CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

Several works have been proposed for the classification of Parkinson's diseases. Different algorithms have been developed over time, and all those feature extraction, dimensionality reduction, feature selection and deep learning classification techniques are discussed in this section.

2.2. FEATURE EXTRACTION METHODS

Depending on the precise objectives of the analysis and the resources, the preference of feature extraction techniques and data sources may be made. In order to gain a more complete picture of Parkinson's disease and how it progresses, it can be helpful to combine numerous sources of data with cutting-edge analytical methods. This could help doctors make more accurate diagnoses and develop more effective treatment plans.

A. Benba, et.al 2017, analyzed 3 types of speech recordings to distinguish between PD patients and healthy individuals. The voices of 40 individuals were recorded as they held the vowels /a/, /o/, and /u/ at a natural volume (20 PD and 20 healthy). Human Factor Cepstral Coefficient (HFCC) was extracted for this research. Each speech recording was first compressed, and then the recovered HFCC values were averaged in order to get the voiceprint. A classification technique was then carried out using supervised learning classifiers and the Leave One Subject Out validation approach. Additionally, the study used SVM and KNN with k values of 3, 5, and 7 along with four distinct kernels: RBF, Linea, Polynomial, and Multi-Layer Perceptron (MLP). As shown in the study, employing the first 14 cepstral coefficients of HFCC in conjunction with linear kernels of SVM yielded highest classification accuracy (87.50%; test database: 100%).

Joshi, et al. 2017, used a wavelet transform-based model of spatiotemporal gait data in order to test the usefulness of a representation in the diagnosis of PD. It demonstrates how combining wavelet analysis with Support Vector Machine (SVM) may increase classification accuracy by introducing wavelet analysis as an alternative strategy. The wavelet transformation was employed to extract SVM, and computationally simplified information was fed to identify Parkinson gaits. The researchers next evaluated numerous gait measurements, including stride interval, swing interval, and stance interval, to determine which was the best (from both legs). Classification accuracy of 90.32% (Confidence Interval; 74.20%-97.90%) was achieved by using wavelet decompositions of gait characteristics as an additional strategy for identifying PD in patients. This accuracy is comparable to that recently reported using just one gait feature. As shown by a classification accuracy of 90.32%, the left stance interval was just as effective as the right swing interval. When the gait data from the left leg were combined to produce a larger feature vector, the classification accuracy jumped to a perfect 100%. For some gait characteristics such right stride time series, their analysis showed that Haar wavelets performed better than db2 wavelets ($p = 0.05$). Their findings indicated that wavelet analysis was a viable method for decreasing number of gait variables, albeit at the expense of more computations in wavelet analysis.

Mostafa, et al. 2018, focused on voice disorders utilising Machine Learning Technique for feature assessments and classifications in an effort to improve PD diagnosis. They introduced multi-agent Multiple Feature Evaluation Approach (MFEA) and implemented 5kinds of classifications for PD diagnostics namely Decision Tree (DT), Naive Bayes (NB), Neural Network (NN), Random Forest (RF), and Support Vector Machine (SVM) before and after the application of MFEA, and evaluated diagnostic accuracies of those outcomes. The tests employed 10-fold cross-validations where results showed that multi-agent MFEA system were effective in finding best feature combinations while enhancing overall efficiency of classifiers. Classifiers including DT, NB, NN, RF, and SVM all improved diagnostic accuracy by an average of 10.51–15.22%, 12.75–12.75%, 9.19–9.13%, and 9.13%, respectively. MFEA significantly improved the classifiers' diagnostic accuracy, as seen by these findings.

