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A Survey on Parkinson's Disease Detection Using Hybrid Deep Learning

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***Abstract*— Parkinson's Disease is a neurological disorder affecting movement , talking pattern and early diagnosis is crucial an innovative approach for Parkinson's disease detection and classification leveraging state-of-the-art deep learning techniques and traditional machine learning algorithms The primary focus will be on the integration of Convolutional Neural Networks (CNNs), Convolutional Long Short-Term Memory networks (CLSTMs), and Support Vector Machines (SVMs) to enhance the accuracy and efficiency of PD diagnosis. It will involve the development of a comprehensive dataset comprising diverse speech pattern in which these signals are derived from data sourced from the UCI Machine Learning Repository.**

***Keywords*— PD (Parkinson Disease), CNN (Convolutional Neural Networks), CLSTMs (Convolutional Long Short-Term Memory networks), SVM (Support Vector Machine), MLAs (Machine Learning Algorithms)**

1. INTRODUCTION

Parkinson's disease (PD) is a prevalent and a progressive neurological condition that impacts millions of individuals globally, progressively impairing motor functions and often leading to significant deterioration in quality of life. Timely and accurate diagnosis is imperative for initiating appropriate interventions and enhancing patient outcomes. The conventional diagnostic methods for Parkinson's disease often rely on subjective clinical assessments, posing challenges in early detection Ease of Use. An advanced approach to Parkinson's disease identification and categorization using cutting-edge deep learning techniques. Leveraging the power of Convolutional Neural Networks (CNNs), Convolutional Long Short-Term Memory networks (CLSTMs), and Support Vector Machines (SVMs), our work mainly focused on creating a robust diagnostic tool capable of efficiently analyzing gait and speech patterns associated with Parkinson's disease. Gait analysis, captured through images, will be processed using CNNs to extract discriminative features, while CLSTMs will handle temporal dependencies in speech signals. The combination of these techniques with SVMs for classification is designed to elevate the accuracy and reliability of Parkinson's disease diagnosis. By employing these advanced deep learning algorithms, we aspire to enrich to the headway of a more objective, efficient, and accessible diagnostic tool for Parkinson's disease, potentially revolutionizing early detection practices in clinical setup. The implementation of the intended model will be conducted using Python and popular deep learning libraries, ensuring versatility and ease of integration into healthcare systems.

2. LITERATURE SURVEY

Quan, et al. [1] presents a novel approach for early Parkinson's Disease (PD) detection through voice analysis. By exploring static and dynamic speech features, the study identifies significant differences in articulation transitions between healthy and PD individuals. The proposed method employs a Bidirectional LSTM model to capture time-series dynamic features, specifically focusing on energy content during transitions between voiced and unvoiced segments. Evaluation through 10-fold cross-validation and individual dataset splitting demonstrates the method's superior accuracy in PD detection compared to traditional machine learning models utilizing static features. The innovative combination of dynamic articulation features and deep learning contributes to early PD identification using speech signals.

Wang, et al. [2] This paper introduces a state-of-art deep learning model for early Parkinson's Disease (PD) detection, focusing on premotor features such as Rapid Eye Movement (REM) sleep behavior disorder and olfactory loss. The model outperforms twelve machine learning approaches achieving an average accuracy of 96.45%, showcasing its superior capability in discriminating between normal individuals and early PD patients. The study emphasizes the significance of early PD detection for therapeutic interventions and understanding the disease causes. While acknowledging the promising results, the authors suggest that the deep learning model's potential may further manifest with larger and more complex datasets, marking a significant step toward cutting-edge research in early disease detection.

Gunduz, et al. [3] The paper consists of two Convolutional Neural Network (CNN) frameworks for Parkinson's Disease (PD) classification based on vocal features. The study addresses vocal impairments in early PD stages and focuses on classification using speech features. The first framework combines various feature sets before inputting them into a 9-layered CNN, while the second employs parallel input layers connected to convolution layers for simultaneous feature

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extraction before merging. Trained on a UCI Machine Learning repository dataset, both models undergo validation using Leave-One-Person-Out Cross Validation. The second framework, extracting deep features via parallel convolution layers, demonstrates promise by effectively distinguishing PD patients and enhancing classifier discriminative power.

