A Review of Parkinson Disease Detection Techniques

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***Abstract*—Parkinson's disease (PD) is a progressive disorder that is caused by degeneration of nerve cells in the part of the brain called the substantia nigra, which controls movement. These nerve cells die or become impaired, losing the ability to produce an important chemical called dopamine. Studies have shown that symptoms of Parkinson's develop in patients with an 80 percent or greater loss of dopamine-producing cells in the substantia nigra. Normally, dopamine operates in a delicate balance with other neurotransmitters to help coordinate the millions of nerve and muscle cells involved in movement. Without enough dopamine, this balance is disrupted, resulting in tremor (trembling in the hands, arms, legs and jaw); rigidity (stiffness of the limbs); slowness of movement; and impaired balance and coordination – the hallmark symptoms of Parkinson's. The cause of Parkinson's essentially remains unknown. However, theories involving oxidative damage, environmental toxins, genetic factors and accelerated aging have been discussed as potential causes for the disease. In 2005, researchers discovered a single mutation in a Parkinson's disease gene (first identified in 1997), which is believed responsible for five percent of inherited cases.**

***Keywords*—Parkinson's disease, Deep learning, Multi-modal data analysis, Disease prediction**

I. INTRODUCTION

Parkinson's disease is a chronic and progressive neurodegenerative disorder that mainly affects the motor system. It is the second most common neurodegenerative disorder after Alzheimer's disease. Parkinson's disease is characterized by a triad of symptoms: tremor, rigidity, and bradykinesia. Other symptoms may include postural instability, cognitive impairment, depression, anxiety, and autonomic dysfunction [1].

The exact cause of Parkinson's disease is unknown, but it is thought to be a combination of genetic and environmental factors. Genetic factors play a role in about 10-15 percent of cases, and the remaining cases are likely caused by a combination of environmental factors, such as exposure to toxins, head injury, and inflammation.

Parkinson's disease is diagnosed based on a medical history and physical examination. There is no single test that can diagnose Parkinson's disease, but doctors may order tests such as blood tests, imaging tests, and neurological tests to rule out other conditions and to assess the severity of the disease. There is no cure for Parkinson's disease, but there are treatments that can help manage the symptoms. Treatment options include medications, deep brain stimulation (DBS), and other therapies such as physical therapy, occupational therapy, and speech therapy.

Early detection of Parkinson's disease is crucial for timely intervention and treatment. Parkinson's is a neurodegenerative disorder causing symptoms like tremors and stiffness due to the loss of dopamine-producing cells in the brain. Detecting the disease early enables healthcare providers to implement appropriate therapies, such as medication and physical therapy, to manage symptoms and slow down its progression.

Early diagnosis facilitates better planning for the future for patients and their families. It allows informed decisions about lifestyle adjustments, financial planning, and long-term care arrangements. With early awareness, individuals can proactively address potential challenges associated with the disease and develop coping strategies to maintain independence and

well-being as symptoms advance.

Moreover, early detection of Parkinson's disease is crucial for advancing research and treatment options. Identifying individuals in the earliest stages enables researchers to study disease progression effectively. This facilitates the development of targeted therapies aimed at slowing or halting its progression and accelerates the recruitment for clinical trials, offering hope for improved outcomes for those affected by Parkinson's disease.

II. Related Works

A. Early Detection of Parkinson's Disease Using Deep Learning and Machine Learning

In their paper the authors stress the importance of identifying Parkinson's disease (PD) at an early stage to facilitate prompt intervention and tailored treatment plans. Utilizing innovative deep learning and machine learning techniques, the study concentrates on identifying premotor signs associated with PD, such as rapid eye movement (REM) behavior disorder (RBD), and loss of smell (olfactory loss). By analyzing data from both healthy individuals and those in the early stages of PD, the research aims to develop a robust model capable of accurately distinguishing between the two groups based on these premotor indicators. The proposed methodology involves constructing a deep learning framework that automatically extracts both linear and nonlinear features from PD data, eliminating the need for manual feature extraction and showcasing the model's superior detection capabilities compared to traditional machine learning methods as shown in Fig. 1.