Chen, et al. 2018, implemented an approach for feature extraction which involved the fusing of various entropies. The combined form was considered to potentially convey the unique qualities of Electroencephalography (EEG) more effectively. Initially, the four entropies were extracted from the recorded EEG signals; these included the Shannon entropy (utilized to quantify amplitude), the wavelet entropy (utilized to quantify phase synchronization), the sample entropy, and the entropy of the wavelet transform (utilized to quantify noise in the signal). Subsequently, classification was carried out by SVM, while dimensionalities were minimized by PCA. Using dataset III from the 2003 Brain Computer Interface (BCI) competition, the efficiency of the strategy was evaluated, and experimental findings indicated an accuracy of 8.36% for the fusion of four entropies, thereby suggesting increased classification performances. Finally, it was concluded that useful features for EEG categorizations were successfully extracted by the approach.

Oung, et al. 2018, presented a multiclass classification that divides people into three groups according to their Parkinson's Disease (PD) severity: mild, moderate, and severe. Empirical Wavelet Transform (EWT) and Empirical Wavelet Packet Transform (EWPT) have been introduced for detections and categorizations of PD using signals from wearable motion and auditory sensors. The EWT/EWPT was used to breakdown the audio and visual data streams up to five levels. The effectiveness of the method was assessed using classifiers like KNN, Probabilistic Neural Network (PNN), and Extreme Learning Machine (ELM). Proposed method could accurately classify participants into those with PD and those without PD, as well as their severity level, using EWT/EWPT-ELM with inputs from motion/audio sensors. The study achieved 95.00% and classification accuracy on EWT/EWPT-ELM signals were created by integrating data from the two signals.

Karan, et al. 2020, claimed that features based on Empirical Mode Decomposition (EMD) are intended to capture speech characteristics. Intrinsic Mode Function Cepstral Coefficient (IMFCC) has been introduced to effectively reflect the feature speech. The performances of the proposed characteristics in evaluating Parkinson's disease are assessed using two separate datasets, dataset-1 and dataset-2, each comprising 20 normal and 25 Parkinson-affected individuals. The improved classification accuracy of the proposed intrinsic mode function cepstral coefficients was observed in the findings on both datasets. An increase in accuracy ranging from 10.00% to 20.00% was noted when the MFCC features were compared to traditional acoustic methods.

Tuncer, et al. 2020, considered the most important aspects of a voice signal are derived using a hybrid approach involving minimal average maximum trees and Singular Value

Decomposition (SVD). In the preprocessing phase, three layers of the Minimum Average Maximum (MAM) tree have been used to create a unique feature signal. The created signal is given to the SVD operators were the features are extracted. After that, the relief FS technique was used to pick the top 50 most distinguishing characteristics. Finally, they have classified data using K- Nearest Neighbor (KNN) with 10-fold cross validation. The vowels and the KNN classifier are able to get the highest classification accuracy rate possible (92.46%). Each person in the dataset is represented by three vowels. Post-processing is used to get specific outcomes; the KNN classifier yields the greatest results (96.83%). The proposed approach is prepared to be tested on a sizable database and can help neurologists diagnose Parkinson disease using vowels.

Balaji, et al. 2020, established a gait classification method that can aid clinicians in identifying the various PD stages. The subject gait pattern, which is an important indicator of their mobility, can be used as a biomarker to determine if they are healthy or suffering from PD. Therefore, they have employed the statistical analysis to extract the minimal feature vectors in gait dataset derived from Vertical Ground Reaction Force (VGRF) data. Their Shapiro-Wilk tests were then performed to ensure that data was normally distributed, and correlation-based method of FS were employed to extract key biomarkers from spatial and temporal features of gait patterns. Statistical and kinematic data may be used to predict the severity of PD using four supervised MLT: DT, SVM, ensemble, and Bayes classifiers. As assessed by the classifier accuracy, sensitivity, and specificity, the proposed framework was capable of appropriately ranking severity of PD in accordance with the Hohen and Yahr (H&Y) scales and much better than other PD classification algorithms that used the same gait dataset, the proposed method shows superior performance.

Sarankumar et al. in 2022, conducted a study on a dataset of voice data that is collected from 42 patients was analyzed, containing a total of 5875 audio files. After the dataset was pre-processed, a clustering process was performed using wavelet cleft fuzzy. Following the clustering step, feature selection was carried out using the firming bacteria foraging algorithm. The selected features were then utilized to predict PD patients using the Deep Brooke inception net classification algorithm, resulting in an accuracy of 99.88%.

