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Survey Paper : Classification Research – Interpretive Research Paper

A Hybrid Deep Learning Approach for Early Parkinson's Detection from Handwriting

C Manoj Kumar [1], Gudivada Lokesh [2]

[1] Department of Computer Science, VEMU Institute of Technology, P. Kothakota, India; manuc689@gmail.com
[2] Department of Computer Science and Engineering, VEMU Institute of Technology, P. Kothakota, India; lokeshgvemu@gmail.com

** Corresponding Author: C. Manoj Kumar ; manuc689@gmail.com*

Abstract: This study presents an enhanced Parkinson's Disease (PD) detection model using deep transfer learning and genetic algorithm-based feature optimization. Unlike traditional approaches relying on error-prone handcrafted features, the proposed method employs VGG19, InceptionV3, and ResNet50 to extract robust features from NEWHANDPD spiral handwriting images. These features are further refined using a genetic algorithm to improve accuracy. K-Nearest Neighbour (KNN) is then used for classification. While Support Vector Machine (SVM) showed limited accuracy, KNN outperformed significantly. As an extension, hyperparameter tuning was applied to KNN, achieving improved accuracy of 96–98%, compared to the standard KNN's 92–95%. This hybrid and optimized approach enhances early PD detection, supporting clinical decision-making with higher reliability.
Keywords: Disease, SVM, Parkinson's Disease, Deep Learning, ML, AI.

1. Introduction

Neurological disorder primarily caused by the depletion of dopamine—a neurotransmitter essential for regulating movement and coordination. As dopamine-producing cells in the brain's basal ganglia deteriorate, individuals begin to experience symptoms such as tremors, muscle stiffness, speech difficulties, and postural instability. Early signs like finger tremors often affect handwriting, leading to micrographic a condition where writing becomes small and cramped. This subtle change can serve as a key indicator for early detection. However, diagnosing PD in its initial stages remains challenging due to the lack of definitive clinical tests. With the evolution of artificial intelligence, particularly deep learning, the potential for early and accurate diagnosis has significantly improved. Convolutional Neural Networks (CNNs) and transfer learning methods now enable the automated analysis of medical data, including handwriting patterns. These approaches have shown exceptional accuracy and promise in identifying PD, offering hope for better symptom management and timely intervention.

2. Literature Survey

2.1. Fang (2022) - Improved K-Nearest Neighbours (KNN) with Entropy

Fang proposed an enhanced version of the KNN algorithm by incorporating entropy-based weighting to improve classification accuracy for PD detection. Using the UCI dataset, the framework emphasized the role of information entropy in distinguishing relevant features from noise, improving decision boundaries. The method utilized a 5-fold cross-validation to validate the model's reliability. This framework advanced the understanding of feature importance in machine learning, highlighting entropy as a vital factor for enhancing classification precision.

2.2. Kaplan et al. (2022) – Handcrafted Feature Engineering with Integrated Multiview (IMV) Learning

Kaplan and colleagues explored PD detection through MRI scan analysis using handcrafted features and multiple feature selectors. The framework adopted patch-based learning combined with IMV analysis to classify PD symptoms, including clinical stages, dementia status, and motor impairment. This hybrid approach demonstrated the importance of integrating clinical knowledge with machine learning techniques to improve the accuracy and robustness of medical diagnostic tools.

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2.3. Gazda et al. (2022) - Ensemble of Convolutional Neural Networks (CNNs)

Gazda et al. implemented an ensemble learning framework using five CNN models for detecting PD through handwriting analysis, utilizing the PaHaW and NewHandPD datasets. This theoretical model leveraged transfer learning to enhance generalization and reduce overfitting. By combining multiple CNN architectures, the ensemble approach aimed to increase diagnostic accuracy and stability across different handwriting tasks, demonstrating the benefits of model diversity.

2.4. Mohaghegh and Gascon (2021) - Vision Transformer (ViT) for Handwritten Data

This framework introduced a Vision Transformer model utilizing spiral and meander drawings for PD detection. The ViT architecture incorporated a multi-layer perceptron classifier and was pre-trained using self-supervised learning techniques (DINO) on ImageNet. The entropy-based dropout layers improved generalization by reducing overfitting. This study illustrated the effectiveness of transformer models in medical image classification, offering a new avenue for neurological disorder detection.

