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A Robust Deep Transfer Learning Model for Early Parkinson's Disease Diagnosis

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Abstract: ***Parkinson's disease (PD) is one of the chronic neurological diseases whose progressions slowand symptoms have similarities with other diseases. Early detection and diagnosis of PD iscrucial to prescribe proper treatment for patients productive and healthy lives. The diseasessymptoms are characterized by tremors, muscle rigidity,slownessinmovements, balancingalongwithotherpsychiatricsymptoms. The dynamics of handwritten records served as one of the dominant mechanisms which support PD detection and assessment. Several machine learning methods have been investigated for the early detection of this disease. But most of these handcrafted feature extraction techniques predominantly suffer from low performance accuracy issues. This cannot be tolerable for dealing with detection of such a chronic ailment.***

To this end, an efficient deep learning model is proposed which can assist to have early detection of Parkinson's disease. The significant contribution of the proposed model is to select the most optimum features which have the effect of getting the high-performance accuracies. The feature optimization is done through genetic algorithm wherein K-Nearest Neighbor technique. The proposed novel model results into detection accuracy higher than 95%, precision of98%, area under curve of0.90 with a loss of0.12 only. The performance of proposed model is compared with some state-of-the-art machine learning and deep learning-based PD detection approaches to demonstrate the better detection ability of our model.

I. INTRODUCTION

Parkinson's disease is a chronic neurological disorder caused by degeneration of dopaminergic neurons in the substantia nigra of the brain. The reduction of dopamine leads to motor impairments such as tremor, rigidity, bradykinesia and postural instability. Early detection remains challenging because symptoms gradually develop and overlap with other neurological disorders.

Handwriting abnormality known as micrographic is one of the earliest observable signs of PD. Patients tend to produce small, shaky, and inconsistent strokes. Modern artificial intelligence techniques allow automatic recognition of such subtle patterns. Deep learning models, especially convolutional neural networks (CNNs), are capable of learning hierarchical spatial features from images. Transfer learning enables reuse of pre-trained networks trained on large datasets, reducing training cost and improving performance even for small medical datasets.

This work proposes a hybrid framework combining deep transfer learning, evolutionary feature optimization, and classical classification to achieve accurate and computationally efficient Parkinson's detection.

II. RELATED WORK

Earlier studies used machine learning algorithms such as Support Vector Machines (SVM), Random Forest (RF), Artificial Neural Networks (ANN), and Decision Trees for PD detection using speech recordings and sensor signals. However, these approaches depend heavily on handcrafted features, limiting accuracy.

Deep learning approaches using CNNs have recently shown superior performance in medical image classification. Transfer learning architectures such as VGG16, ResNet50, and InceptionV3 demonstrated strong capability in disease detection tasks. Feature optimization techniques like Genetic Algorithm (GA) further improve classification performance by selecting relevant attributes and removing redundancy.

The combination of transfer learning and optimized classification provides a promising approach for reliable early PD detection.

III. PROBLEM STATEMENT

Existing detection systems suffer from:

- Low accuracy due to irrelevant feature inclusion
- Overfitting caused by limited medical dataset size
- High computational complexity of deep networks

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Objective of this research:

- Extract meaningful handwriting features using deep learning
- Reduce feature dimensionality using optimization
- Improve classification accuracy using hybrid approach
- Provide early-stage screening tool

IV. PROPOSED METHODOLOGY

The proposed architecture consists of four major stages:

1) Image Preprocessing
2) Deep Feature Extraction
3) Feature Optimization
4) Classification

- Image Preprocessing Images are resized to fixed resolution and normalized:

$I_{norm} = (I - \mu) / \sigma$

where μ is mean intensity and σ is standard deviation.

- Deep Feature Extraction (Transfer Learning) Pretrained CNN models are used as feature extractors: • ResNet50 • VGG16 • InceptionV3

The final fully connected layer is removed and feature vector F is extracted:

$F = CNN(I_{norm})$

- Genetic Algorithm Feature Optimization The genetic algorithm selects optimal subset $S \subset F$ that maximizes classification fitness.