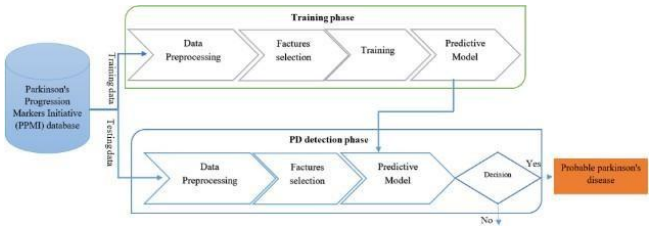

Fig. 1. Flowchart of the proposed PD detection procedure [1]

The outlined methodology covers preprocessing and standardizing raw data to train a deep learning model with optimized parameters for PD detection. Through supervised feed-forward neural networks, the deep learning algorithm extracts hierarchical representations of the data, thereby improving classification accuracy. By comparing the deep learning model with twelve machine learning and ensemble learning techniques, the study demonstrates the effectiveness of the proposed approach, achieving an average accuracy of 96.45% in PD detection. By incorporating advanced data-driven techniques and conducting feature importance analysis, the research offers valuable insights into early PD detection and highlights the potential of deep learning algorithms in enhancing diagnostic capabilities for neurodegenerative diseases. [1].

B. Parkinson's Disease Detection Based on Running Speech Data From Phone Calls

Laganas et al. explored a promising approach for detecting Parkinson's disease (PD) by analyzing speech patterns in everyday phone calls. This method is particularly attractive because it utilizes a convenient and natural source of data, potentially enabling unobtrusive screening for PD [2]. The researchers recruited participants diagnosed with PD and healthy controls. During the study, researchers collected speech samples from regular phone calls made by the participants.

Next, feature extraction was performed on the speech recordings. This process involved extracting quantifiable characteristics from the speech data that might be indicative of PD. These features likely focused on variations in pitch, volume, and speech rate, as these can be subtly affected by the motor and speech impairments associated with Parkinson's disease. Finally, the researchers employed machine learning algorithms as shown in Fig. 2. These algorithms were trained on the extracted features to identify patterns in speech data that differentiate individuals with PD from healthy controls. By leveraging these speech characteristics, the machine learning models aimed to learn a reliable indicator for PD detection.

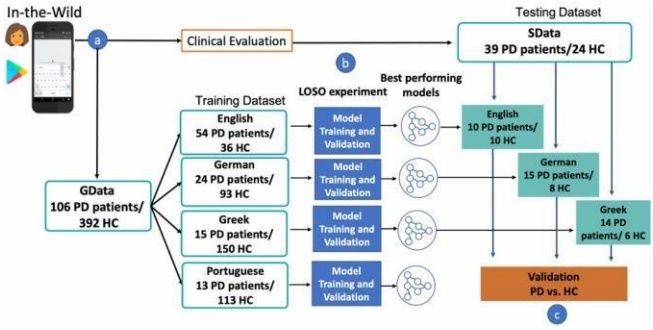

Fig. 2. Overall pipeline for the development and evaluation of the proposed method [2]

C. A Case Study of Parkinson's disease Diagnosis using Artificial Neural Networks

Soleimanian Gharehchopogh and Mohammadi explored using artificial intelligence (AI) to diagnose Parkinson's disease. Their approach centered on utilizing a specific type of AI model called Artificial Neural Networks (ANNs) to analyze clinical data.

First, they collected clinical data from Parkinson's patients and healthy individuals. This data likely included details like tremor assessments, rigidity scores, and demographics. Then, the researchers implemented two types of ANN architectures - Multi-Layer Perceptron (MLP) as shown in Fig. 3 and Radial Basis Function (RBF) networks [4]. These AI models were trained on the collected data, essentially learning to identify

patterns that distinguish between Parkinson's patients and healthy controls. After training, the researchers assessed the ANNs' ability to accurately classify new patient data, gauging their effectiveness as a potential diagnostic tool.

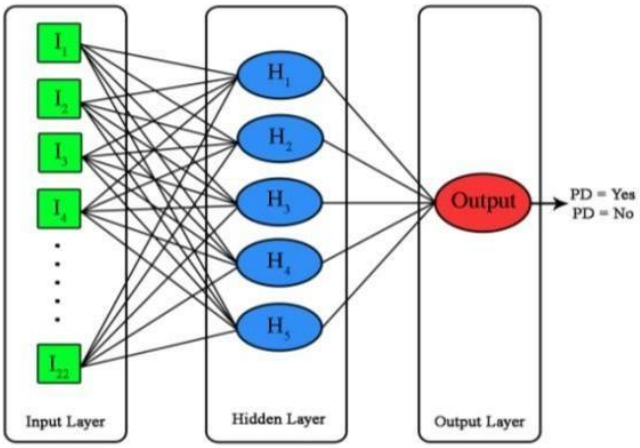

Fig. 3. Multilayer Perceptron Structure [3]