Table .1 Summary Table

Author	Year	Method	Dataset
Fang	2022	Improved KNN (entropy)	UCI Dataset
Kaplan et al.	2022	Handcrafted Feature Engineering & IMV	MRI Scans
Gazda et al.	2022	Ensemble of CNNs	PaHaW & NewHandPD
Mohaghegh and Gascon	2021	Vision Transformer (ViT)	Spiral and Meander Handwriting Data
Fratello et al.	2021	Linear SVM, Medium KNN	Handwriting Data

4. Problem Statement

Traditional Parkinson's Disease detection methods rely heavily on clinical observations and handcrafted features derived from patient data, such as handwriting samples. Machine learning algorithms like Support Vector Machines (SVM) have been applied to identify patterns in handwriting, but their accuracy is often limited due to manual feature extraction, which can be inconsistent and error-prone. These systems require expert intervention to select relevant features, making them less adaptable to diverse datasets. Additionally, the absence of deep learning integration restricts their performance in complex classification tasks, resulting in lower accuracy and delayed diagnosis, especially in early stages of Parkinson's Disease.

5. Proposed Method

This system leverages deep transfer learning and genetic algorithms to enhance the accuracy of Parkinson's Disease detection using spiral handwriting images. Instead of relying on handcrafted features, it uses pre-trained CNN models like VGG19, InceptionV3, and ResNet50 to extract high-level image features.

These features are then optimized through a Genetic Algorithm, selecting only the most relevant ones for classification. Finally, a K-Nearest Neighbour (KNN) classifier is used to predict outcomes.

As an extension, hyperparameter tuning is applied to KNN, further boosting its accuracy to 96–98%. This hybrid method offers a powerful, automated, and scalable solution for early PD detection.

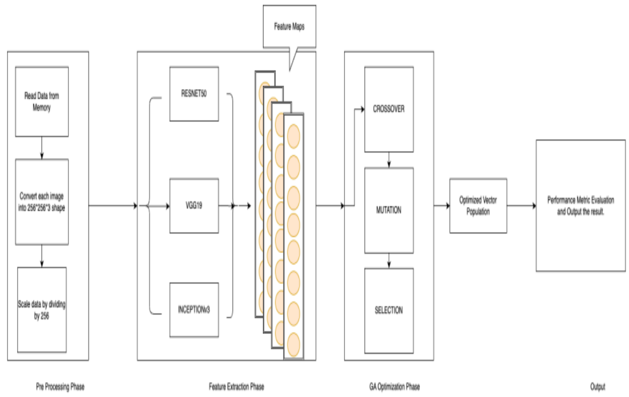

Figure.1 Flow of work Progress

6. Methodology

Dataset Collection and Preprocessing: The NEWHANDPD dataset is used for this study, which contains spiral handwriting images from both healthy individuals and Parkinson's patients. These images are categorized into two folders healthy and affected.

Each image is processed to ensure uniformity in format by resizing, normalizing, and converting them into RGB format suitable for deep learning input. Data is also shuffled to eliminate any bias in the training process. Image preprocessing ensures noise reduction and improves the performance of the models.

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Feature Extraction Using Deep Transfer Learning: Traditional handcrafted features often lack robustness and are prone to human error. Therefore, this work leverages powerful Convolutional Neural Networks (CNNs) through transfer learning. Pre-trained models such as VGG19, InceptionV3, and ResNet50 are utilized to extract deep features from the handwriting images.

These models are originally trained on large-scale image datasets and can detect high-level image patterns that are not visible to the human eye. The last few layers of these networks are fine-tuned to adapt them to the specific task of Parkinson's detection.

Feature Optimization Using Genetic Algorithm: Although the deep learning models extract numerous features, not all of them contribute equally to classification accuracy. To address this, a Genetic Algorithm (GA) is applied to select the most relevant features. GA mimics natural selection processes such as crossover, mutation, and selection to evolve the feature set over generations.