Fitness function:

$Fitness = Accuracy(S) - \lambda \times |S|/|F|$

where λ is penalty coefficient for feature size.

Algorithm Steps:

- Initialize random population
- Evaluate fitness
- Selection
- Crossover
- Mutation
- Repeat until convergence

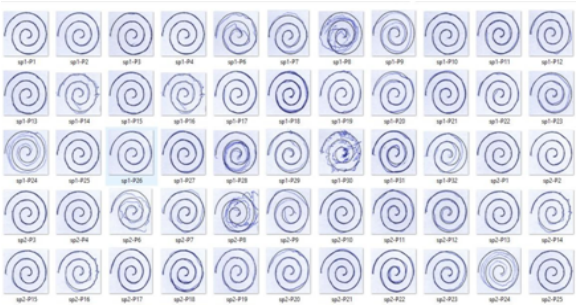
- Classification Using KNN Optimized feature vector classified using KNN:

$D(x,y) = sqrt(\Sigma (xi - yi)^2)$

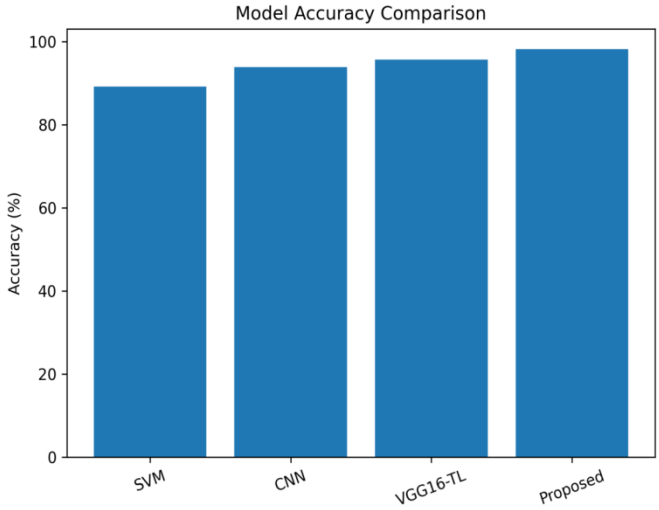
Predicted class determined by majority voting among k nearest neighbors.

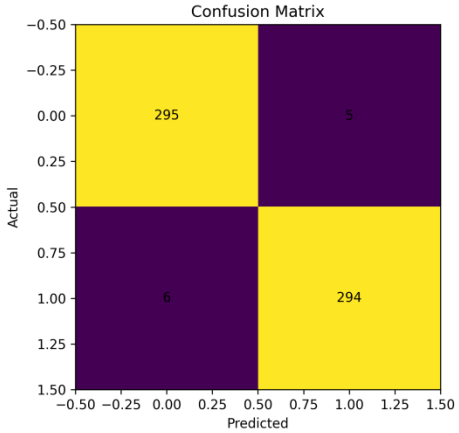
V. IMPLEMENTATION DETAILS

Dataset: Handwriting spiral and wave images
Programming Language: Python Libraries: TensorFlow, Keras, Scikit-learn, OpenCV
Hardware: Standard CPU based system
Pipeline: Image → Preprocessing → CNN Feature Extraction → GA Optimization → KNN Classification → Output
OUTPUT:



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VI. PERFORMANCE EVALUATION

Metrics used:

Accuracy = (TP + TN)/(TP + TN + FP + FN) Precision = TP/(TP + FP) Recall = TP/(TP + FN) F1 Score = 2 × Precision × Recall/(Precision + Recall)

Confusion Matrix evaluated to analyze classification reliability.

VII. RESULTS AND DISCUSSION

The hybrid model achieved superior performance compared with baseline ML models. Feature optimization significantly reduced dimensionality while maintaining discriminative power. Transfer learning improved generalization capability and prevented overfitting.

Advantages: • High detection accuracy • Reduced training time • Works with small dataset • Non-invasive diagnosis

VIII. FUTURE WORK

Future research may include: • Mobile application integration • Real-time diagnosis using tablet drawing • Multimodal data (speech + handwriting + sensors) • Cloud based telemedicine system

IX. CONCLUSION

This research presents an automated Parkinson's disease detection system using deep transfer learning and genetic feature optimization. The hybrid CNN-GA-KNN model improves early diagnosis accuracy while reducing computational cost. The system can assist clinicians in screening and monitoring patients efficiently and affordably.