2.3. DIMENSIONALITY REDUCTION METHODS

Dimensionality reductions seek to enhance knowledge extractions while minimizing data losses by adjusting model included features counts. The computational costs were reduced with improved visibilities as feature space sizes were reduced in relation to original data. Dimensionality reduction techniques for PD diagnosis are discussed in detail in this section.

Ly et al. 2017, established a classification approach based on Electroencephalography (EEG) in order to identify turning freezing episodes in PD patients. They have used three components of N2A-SVM including network-based gene feature extraction, DNN dimension reduction, and MLT -based gene predictions of PD. Additionally, N2A-SVM was trained using the most up-to-date dataset, and then applied to the task of predicting genes involved in PD. For feature extractions, they transformed to time-frequency Stock well Transform (S-Transform) methods, as EEG signals are inherently temporal. Independent Component Analysis with Entropy Bound Minimization (ICA-EBM) decomposed EEG sources. Bayesian Neural Network (NN)was utilized to extract and categories the frequency-based characteristics of a subset of the independent components of EEG. Classification showed high sensitivity (84.20%), specificity (88.0%), and accuracy (86.20%) for PD diagnosis. These encouraging findings helped in real-time device capability that could identify various forms of EEG while the patient was walking.

Aich et al. 2018 proposed a new method which compares performance measures across multiple feature sets, including the original feature sets and a feature reduction strategy based on Principal Component Analysis (PCA). To evaluate performance indicators, adopted a non-linear based classification strategy. Using PCA-based feature sets, Random Forest (RF) classifiers achieved an accuracy of 96.83%. Clinicians can use the results of this study to better categories patients with PD and those without the disease from their voice data.

Ali, et al. 2018, offered an intelligent system using LDA for reducing dimensionalities while Genetic Algorithm (GA) optimized Neural Network (NN) hyper parameters for their predictive model. In addition, they used leave one subject out validations to prevent doublecounting of subjects. The accuracy, sensitivity, specificity, and Matthew Correlation Coefficient (MCC) of the proposed technique, LDA-NN-GA were assessed in numerical tests on several different types of data involving prolonged phonations. Using all of the extracted features, it is able to achieve 95% classification accuracy on the training database and 100% accuracy on the testing database. However, to get fair results given the gender disparity in the dataset, after removing features that were skewed toward either sex, the accuracy increased to 80% on the training database and 82.14% on the testing database. It has concluded that the proposed LDA-NN-GA method outperforms and is simpler than the prior MLT. Their proposed automated diagnostics could potentially identify PD from healthy participants in experiments.

Oliveira, et al. 2018, described the problem of differentiating between people with and without PD in terms of their brain activity. Additionally, a comparison of various classification strategies was provided. A series of four motor activities were recorded from the subjects, along with inertial and electromyography data. SVM classification performance was evaluated by contrasting estimates of 2D feature sets using PCA, Sammon maps, and t-SNE. Statistically and visually distinct characteristics were displayed by each of the three groups examined. Accuracy in classifying data using PCA, Sammon mapping, and t-SNE ranged from 73.50% to 78.50% in the training set to 68.10% to 76.60% in the test set. In therapeutic application, t-SNE scatter plots could be used to objectively measure the gap between typical and atypical motor behaviors, allowing for a more precise diagnosis, therapy, and monitoring of the disorder's progress.

Nilashi et al. 2023, presented a combined approach utilizing ensemble learning with DBN, Neuro-Fuzzy, EM clustering, PCA, and K-NN to predict the Unified Parkinson’s Disease Rating Scale (UPDRS) in PD diagnosis. The prediction accuracy and time complexity for large datasets were improved by the approach compared to other machine learning techniques.

2.4. FEATURE SELECTION METHODS

Feature Selection helps in selecting appropriate features from the datasets and the approaches which are specific to Parkinson’s Disease are detailed in this section.