Features that yield higher classification accuracy are retained, while less significant ones are discarded. This optimization step not only reduces computational complexity but also improves the model's generalization.

Classification Using K-Nearest Neighbour (KNN): The optimized feature set is then fed into the K-Nearest Neighbour (KNN) classifier. KNN is chosen for its simplicity and effectiveness in handling feature-based classification tasks.

It predicts the class of a new sample based on the majority class of its 'k' nearest neighbours in the feature space. The accuracy of KNN improves significantly when fed with high-quality, optimized features.

Hyperparameter Tuning: To further enhance the performance of the KNN classifier, hyperparameter tuning is introduced. Parameters such as the value of 'k', distance metrics, and weighting functions are systematically varied to find the best combination.

After tuning, the accuracy improves from an initial 92–95% to a range of 96–98%, showing a clear performance boost.

Evaluation Metrics: The model's effectiveness is evaluated using standard metrics like accuracy, precision, recall, F1-score, and ROC curves. Confusion matrices are also generated to visualize the classification results.

7. Result

Hyperparameter tuning was applied to KNN, achieving improved accuracy of 96–98%, compared to the standard KNN's 92–95%. This hybrid and optimized approach enhances early PD detection.

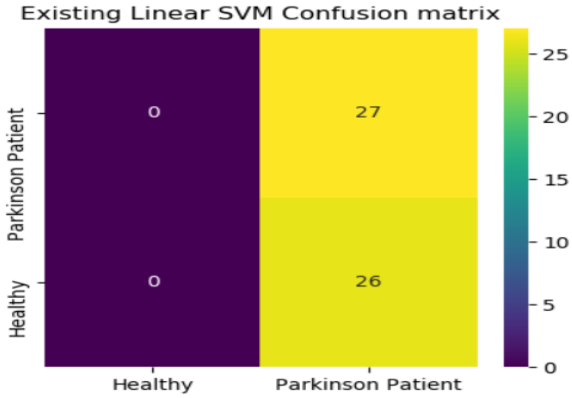

Figure 1. Training Linear SVM got 50% accuracy

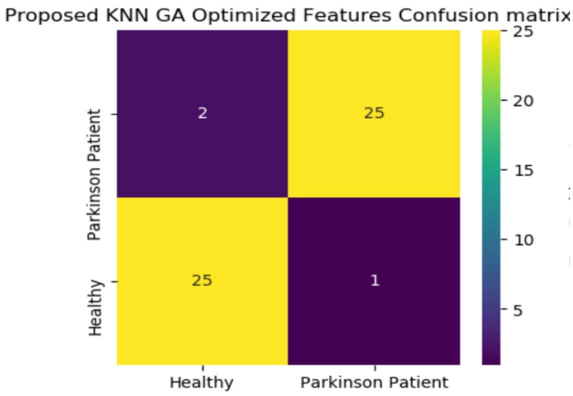

Figure 2. Training KNN GA Optimized Features got 94% accuracy

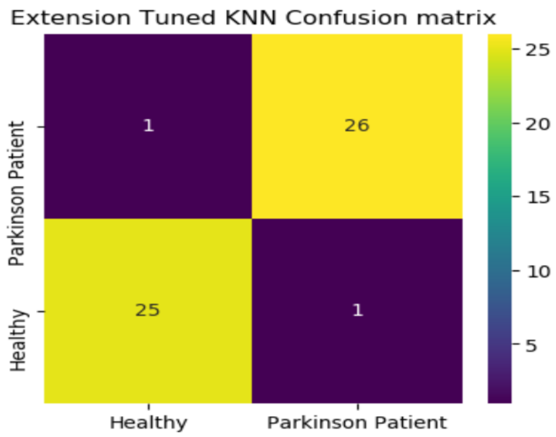

Figure 3. Training Tuned KNN got 96% accuracy

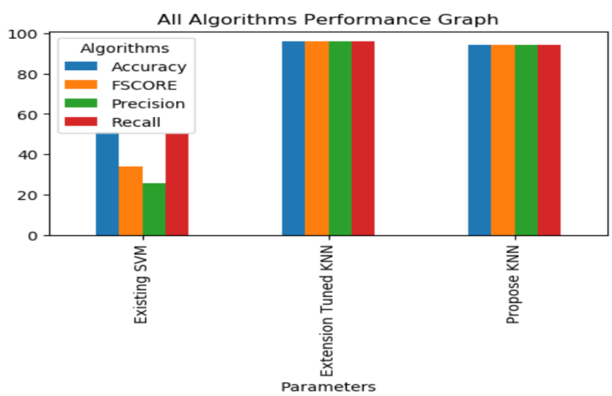

Figure 4. Models Comparison Graph

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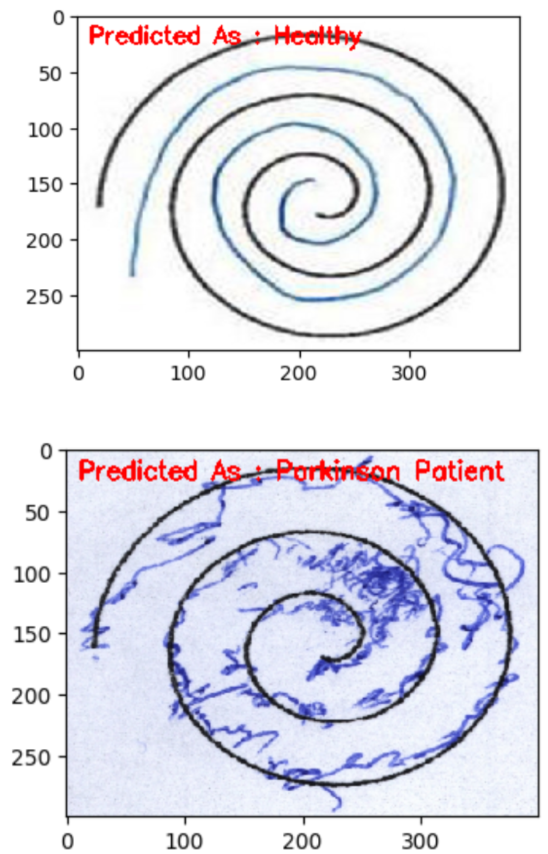

Figure 4. Predicted Parkison disease using extension tuned KNN

7. Conclusion and Future Scope