Gil-Martín, et al. [4] This paper explores Parkinson's Disease (PD) detection through drawing movements with a Convolutional Neural Network (CNN). Utilizing the Fast Fourier Transform module with frequencies in between 0 Hz and 25 Hz as inputs, the CNN consists of convolutional layers for feature extraction and fully connected layers for classification. Analyzing different directions in drawing movements, the study achieves optimal output for X and Y directions, with an impressive accuracy of 96.5%, F1-score of 97.7%, and an area under the curve of 99.2%. This approach validates drawing movements as a non-invasive biomarker for PD detection, facilitating medical-decision support tools and long-term patient supervision.

Rizvi, et al. [5] This paper investigates voice-based Parkinson's Disease (PD) using deep learning, specifically employing a deep neural network (DNN) and long short-term memory (LSTM) network. Analyzing subject voice samples, the models achieve high accuracies of 97.12% for DNN and 99.03% for LSTM, showcasing their efficacy in noninvasive PD diagnosis. The claimed approach allows remote monitoring, minimizing the necessity for in-person clinic appointments. Through fine-tuning hyperparameters, the study establishes these models as reliable and superior to existing voice-based PD detection methods, offering potential advancements in remote PD diagnosis and progress monitoring.

Mathur, et al. [6] This paper addresses the prediction of Parkinson's Disease utilizing machine learning algorithms (MLAs) on heterogeneous medical datasets, emphasizing the prevalence of speech disorders in patients. Leveraging big data analysis, the study explores various MLAs for early detection, with a focus on improving elderly individuals' lifespan and lifestyle. Through comparisons, the combined effect of KNN algorithm with ANN is identified as the most effective, showcasing superior accuracy. The conclusion briefly shifts to a tangential topic, discussing the overstated predictive power of Twitter in elections and advocating for a comprehensive approach considering various social media sources and advanced tools for insightful data mining.

Wirdefeldt, et al. [7] In This paper we will get the insights into the prevalence and incidence of Parkinson's disease (PD) based on available epidemiological evidence. It discusses various environmental, genetic, and lifestyle elements which are associated with the development of PD. The research highlights geographical variations in PD prevalence and incidence, suggesting potential environmental influences. It explores gender and age differences in PD occurrence and progression. The paper examines the role of occupational exposures in PD development, shedding light on potential occupational risk factors. It discusses interactions between genetic predisposition and environmental factors in PD etiology. The presence of bias and confounding variables in some epidemiological studies could influence the interpretation of results.

A. Q. Rana, et al. [8] This paper offers intuition into the prevalence and spectrum of non-motor symptoms (NMS) in Parkinson's disease (PD) patients. It discusses various non-motor symptoms such as cognitive impairment, psychiatric symptoms, autonomic dysfunction, and sleep disturbances commonly observed in PD. The research highlights the significant impact of non-motor symptoms on the overall quality of life of PD patients, often overshadowing motor symptoms. It addresses the under-recognition and under-treatment of non-motor symptoms in clinical practice, emphasizing the significance of comprehensive assessment and management. The paper explores the association between non-motor symptoms and disease progression in PD, suggesting potential implications for prognosis and treatment planning.

S. Perez-Lloret, et al. [9] This paper includes the details on the prevalence of oro-buccal symptoms, including dysphagia (difficulty swallowing), dysarthria (speech difficulties), and sialorrhea (excessive saliva production), which are present in the patients who are affected Parkinson's disease (PD). It discusses the significant impact of oro-buccal symptoms on the standard living of PD patients, affecting their ability to eat, speak, and socialize. The research highlights the association between oro-buccal symptoms and disease severity in PD, citing that the mentioned symptoms may worsen as the disease progresses. The paper review various clinical assessment tools used to evaluate oro-buccal symptoms in PD patients, aiding in diagnosis and monitoring. It discusses pharmacological and non-pharmacological treatment strategies for managing oro-buccal symptoms in PD, including medications, speech therapy, and swallowing exercises.