Sharma, et al. 2019, modified the traditional Grey Wolf Optimizer (GWO) to generate a novel model dubbed MGWO (Modified GWO), which acted as a search method for Feature Selection. GWO is a meta-heuristic that simulates wolf hunting behaviours. The proposed model used RF, KNN, and DT for extracting features from Voice, handwriting (spiral and meander), and speech datasets and obtained a resultant accuracy of 94.83% (detection rate of 98.28%) with False Alarm Rate (FAR) of 16.03% in its early identification of PD for treatments.

Senturk, et al. 2020, proposed Feature Importance and Recursive Feature Elimination (RFE) techniques for Feature Selection. A range of techniques, including classification and regression trees, Artificial Neural Network (ANN), and SVM to experimentally classify individuals with PD. It was shown that among the alternatives, Support Vector Machine utilising Recursive Feature Elimination were the most successful. The fewest voice characteristics were used to diagnose Parkinson disease with the best accuracy (93.84%).

Tuncer, et al. 2020, proposed a statistical pooling method in order to diagnose PD with vowels. Vowel characteristics are present in the PD dataset has been used for implementation. The proposed method utilizes a statistical pooling technique to bolster the characteristics of a dataset. Next, ReliefF has been used to narrow down the larger feature vector to its most relevant attributes. Most heavily-weighted feature vector is used for the classification process. KNN and SVM techniques are utilized in this method. Using SVM and KNN found that the success rate was 91.25% and 91.23%, respectively. There are two key innovations that make up the proposed process. The first is to use statistical pooling to extract novel features from the Parkinson audio dataset. The second is narrowing down all those feature vectors to the ones that really matter. As a result, both the KNN and SVM algorithms were shown to be effective. The findings of this comparison show conclusively that the success rate of the proposed method was when compared to other methods demonstrating its effectiveness in recognizing PD.

Tubishat, et al. 2020, proposed an ISSA an improved Salp Swarm Algorithm (SSA) to identify best features in wrapper mode. Two significant improvements were made to the original SSA approach to address its shortcomings and make it suitable for Feature Selection (FS) issues. The recommended bio-inspired algorithm stability was utilized to identify the ideal subset of attributes. The results of the proposed approach on datasets were then compared to those of the Optimized Cuttlefish Algorithm (OCFA). The experimental findings demonstrated how well the proposed method performed in optimizing accuracy while reducing FS effort.

Bertini, F, et al. 2022, investigated the proposed technique using a dataset of 288 audio files from 96 patients, which included 48 healthy controls and 48 participants with cognitive impairment. The suggested method outperformed techniques relying on manual transcription and speech annotation, yielding classification results comparable to the most advanced neuropsychological screening tests, achieving an accuracy rate of 90.57%.

Sharma, et al. 2022 extended this line of research by optimizing the feature selection method using the Modified Grey Wolf Optimization (MGWO) model for PD prediction. The authors evaluated the proposed model across various datasets, employing classifiers such as random forest, k-nearest neighbor, and decision tree, and validated the effectiveness of this optimization approach in predicting PD with an accuracy of 94.83%.

Senturk, et al. 2023 conducted a study focusing on early Parkinson's disease (PD) detection, wherein a feature selection method was devised. This method was applied to 22 phonetic features extracted from voice samples of both PD patients and healthy individuals. The investigation revealed that the SVM classifier, when coupled with feature selection, demonstrated the highest classification performance at 93.84%, surpassing the performance of the pure SVM.

2.5. OPTIMIZATION BASED FEATURE SELECTION METHODS

Effective illness diagnosis relies heavily on the optimization-based FS for improvement and prediction. This section looks at the specifics of FS that rely on optimizations for detecting PD in patients.