This study presents an efficient and accurate system for early Parkinson's Disease detection using deep transfer learning and genetic algorithm-based feature optimization. By replacing traditional, error-prone handcrafted feature techniques with pre-trained CNN models like VGG19, InceptionV3, and ResNet50, the system effectively extracts high-quality image features from spiral handwriting data. These features are further refined using a Genetic Algorithm to improve classification performance. The optimized feature set is then classified using K-Nearest Neighbour (KNN), which, after hyperparameter tuning, achieves an impressive accuracy of up to 98%. Overall, the proposed method demonstrates a reliable and scalable approach that can support medical professionals in the early diagnosis of Parkinson's Disease, potentially leading to better treatment outcomes and quality of life.

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Authors Profile

C Manoj Kumar earned his B. Tech in Mechanical Engineering from Mother Theresa Institute of Engineering and technology, Palamaner in 2019, He is currently pursuing M. Tech from VEMU Institute of Technology, Chittoor and he has 4yrs of experience in developing windows desktop applications as a Software Engineer.

Gudivada Lokesh earned his B. Tech., M.E in computer science and engineering from Kuppam engineering college, Sathyabama University in 2010, 2012 respectively. Presently he is pursuing Ph.D in Computer Science & Engineering from Mohan Babu University, Tirupathi, and Under the Supervisions of Dr Baby Maruthi, Dr K K Baseer. Lokesh's teaching and research interests include Networks, Cloud Computing Environment, Grid Computing, Mobile Computing, and Computer Organization. Lokesh is committed to providing quality education to his students and his passion for teaching has earned his recognition in the field of academics and focus in the field of Computer Science & Engineering. With 12 years of experience, he has proven his expertise in guiding students, Undergraduate and Post Graduate levels in their academics, research projects and research papers.