D. Detection of Parkinson's Disease using Machine Learning Algorithms and Handwriting Analysis

In their study on Parkinson's disease (PD) detection, Ranjan et al. focused on handwriting analysis coupled with machine learning. This method offers a non-invasive and potentially cost-effective way to screen for PD [3]. The researchers recruited participants with PD and healthy controls. These participants were asked to complete specific drawing tasks, such as spirals or waves. Following data collection, the

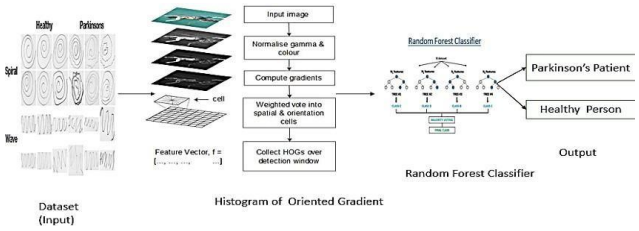

Fig. 4. Proposed System for the classification of Parkinson's patient and Healthy Person [4]

researchers employed a technique called feature extraction to analyze the drawings. This process essentially captures quantifiable characteristics from the handwriting that might be indicative of PD. Examples of these features could be shakiness in the lines, variations in line thickness, and how well the drawn shapes stay within defined boundaries. Finally, they used machine learning algorithms to analyze the extracted features as shown in Fig 4. These algorithms were trained to identify patterns in the handwriting data that differentiate individuals with PD from healthy controls. By analyzing these features, the machine learning models aimed to learn a method for detecting PD based on handwriting characteristics.

E. Deep Learning-based Early Parkinson's Disease Detection from Brain MRI Image

Magnetic resonance imaging (MRI) offers detailed insights into brain structure and has been used to identify abnormalities associated with PD. However, manual MRI analysis is time-consuming and subjective, limiting its routine clinical application.

The proposed methodology in the study as shown in Fig. 5 focuses on developing a deep learning-based technique for extracting features from segmented brain regions to identify and classify normal and pathological brain cells in a large dataset of human brain MRI images. The neural network is utilized as a multi-class classifier to extract texture and shape characteristics from MRI scans, aiding in determining different stages of Parkinson's disease. This approach aims to enhance accuracy compared to traditional methods.

The architecture for the proposed network includes five convolutional layers with varying numbers of filters in each layer (16 filters for the first layer, 32 for the second, and 64 for the last three layers) and ReLU activation in each layer. Additionally, five max-pooling layers are incorporated to downsample the feature maps. A flatten layer is placed between the final pooling layer and the first dense layer, followed by two dense layers with ReLU activation in the primary layer and SoftMax activation in the final layer. The primary layer consists of 128 units, while the second layer has 2 units. The dataset used in the study was obtained from the

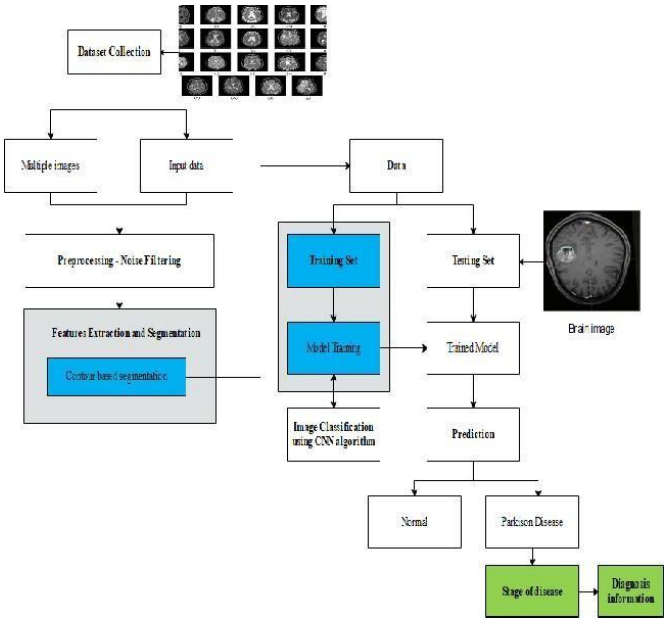

Fig. 5. Architecture for Proposed Network [5]

PPMI, consisting of 458 T2-weighted MRI scans in DICOM format, with 229 scans for Parkinson's disease (PD) and 229 for healthy controls (HC). The data is divided into training, validation, and testing sets with ratios of 75%, 15%, and 10%, respectively. Pre-processing techniques include median filtering to reduce image noise effectively. This nonlinear

method helps preserve edges and is particularly useful for removing "salt and pepper" noise in images. Each pixel value is replaced with the median value of its neighbors, enhancing the quality of the MRI scans [9].