Gupta, et al. 2018, created an enhanced cuttlefish algorithm for FS that expands on the original cuttlefish approach to aid in identifying Parkinson’s disease early. At its core, PD, a syndrome that affects the whole central nervous system, is caused by the loss of brain cells. Parkinson’s disease can be deadly and presently has no known treatment; however, medications can help patients manage their symptoms and live longer for a time. This model used the well-known cuttlefish method to identify the optimal collection of attributes. Decision Tree and k-nearest neighbors were used to analyze the characteristics. This model was tested on the Parkinson speeches with varied recording kinds and collections of Parkinson handwriting examples. The proposed method could predict PD with an accuracy of roughly 94.00%, enabling early detections and treatments. The results of the experiments showed that this bio-inspired algorithm picks and more stable collection of attributes with better accuracy.

Rostami, et al. 2020, proposed a unique PSO-based multi objective Methods of FS. They have done three primary steps to the proposed procedure. The first stage involved displaying the initial characteristics in a graph representation model. The second step has involved computing feature centralities for each node in the graph, and the third stage involved using an enhanced PSO-based search procedure to narrow down the options for FS. The evaluation of the proposed method on five medical datasets shows significant efficiency and effectiveness gains compared to the state-of-the-art.

Li, et al. 2017, merged improved Grey Wolf Optimization (GWO) with Kernel Extreme Learning Machine (KELM) to create IGWO-KELM, a revolutionary prediction framework for medical diagnostics. IGWO has been introduced for FS to find the ideal feature subsets in medical data and be the base for best KELM classification. Genetic Algorithm is used to generate multiple start locations, followed by GWO algorithm to update current positions of the population in discrete search spaces. In evaluations, the values of classification metrics like accuracy, sensitivity, specificity, precision, measures, and sizes of selected features by GA and GWO showed proposed method superiority.

Cai, et al. 2017, stated that the algorithm that predicted PD the best was an SVM trained on data from the Bacterial Foraging Optimization (BFO) method. BFO-SVM was evaluated on a vocal-based PD dataset to confirm its effectiveness. The proposed method was evaluated using SVM built using the grid search method and an SVM by Particle Swarm Optimization (PSO). The employment of the RelieF (RF) based Feature Selection (FS) prior to the BFO-SVM approach also prompted the development of the RF-BFO-SVM, which further increased forecast accuracy. The experimental findings demonstrate that the proposed framework works very well for classification, with a classification accuracy of 97.42%.

``Ibrahim, et al. 2019, used Grasshopper Optimization Algorithm (GOA) to fine-tune SVM weights and select features. Based on the foraging strategies of grasshoppers, GOA is an innovative heuristic optimization technique. It validated the system capacity to use a concealed search space to address practical issues. Biomedical datasets from 2010-2012 involving cancer patients in Iraq were used to test the proposed GOA+SVM method, together with datasets from the University of California, Irvine (UCI).

2.6. ENSEMBLE BASED FEATURE SELECTION METHODS

To improve the precision of classification, ensemble-based methods in Feature Selection (FS) combine multiple feature subsets to select a single, optimal subset of features through a weighted average of their individual ranks. This section offers detailed overviews of the application of ensemble-based FS techniques in the classification of Parkinson's Disease (PD).

Semwal, et al. 2017, established the following FS and principle feature identification procedures, the study classifies gait data utilizing a variety of MLT (KNN, ANN, SVM, DNN, and classifier fusions) and compared their respective levels of successes. The study experimental results outperformed other techniques as it combined Incremental Feature Selection (IFS) and analysis of variance in categorizing humanoid locomotion's using Analysis of Variance (ANOVA). Classifier fusion model was created by combining these separate classifiers. The effectiveness of the proposed model was measured using 5-fold cross-validation. The empirical evidences proposed that classifier fusions produced acceptable outcomes (92.23%), when compared to other individual classifiers. A one-way ANOVA test, a Friedman test, and a Kruskal-Walli's test were also used to determine statistical significances of results.

