clinical data they trained Convolutional Nueral Network to categorise pd patients. This study also explored ICB [Impulse Control Behaviours] and how structural and functional brain abnormalities affect PD patients. They have measured white and grey matter brain volume by using MRI data.

In another study they tried to separate PD and (PSP-RS), and Health controls by using MRI datasets( T1 weighted, T2 weighted, and Diffusion Tensor Images).Brain Morphology using T1 weighted and brain iron metabolism using T2 weighted are extracted from MRI datasets and applied multiple ML techniques for classifications [[17](https://www.frontiersin.org/journals/neurology/articles/10.3389/fneur.2021.648548/full)].

A 3D CNN model was developed in a study to identify the PD by recognizing complicated patterns in MRI data. Among 406 people 203 with Parkison’s disease are selected for experiment [18]. Another method used the Parkinson’s Progression Markers Initiative (PPMI) database to train a deep neural network (DNN) using both T1 MRI and DaTscan data. This hybrid model achieved great accuracy and interpretability [[19](https://arxiv.org/abs/1911.10653)].

Some studies only examined the Grey and White Matter regions of the MRI images using ensemble deep learning models rather of analysing the whole MRI scan, as a result the accuracy increased to 94.7% [20]. In order to figure out which regions of the brain affected the model’s decisions, Scientists also utilized occlusion analysis.

A eight-layered CNN has been trained on 3D T1 weighted MRI images in order to differentiate between people with PD and Healthy. While they are training the model, they also used group and batch normalization techniques to increase the accuracy up to 100% [[22](https://arxiv.org/abs/1806.05233)]. Similarly, T2-weighted MRI scans from the PPMI database they extracted the middle 500 slices of each scan and used them for classification [[23](https://ieeexplore.ieee.org/document/8749023)].

Other researchers explored different types of ML models to differentiate PD from and above non-proliferative osteoporosis (NPOD) based on different types of morphometric brain measurements as cortical thickness and volumetric changes as of now [[24](https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11597/2581233/Differentiation-of-Parkinsons-disease-and-non-Parkinsonian-olfactory-dysfunction-with/10.1117/12.2581233.short)],A separate study used ML as to classify tumor locations in the brain based on MRI scans for 30 patients. They have also applied preprocessing techniques such as Social Group Optimization (SGO) & Fuzzy-Tsallis thresholding, followed up by Level-Set Segmentation (LSS) to refined tumor area extraction [25].

**Studies Using SPECT DaTscan Data**

Thakur[11] developed a CNN model to detect key regions of interest (ROI) in DaTscan images for PD classification. They also analysed total of 1,390 DaTscan images using a ultra soft-attention block based on DenseNet-121. Soft Attention Maps helped very much to highlight important areas on the images, making the model’s predictions more and more explainable.

Another study has introduced an ensemble deep learning method for predicting the PD progression. They have used retrospective data of 198 PD patients & split it into training (118), validation (40), and test (40) sets. This latest and advanced model analyse both DaTscan images & clinical motor, assessments before the training of an ensemble of deep neural networks to predict patient outcomes over four years [[26](https://ejnmmires.springeropen.com/articles/10.1186/s13550-021-00795-6)].

One CNN-based model focused on separating PD patients from healthy individuals using SPECT images and helped to get report faster. Their dataset included 2,723 images (1,364 PD, 1,359 HC). They applied image normalization to enhance the ROIs and used tenfold cross-validation for evaluation [[27](https://www.sciencedirect.com/science/article/pii/S0895611120301051?via%3Dihub)]. Another study experimented with 6 interpretation techniques and four deep CNN models to make the PD detection more and more understandable for clinicians and doctors, [28].

Another research used a transfer method learning on a CNN (VGG16) trained on DaTscan images from the PPMI database, achieving 95.2% accuracy also They used Local Interpretable Model-Agnostic Explainer (LIME) to highly improve the model’s explainability, helping medical professionals trust and AI-based diagnoses [29].

In a unique, separate study, an artificial neural network (ANN) had been used along with image processing techniques to detect early-stage PD faster. The dataset included 200 SPECT scans (130 normal, 70 PD). They used sequential grassfire algorithm to segment the caudate & putamen regions, before training the ANN for classification and this method was also very effiecient. [30].

Other studies introduced different 3D CNN models that are trained to distinguish PD from healthy controls. To avoid overfitting and clumsiness, they used data augmentation techniques on sagittal plane images [[33](https://link.springer.com/chapter/10.1007/978-3-319-59740-9_32)]. Some of the ANN-based models focused on recognizing patterns in key brain regions, mimicking how human experts analyse medical scans and Reports. These AI models showed promising results in improving PD diagnosis and Helps Medical Sector a lot.

**Novel Contributions**

In this study, we propose four deep learning models optimized which used Grey Wolf Optimization (GWO): GWO-VGG16, GWO-DenseNet, GWO-DenseNet + LSTM, and GWO-InceptionV3. Additionally, we introduce a hybrid data model (GWO-VGG16+InceptionV3) that even integrates multiple architectures for better PD detection. Unlik the previous studies, our models are applied to both T1, T2-weighted MRI, & SPECT DaTscan datasets. Furthermore, this study tackles a major issue where empty tuples would reduce model performance, something not explicitly addressed in prior research.

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