A Study of Feature Selection with Machine Learning based Decision Making Models for Parkinson's Disease Classification

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Abstract : Parkinson's disease (PD) refers to a neurodegenerative disease that affects many persons globally and cannot be cured basically. It is highly essential to diagnosePD in the early phases so that an individual could live a healthy life for a long time. The severe stages of PD were extremely risky because the victims get stiffness, which leads to walking or standing inability. Previous researchers had a focus on detecting PD efficiently by utilizing writing exams and voice and speech exams. In recent times, count of features and count of instances that make data louder have enhanced data. Nowadays, automatic detection of initialPD on feature data sets seems to be difficult tasks in healthcare sector. Most of the features in such data were unusable or involves problems such as noise, which affect the learning procedure and rises the computational burden. Feature selection becomes one of the most significant and broadly utilized methods for data pre-processing. It can be typically utilized for finding the optimum subset of features, eliminate redundant and irrelevant features, reduce computing complexity, and enhance the performance of classification recognition. Existing works are mainly based on feature selection with machine learning (ML) based PD classification models. Since numerous works existed in the literature, this paper focuses on the performance validation of different PD classification models. The recently developed feature selection with data classification models using ML and deep learning (DL) for PD classification is examined. In addition, the performance analysis of different PD classification models is made and the results are inspected interms of different measures.

Keywords: Parkinson's disease; Machine learning; Data mining; Feature selection; Deep learning; Data classification

1. Introduction

Data mining was utilized in several industries for enhancing customer experience and satisfaction, and rise product safety and usability. Data mining in medical sector has proved effective in areas like detection of fraud and abuse, predictive medicine, management of healthcare, customer relationship management, and estimating the efficiency of some medications [1]. This application of data mining in healthcare includes contrasting and comparing symptoms, causes, and courses of medication for identifying an effectual procedure or method for some illness or condition [2]. For instance, patient who was treated with various drug regimens is associated with determining which treatment procedure would work well and saving money. Additionally, the continual usage of this data mining application aid in standardizing a technique of treatment for particular diseases, therefore making the treatment and diagnosis process easier and quicker. Parkinson's disease (PD) will affect the movement of an individual, which includes the variances in stiffness in muscles, writing skills, tremors, and speech. It was important to identify the PD in the early phases thereby the person has healthy life for ling time [3]. The serious stages of PD were extremely perilous since patients get advanced stiffness that leads to the incapability of walking or standing. Previous research works had focused in detecting PD efficiently through writing exams and voice and speech exams. In recent times, data were enhanced by number of features and instances that make data noisier [4]. Fig. 1 demonstrates the applications of data mining in healthcare system.

Fig. 1. Application of Data mining in healthcare

Owing to a great upsurge in data volume, several data-based issues creep in and noise started to increase. Increased features and instances result in lot of processing and pre-processing work [5]. Augmented noise will cause performance to drop and outcomes will be degraded. A higher volume of data results in a rise in complexity and computational cost. Feature Selection (FS) would keep the data volume in control, later diminishing computational cost and complexity. It evades method over-fitting and avoids curse of dimensionality [6]. It serves a dynamic role in constructing ML methods. FS or otherwise known as attribute or variable selection. In this, a feature subset can be chosen from all accessible attributes. The predominant aspect that can be considered as model accuracy, which can be calculated before and after FS. FS was categorized as a wrapper-related and filter-related algorithm [7]. The filter-based technique uses statistical methods to find the significance of every attribute. Wrapper-based method utilizes ML technique. Wrapper-based method computation was expensive compared to filter-based technique.

Wrapper techniques were further categorized as Heuristic-and-Sequential Search Algorithm. Evolutionary algorithm was considered a part of artificial intelligence (AI) that had the main focus toward biological evolution [8]. Biological evolution has 4 predominant processes selection, reproduction, mutation, and recombination. Dissimilar to conventional optimized methods, evolutionary techniques rely on random sampling. Such process can be repetitively implemented on the solutions officially specified as population and the fitness function can be utilized for determining the solution quality [9]. Such solutions vary in accordance with the evolutionary procedure which will be helpful in identifying the global solution to the issue. Evolutionary methods were known for performing effectively in different circumstances since not assume the basic fitness landscapes. Smooth simple evolutionary methods could resolve complicated issues easily. One disadvantage in evolutionary methods is the computation cost factor which is minimized by utilizing fitness function approximation [10]. There were several kinds of evolutionary algorithms, few were evolutionary strategies, genetic algorithms, and evolutionary programming.

Existing works are mainly based on feature selection with machine learning (ML) based PD classification models. Since numerous works existed in the literature, this paper focuses on the performance validation of different PD classification models. The recently developed feature selection with data classification models using ML and deep learning (DL) for PD classification is examined. In addition, the performance analysis of different PD classification models is made and the results are inspected interms of different measures.