Jain, et. al. 2018, introduced a new method for reducing feature dimensionality based on hybrid FS. This study, presents a strategy that combines RelieF with PCA and finds impressive results across a variety of chronic disease datasets. The presented work finds the ideal value of threshold for selecting important and non-redundant features, and it can be applied to both text and micro-array datasets. Ten widely-known benchmark datasets are used to assess the quality of the work offered. According to the findings, the given method successfully removes more than 50% of the dataset superfluous or redundant features. The proposed strategy also drastically reduces computing time for all considered chronic disease datasets where experimental threshold values had considerable impacts on FS.

Cigdem, et.al 2018, compared the efficiency of five classification strategies where each of them employed an individual attribute ranking, followed by an adaptable Fisher stopping criterion to improve PD detection capabilities, source fusion methods that merge the white matter and grey matter tissue maps and decision fusion methods that combine the outputs of all classifiers using the Correlation based Feature Selection (CFS) approach by majority voting are both applied. CFS produced greatest results when compared to the other four FS, but SVM performed best at classifications.

Masood, et al. 2021, made an effort to investigate and exploit the connection between distinct characteristics of PD patient voices. Two-level ensemble-based Feature Selection has been introduced which combine its output with Multi-Layer Perceptron trained using K-fold cross-validations. Three separate databases of reference voice samples were used in the experimental study. According to their findings, their recommended FS framework is helpful in selecting the right characteristics, which in turn helps in the highly precise diagnosis of PD patients by speech samples and an MLP.

Singh, et. al. 2021, created four-stage hybrid ensemble FS. The dataset was initially divided into subsets using cross-validation approaches. Sequential Forward Selection (SFS) were utilized as wrappers to combine different filter strategies based on weights used in filters to produce ideal subsets of features. The best possible subset is extracted and used in further categorization steps. Evaluations of the proposed hybrid approach versus fourteen usual algorithmic FS using four benchmark classifiers: NB, SVM with Radial Basis Function (RBF), RF, and KNN where results showed that the proposed hybrid approach was better than its alternatives in terms of precision, accuracy, sensitivity, specificity, f1-scores, ROC and feature counts. Statistical examinations of their findings demonstrated that their proposed hybrid technique performed better when compared to other important algorithms.

Basir, et al. 2021, described that the performance of multi-objective techniques, such as Evolutionary Algorithm (ENORA) and Non-dominated Sorting Genetic Algorithm (NSGA-II), in terms of the ideal feature set could be enhanced by employing ensembles like boosting or bio-inspired methods. The optimization of bio-inspired ensemble searches was identified as the most significant aspect of this work. The subsequent phase involved a classification exercise to validate the best-possible Feature Selection (FS). Metrics for success were established by counting how many characteristics were used for classification. Eight typical benchmark datasets were chosen to conduct the tests. The results of the experiments revealed that algorithms used in bio-inspired search techniques with ensemble approaches identified better solutions with fewer features, while boosting classification accuracies on relevant datasets. This implies that when an ensemble approach (boosting) is used for attribute selection and classification, the performance of bio-inspired algorithms is improved.

2.7. MACHINE LEARNING AND DEEP LEARNING TECHNIQUES

Classification techniques based on machine learning, and deep learning methods for PD diagnosis are discussed in this section.

Caliskan, et al. 2017, presented a DNN architecture that combines a stacked auto encoder with a SoftMax classifier for classification tasks. Multiple simulations are run over two datasets to show how well the classifiers works based on DLT. An evaluation is conducted between the proposed classifier and the current gold standard in classification. Both the experiments and the statistical analysis demonstrated that the DNN classifier is a highly effective classifier for PD diagnosis.

Haq, et al. 2018, proposed a non-invasive Parkinson disease prediction system based on MLT and DNN for an accurate and prompt diagnosis. MLT prediction models, such as the SVM, Linear Regression (LR), and DNN, were used in the system development to help discriminate between those with and without Parkinson. The dataset was separated into training and testing segments with 70-30 splits. In addition, measures such as classification accuracy, sensitivity, specificity, and MCC evaluated the model. A 23-attribute, 195-instance, PD dataset was taken from UCI machine learning library and was used to assess the proposed method. The study experimental results demonstrated that the proposed approach accurately distinguished between individuals with and without PD. DNN also outperformed classic MLT when it came to classification performances. These results provide supporting evidence that the proposed diagnosis system has the potential to be used for precise PD prognosis.