V. Delić, et al. [10] The paper provides information on the progress of speech technology based on new machine learning paradigms, highlighting recent developments in this field. It articulates diverse machine learning mythologies applied to speech technology, incorporating deep learning models like convolutional neural networks (CNNs) and recurrent neural networks (RNNs). The research evaluates the verity of speech recognition framework build upon new machine learning paradigms, demonstrating improvements over traditional approaches. It explores the use of machine learning in natural language processing tasks, such as speech synthesis, sentiment analysis, and language translation.

K. Chenausky, et al. [11] The paper deals with the acoustic characteristics of speech in individuals with Parkinson's disease, focusing on parameters such as pitch, intensity, and temporal features. It discusses the specific speech impairments observed in PD patients, including hypophonia (reduced speech

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volume), dysphonia (abnormal voice quality), and dysarthria (impaired articulation and intelligibility). The research involves quantitative assessment methods for analyzing PD speech, such as acoustic analysis software and objective metrics to quantify speech characteristics. It explores the correlation between acoustic features of PD speech and disease severity, suggesting potential applications for speech-based biomarkers in disease monitoring.

C. O. Sakar, et al. [12] The paper explores the feasibility of using measurements of dysphonia (voice abnormalities) for the telediagnosis of Parkinson's disease, allowing for remote assessment and monitoring of PD patients. It discusses various voice analysis techniques employed for telediagnosis, including acoustic features such as pitch, intensity, and formant frequencies, as well as algorithms for processing signals to extract feature and classification. The research evaluates the diagnostic accuracy of dysphonia measurements for identifying PD patients, comparing them against standard clinical assessments or diagnostic criteria. It explores the potential for using telediagnosis techniques to remotely monitor PD patients' disease progression and treatment response based on changes in voice characteristics over time.

M. Can, et al. [13] The paper defies the application of neural networks for diagnosing Parkinson's disease, leveraging ML techniques to analyze various data inputs and make accurate predictions. It reports on the diagnostic accuracy of neural network models in distinguishing between individuals with healthy controls and Parkinson's disease, demonstrating the effectiveness of the approach. The research discusses the extraction of relevant features from patient data, such as clinical assessments, imaging results, or biomarker measurements, to input into the neural network model. It details the refinement process for neural network models, including parameter tuning, network architecture selection, and training strategies, to improve diagnostic performance.

J. S. Almeida, et al. [14] In this paper, perpetual phonation and speech signals are used to investigate the use of methods of ML for Parkinson's disease detection., offering a non-invasive and potentially cost-effective diagnostic approach It discusses the extraction of relevant features from perpetual phonation and speech signals, including acoustic parameters such as pitch, intensity, formants, and prosodic features.

F. Åström, et al. [15] The paper deals with the impact of parallel neural network models which provides a significant result for PD prediction, leveraging the capabilities of multiple interconnected networks to improve predictive performance. The selection of relevant features from patient data, such as clinical assessments, demographic information, or biomarker measurements, to input into the parallel neural network model. The research gives the armature of the parallel models based on neural network, including the number of layers, nodes, and connections, as well as the activation functions used in each network.

C. Ma, et al. [16] The paper presents an coherent identifiaction system for Parkinson's disease (PD) using a kernel-based extreme learning machine (ELM) alongside a subtractive clustering feature weighting approach, aiming to improve diagnostic accuracy and efficiency. It provides the details on the use of subtractive clustering to select relevant features from patient data, such as clinical assessments, imaging results, or biomarker measurements, to input into the ELM model. The implementation of a kernel-based ELM model for PD diagnosis, leveraging nonlinear mapping functions to confine convoluted relationships between input features and diagnostic outcomes.

S. Lahmiri, et al. [17] The paper provides the details on the use of dysphonia measurements for detecting Parkinson's disease, focusing on voice abnormalities as potential biomarkers for early diagnosis. The extraction of relevant features from dysphonia measurements, including acoustic parameters such as pitch, intensity, jitter, shimmer, and formant frequencies, to characterize voice abnormalities associated with Parkinson's disease. The research employs various machine learning (MLA)algorithms for classification, such as support vector machines (SVM), artificial neural networks (ANN), decision trees, or logistic regression, to differentiate between individuals with Individuals with Parkinson's disease compared to healthy controls on dysphonia measurements.