III. DISCUSSION AND ANALYSIS OF PARKINSON'S DISEASE DETECTION

Researchers have explored a range of innovative approaches, including handwriting analysis, speech data analysis, and the utilization of Artificial Neural Networks (ANNs), to aid in the early identification of Parkinson's disease. By utilizing machine learning algorithms, researchers have been able to extract key features from handwriting samples and speech patterns to differentiate individuals with Parkinson's disease from healthy controls. These non-invasive methods offer a convenient and potentially cost-effective way to screen for Parkinson's disease, enabling healthcare providers to implement appropriate therapies and effectively manage symptoms.

Furthermore, the integration of deep learning and machine learning techniques has been highlighted in the paper to detect premotor signs associated with Parkinson's disease, such as rapid eye movement (REM) behavior disorder and loss of smell. By developing robust models capable of accurately distinguishing between healthy individuals and those in the early stages of Parkinson's disease as shown in Table 1, researchers aim to enhance diagnostic capabilities and improve outcomes for patients. The incorporation of advanced data-driven techniques and feature importance analysis demonstrates the potential of deep learning algorithms in enhancing early Parkinson's disease detection and diagnosis.

Moreover, the paper delves into the role of Artificial Neural Networks (ANNs), specifically Multi-Layer Perceptron (MLP) and Radial Basis Function (RBF) networks, in analyzing clinical data to identify patterns that differentiate Parkinson's patients from healthy controls. By training these ANNs on collected data, researchers aim to develop effective diagnostic tools for Parkinson's disease. These AI models learn to recognize patterns indicative of Parkinson's disease, enabling accurate classification of new patient data and potentially revolutionizing the diagnostic process for this complex disorder.

The research presented in the paper underscores the significance of early detection in Parkinson's disease for advancing research, facilitating targeted therapies, and improving patient outcomes. By exploring a variety of detection techniques, including machine learning algorithms, handwriting analysis, speech data analysis, and Artificial Neural Networks, researchers aim to enhance diagnostic capabilities and enable proactive management of Parkinson's disease symptoms. These innovative approaches offer promising avenues for early screening, timely intervention, and personalized treatment strategies for individuals affected by Parkinson's disease.

TABLE I
ACCURACY OF REFERRED PAPERS ON PARKINSON'S DISEASE DETECTION

Literature Survey	Accuracy
Early Detection of Parkinson's Disease Using Deep Learning and Machine Learning	The designed model achieves 96.45% accuracy on average.
Parkinson's Disease Detection Based on Running Speech Data From Phone Calls	The language-specific models showed varying levels of accuracy, with the Greek cohort having the highest AUC of 0.93, followed by the English cohort with an AUC of 0.84 and the German cohort with an AUC of 0.83.
A Case Study of Parkinson's Disease using Artificial Neural Network	MLP is the best classification with 93.22% accuracy for the data set and 86.44% accuracy in RBF classification.
Detection of Parkinson's Disease using Machine Learning Algorithms and Handwriting Analysis	This model achieved an accuracy of 86.67% in the case of spiral drawing and 83.30% with wave drawing.
Deep Learning-based Early Parkinson's Disease Detection from Brain MRI Image	The categorization accuracy varies between 94% and 98%.

IV. CONCLUSION

In conclusion, the research presented in the paper emphasizes the critical significance of early detection in Parkinson's disease for advancing research, facilitating targeted therapies, and improving patient outcomes. By employing a variety of innovative detection techniques such as machine learning algorithms, handwriting analysis, speech data analysis, and Artificial Neural Networks, researchers aim to enhance diagnostic capabilities and enable proactive management of Parkinson's disease symptoms. These cutting-edge approaches offer promising avenues for early screening, timely intervention, and personalized treatment strategies for individuals affected by Parkinson's disease. The integration of deep learning and machine learning techniques, along with the utilization of advanced data-driven methods, showcases the potential of artificial intelligence in enhancing early Parkinson's disease detection and diagnosis. By leveraging these sophisticated technologies, researchers strive to develop robust models capable of accurately distinguishing between healthy individuals and those in the early stages of Parkinson's disease, ultimately aiming to revolutionize the diagnostic process for this complex disorder.

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