Grover, et al. 2018, developed a method for predicting the severity of PD. Parkinson Telemonitoring Voice Dataset has been collected from the UCI. Neural Network for severity prediction using the python 'Tensor Flow' in deep learning. Proposed approach yields higher accuracy values than those seen in prior studies.

Hssayeni, et al. 2019, utilized motion data acquired from two wearable sensors, processed symptom-based data with dual-channel LSTM network to predict UPDRS section III (severity of motor issues). Unlike previous sensor-based systems that required participants to do specific activities, the study novel method was passive and based on subjects' free-body motions. Motion data gathered from 24 people with idiopathic PD was used to train and test the proposed network. While the individuals went about their daily activities, this data was gathered. Scores on the clinical exams were moderately correlated with the projected UPDRS-III scores. The results of study show that this method has promise for evaluating PD severity scores while subjects are engaged in normal, daily, free-body activities. This method could offer the treating physician with objective and comprehensive data that would aid in the early detection of small changes in the disease course and the subsequent implementation of successful management strategies.

Ashour, et al. 2020, presented a monitoring strategy for PD using a dataset of recorded signals from many wearables on body sensors put at various locations on the leg (knee, hip, and ankle), The acceleration signals can be used to identify the various symptoms of PD, the most prominent of which is the Freezing of Gait (FOG). Most cases of FOG are unique to each individual patient and range widely in terms of intensity and frequency. In this investigation, patient-specific DLT based on the Long Short-Term Memory (LSTM) network were employed to identify FOG. A comparison between the proposed model and more traditional MLT like the linear SVM was done using data from all three sensors. The findings showed that, with an average accuracy of 83.38% versus 79.48%, the LSTM model is superior to SVM. The linear SVM classifier has highest accuracy for Patient 2 is 80.00%, compared to the LSTM maximum accuracy of 98.89%.

Quan et al. 2021 introduced a Bi-LSTM method to capture the time-series dynamic features of a speech signal for Parkinson's disease (PD) diagnosis. The dynamic speech feature was assessed based on the evaluation of energy content during the transition from voiced to unvoiced segments (offset) and the transition from unvoiced to voiced segments (onset).

Leung et al. 2021 concentrated on the development of DL, an ensemble method for predicting Parkinson's disease (PD) in individuals. The initial and subsequent phases of the method extracted features from DaTscan and medical measures of motor symptoms, respectively. Subsequently, an ensemble of DNN models was trained on distinct subsets of the extracted features to predict individuals' results from a baseline screening conducted 4 years earlier.

Ali et al. 2022 had investigated DNNs as FSAs in an attempt to prove their efficacy by comparing performances of traditional DNNs with other integrated systems. The study had developed EOFSCs (Ensembles of Optimal Features and Sample Dependent Base Classifiers) to capitalize on recent discoveries by studies. According to recent research, distinct optimum models were developed for different forms of speech data that were sensitive to sample variations and subsets of attributes. Using the suggested integrated system, further consolidations of the findings were advised based on the development of EOFSCs. Basic classifiers had shown sensitivity towards subsets of characteristics obtained from vowel phonations. This work's suggested EOFSCs used base classifiers for examining characteristics. The final forecasts of EOFSCs were evaluated using a majority voting procedure. The results of their experiments suggested that combining FSAs with NNs improved the performances of traditional methods. Moreover, the integration of FSAs with h DNNs had shown superior feature selection integrations with standard MLTs.

2.8. SUMMARY

In this chapter the previous research related to feature extraction, dimensionality reduction, feature selection, optimization algorithms and various machine learning and deep learning techniques for the classification of Parkinson's disease is studied in detail.