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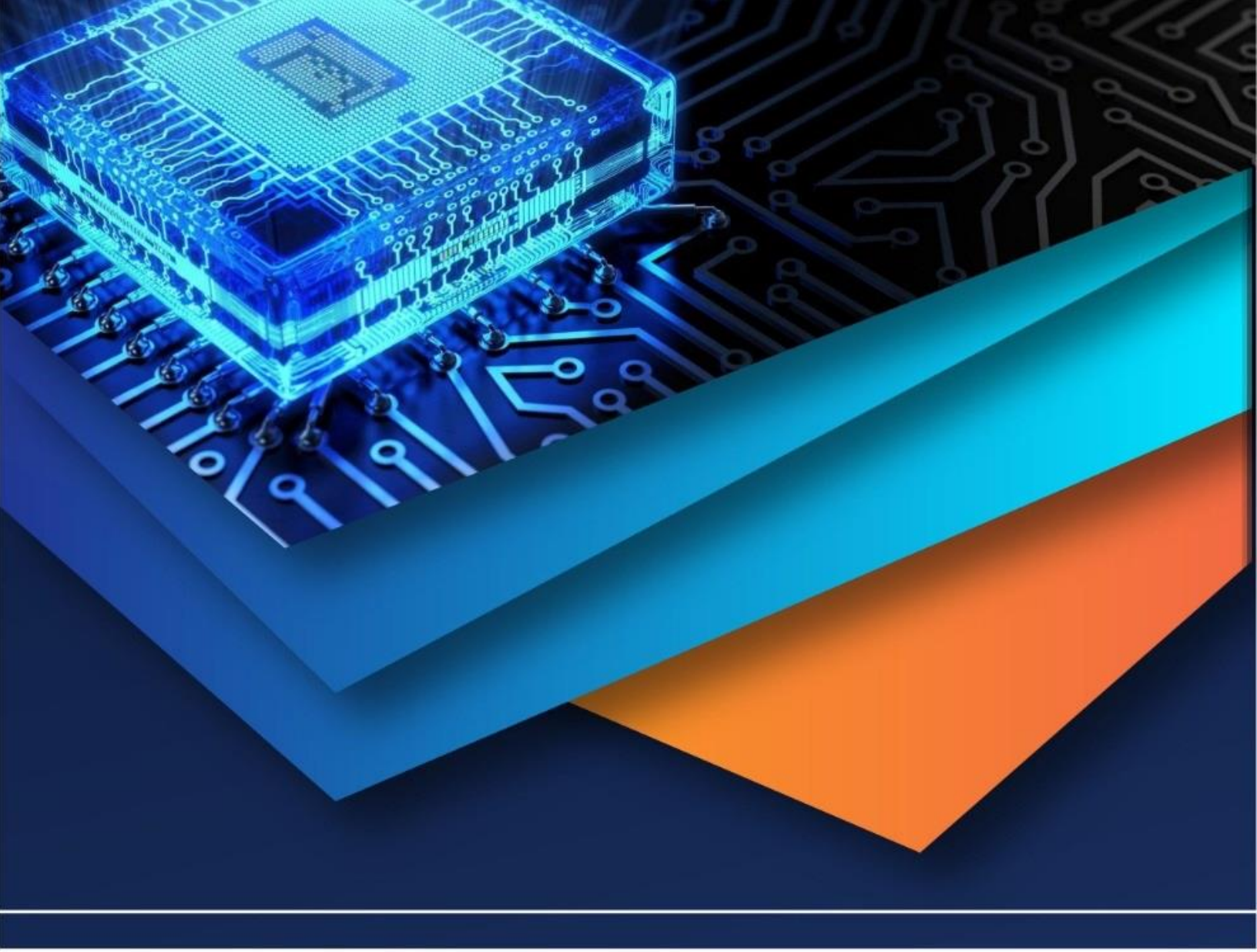
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