2. Background Information

PD can be considered a brain disorder which leads to uncontrollable or unintended actions like trembling, rigorousness, and trouble with coordination and balance. Symptoms generally commence progressively and deteriorate for the period. Since the disease develops, persons might face complexity in talking and walking. It could have behavioural and psychological variations, sleep issues, fatigue, depression, and memory difficulties. Elder females and her caregiver almost at the risk of formulating Parkinson's, certain research works propose this illness will affect higher males compared than females. It's uncertain because the studies remain underway for comprehending features that might rise an individual's risk. Single clear risk was age: Though many persons having Parkinson's initially advance the illness afterward age 60, approximately 5% to 10% have commencement earlier the age of 50. Initial -onset forms of Parkinson's remain frequently, nevertheless not continuously, hereditary, and certain states were connected to definite gene alterations. The maximum projected symptoms and signs of PD happen once nerve cells present in the basal ganglia, a zone of the brain that would control movement, developed weakened, or die. Usually, such neurons or nerve cells degenerate a significant brain chemical called dopamine. Once the neurons become impaired or die, it degenerates less dopamine which makes the movement difficult linked with the disease. Experts do not see what will be the reason for death of neurons. Persons endured by PD even lose the nerve finishes that degenerate noradrenaline, the core chemical messenger of the understanding nervous system that manages several body functions, like blood pressure and heart rate. The damage of noradrenaline may be helpful in explaining certain non-movement structures of Parkinson's, like tiredness, uneven blood pressure, reduced drive of food over the digestive area, and abrupt drip in blood pressure whenever an individual stands up from a lying or sitting position. Numerous brain cells of persons having PD have uncommon clumps of the protein alpha-synuclein, Lewy bodies. Authors were endeavouring to better comprehend the abnormal and normal roles of alpha-synuclein and its association with genetic mutations that effect Lewy body dementia and Parkinson's.

Certain cases of PD are hereditary, and some are sketched to detailed genetic mutations. When genetics was reached to piece a role in Parkinson's, in many cases the illness did not seem to run in relation. Several academics today trust that Parkinson's outcomes are from a grouping of environmental and genetic features, like exposure to toxins.

Symptoms of PD

Parkinson's contains 4 key symptoms:

- Impaired balance and coordination, occasionally leading to falls
- Tremor in hands, head, arms, legs, or jaw,
- Slowness of movement
- Muscle stiffness, wherever muscle will be remaining contracted for a longer period

Other symptoms may include:

- Skin problems
- Depression and other expressive variations
- Urinary difficulties or stultification
- Difficulty swallowing, chewing and speaking

The signs of Parkinson's and the development rate vary amongst persons. Initial signs of this disease were subtle and happen progressively. For instance, individuals might encounter mild earthquakes or have trouble receiving out of a chair. They might note that they say too gently, or that their handwriting was deliberate and looks small or cramped. Family members or Friends might be the primary to note variations in somebody by initial Parkinson's. They might see that the face of an individual lacks animation and expression or that the individual does not move a leg or arm usually.

Indications frequently begin on single side of the physique or in one limb on single body side. Since the disease develops, it finally disturbs both sides. But the indications might be simpler on single side than the other. Several persons having PD noticed that previous to feeling tremors and stiffness, they encounter sleep difficulties, stultification, restless legs, and loss of smell. When certain indications might occur with normal aging, talk with your doctor if such symptoms deteriorate or begin to delay daily living.

Diagnosis of PD

There was currently laboratory or no blood tests for diagnosing non-genetic cases of Parkinson's. Clinicians regularly analyze the ailment by captivating an individual's health history and accomplishing neurological check-ups. If indications progress after preliminary to take medicine, it's another pointer that the individual has Parkinson's. Several syndromes could cause indications as same as PD. Individuals with Parkinson's-like indications that result from other causes, like multiple system dementia and atrophy with Lewy bodies, were occasionally supposed to have parkinsonism. Though such ailments originally might be misdiagnosed as Parkinson's, convinced health tests, along with response to drug conduct, might aid in better assessing the cause. Several other illnesses have alike attributes but need various treatments, thereby it is significant to receive a precise diagnosis as soon as possible.

3. Existing PD Classification Models

This section examines the different PD classification models available in the literature. Mohammed et al. [11] focused on inspecting PD diagnoses by using the features of voice information. A novel multi-agent feature filter (MAFT) technique has been developed for selecting the better feature from the voice data. The presented approach is intended for selecting a feature set to enhance the comprehensive review of predictive model and possibly prevent overfitting because of extreme feature reduction. Furthermore, the study's aim is to build a robust training model, decrease the complexity of the prediction, and accelerate the training phase. Dash et al. [12] proposed a chaos-based stochastic technique by integrating the features of chaotic firefly algorithm (FA) with Kernel-based NB (KNB) method for the diagnoses of PD at earlier stages. The dynamics of chaos optimization algorithm improve the FA by presenting six different kinds of chaotic maps that might rises the intensification and diversification ability of chaos-based FA.

Khoury et al. [13] introduced a ML technique for the detection of PD based on the usage of vertical Ground Reaction Forces (vGRFs) information gathered from the gait cycle. A classification engine allocates subjects to Parkinsonian or healthy classes. The diagnosis technique includes 4 major stages: performance evaluation, data pre-processing, data classification, feature selection (FS), and extraction. The selected feature is utilized as input for all the classifiers. FS can be accomplished by means of wrapper technique has been formulated by the RF (RF) algorithm. Lamba et al. [14] a new PD diagnoses technique is proposed by examining the extracted kinematic feature from the handwritten spirals drawn by the patient. The openly accessible University of California, Irvine PD spiral drawing by means of digitized graphics tablet data is applied. An overall of twenty-nine extracted kinematics features from the data. Related feature is carefully chosen by means of the mutual information gain FS technique and genetic algorithm (GA).