A. Dawson, et al. [18] The paper analyses the performance of various machine learning methods in diagnosing Parkinson's disease using dysphonia measures, assessing their ability to accurately classify individuals with Parkinson's disease and healthy controls. The selection of relevant features from dysphonia measures, including acoustic parameters such as pitch, intensity, jitter, shimmer, and formant frequencies, to input into the machine learning models for PD diagnosis. The evaluation metrics such as sensitivity, specificity, accuracy, and area under the receiver operating characteristic curve (AUC) to assess the performance of machine learning methods in discriminating between PD patients and healthy individuals.

R. K. S. Saloni, et al. [19] The paper examines the usage of clinical voice data mining for of Parkinson's disease divination, utilizing machine learning and data mining techniques to analyses voice recordings as potential biomarkers for diagnosis. The extraction of relevant features from clinical voice data, including acoustic parameters such as pitch, intensity, jitter, shimmer, and formant frequencies, as well as prosodic features, to characterize voice abnormalities associated with Parkinson's disease. The research employs various data mining techniques, such as clustering, classification, and association rule mining, to uncover patterns and relationships in clinical voice data that can aid in the discovery of Parkinson's disease.

M. Shahbakhi, et al. [20] The paper investigates the dibs of speech analysis methods for the spotting Parkinson's disease, employing genetic algorithm (GA) and support vector machine

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(SVM) for classification based on speech features. It discusses the use of genetic algorithm (GA) to select relevant speech features for Parkinson's disease diagnosis, optimizing the feature set to improve the performance of the classification model. It employs support vector machine (SVM) as the classification algorithm to distinguish between individuals with Parkinson's disease and without it based on speech features extracted from voice recordings. It utilizes cross-validation techniques to obtain the generalizability of the SVM model across different datasets and ensure robust performance in real-world settings.

3. OUTCOME OF THE SURVEY

Various studies have introduced inventive deep learning models for early PD detection, focusing on diverse modalities such as voice analysis, gait analysis, drawing movements, and sustained phonation. Deep learning models, including Convolutional Neural Networks (CNNs), Bidirectional LSTM models, and parallel neural network architectures, have demonstrated superior performance in distinguishing PD patients from healthy individuals. Deep learning-based approaches facilitate remote monitoring and diagnosis of PD, which will reduce the visiting period to clinic and enhancing accessibility to healthcare services. Researchers have explored the amalgamation of multiple data modalities, such as speech features, gait analysis, and drawing movements, to embellish the robustness and accuracy of PD diagnosis systems. Studies employ optimization approaches such as genetic algorithms (GA) for feature parameter tuning, enhancing the diagnostic performance of machine learning models. The discussed approaches address the clinical relevance of PD symptoms, including non-motor symptoms, oro-buccal symptoms, and speech abnormalities, emphasizing their impact on patients' quality of life and disease progression. omnifarious machine learning methods, including support vector machines (SVM), artificial neural networks (ANN), decision trees, and extreme learning machines (ELM), are utilized for PD diagnosis based on dysphonia measures and speech analysis Studies employ rigorous validation techniques such as cross-validation and leave-one-person-out cross-validation to evaluate the generalizability and performance of proposed models across different datasets. The discussed methods show potential for clinical usage, offering potential advancements in early PD detection, disease monitoring, and therapeutic interventions.

4. CONCLUSION

In conclusion, this survey highlights the pressing need for accurate and timely detection of Parkinson's disease (PD) due to its debilitating nature and impact on individuals' quality of life. The amalgamation of state-of-the-art Hybridizing deep learning techniques with conventional machine learning methods algorithms presents a promising avenue for enhancing PD detection and classification. The innovative approach proposed in this survey leverages Convolutional Neural Networks (CNNs), Convolutional Long Short-Term Memory networks (CLSTMs), and Support Vector Machines (SVMs) to analyze gait and speech patterns associated with PD. By extracting discriminative features from diverse speech patterns and gait analysis, the proposed model aims to provide a more objective, efficient, and accessible diagnostic tool for PD. The related works reviewed in this survey demonstrate the growing interest and advancements in using deep learning and machine learning techniques for PD detection, ranging from voice analysis to drawing movements and clinical voice data mining. These studies collectively put up to the ongoing efforts to improve early diagnosis and understanding of PD.

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