In Xiong and Lu [15], the vocal feature of PD infected individuals can be analyzed by means of complicated computation model. In the beginning, the sample is pre-processed, since it encompasses additional missing values. Next, the predictor candidate set is recognized from the processed vocal feature by means of Adaptive GWO technique, a metaheuristic global search optimized approach. Moreover, the hidden description of the candidate feature is extracted by the sparse auto encoder (SAE) for efficient discrimination among the PD affected and control cases. For classification, six supervised ML algorithm was applied. The presented technique can be trained using the information, classified by tenfold cross-validation system, and evaluated the performance on the basis of validation metrics.

Li et al. [16] developed a hybrid FS procedure based on better discrete ABC approach for improving the efficacy of FS. The presented method integrates the benefits of wrappers and filters to remove the noisy or uncorrelated features and define the optimum set of features. In the filter, three distinct variable ranking techniques are applied to pre-rank the candidate feature, next the population of ANC is initialized according to the consequence degree of re-rank feature. In the wrapper, the ABC technique estimates individual (feature subset) according to the classification performance of the classification for achieving the optimum set of features. Furthermore, the study originally introduced the approach which could automatically choose the better classification in the search technique rapidly.

Rezaee et al. [17] aim are to employ pretrained deep transfer learning (DTL) structure and traditional ML algorithm as an automatic technique for diagnosing PD from sEMG signal. Initially, stack the feature extracted from 3 deep pretrained models involving VGG-f, CaffeNet, and AlexNet, to produce the discriminatory features. Even though the many stacked features from the three deep structures were larger, the relevant feature is efficient in increasing the robustness to added noise with diverse levels and overwhelming the challenges of overfitting.

Ul Haq et al. [18] developed an ML related technique for the detection of PD. Particularly, a hybrid FS technique was developed by incorporating the Relief and ACO techniques for selecting related features to train the method. Furthermore, the SVM was trained and tested on the selected feature to accomplish optimum classifier performance. In addition, the K-fold cross-validation approach was implemented for the optimum hyperparameter assessment. Augustine and Jereesh [19] developed a computation architecture to forecast PD from blood-based microarray gene expression dataset. Data balancing, Pre-processing, and feature reduction, and prediction are the four phases of the presented method. During the pre-processing phase, integration, annotation, and cross-platform normalisation have been implemented. Balanced subset was constructed using k-means clustering on random under sampling and majority samples. The ANOVA filter extracted crucial features from balanced subset in the feature reduction phase, along with ensemble and different cost-sensitive classification models have been constructed in the prediction phase.

Goyal et al. [20] explored an FS technique in PD diagnoses using speech features. In the study, two phase FS technique is employed that incorporates the advantages of GA and SVM-Recursive Feature Elimination methods into one. Classification can be performed by means of SVM and outcomes were to SVM without FS and separate selection technique. The two phase FS method decreased the dimensionality of data and enhanced the system performance.

Sehgal et al. [21] introduced a Modified Grasshopper Optimization technique based on Grasshopper Optimization Algorithm (GOA) and search technique for FS. The presented GOA was comparatively a heuristic optimization swarm intelligence technique that is inspired by grasshopper search for food. This population-based technique can offer solutions for real-time challenges in undetermined search space. It simulates grasshopper social interaction and swarming behaviour. Conventional techniques such as RF, DT, and KNN classifiers have been employed. Dissimilar data of handwriting (spiral and meander), voice, and speech are applied to evaluate the suggested algorithm.

Bahaddad et al. [22] designed a better sailfish optimization technique with DL (ISFO-DL) algorithm for the diagnosis and classification of PD. The study employs the DL model and ISFO algorithm to define PD and thus improves the survival rate. The proposed method is a metaheuristic approach that is stimulated by the group of hunting sailfish to define the optimal solution. Initially, ISFO approach is employed for deriving an optimum set of features with fitness function of maximal classifier performance. All together, the rat swarming optimizer (RSO) using BiGRU is applied as a classification for determining the presence of PD.

Gupta et al. [23] proposed an enhanced cuttlefish technique for FS based conventional cuttlefish approach that is utilized for diagnoses of PD at the earlier phase. PD was incurable and ultimately result in demise but medication tries to control symptoms and lengthen patient life to certain period. The study employs the conventional cuttlefish approach as a search technique to determine the optimum feature set. The KNN and DT classifiers as a conclusion on FS. The Parkinson speech with different kinds of sound recording and Parkinson Handwriting sample dataset is utilized for evaluating the presented technique.

Sharma et al. [24] introduced the Modified Grey Wolf Optimization (MGWO) technique that assists detection of symptoms of PD at earlier stages. PD is type of movement malady that is not cured at the right time could demonstrate to be fatal. Therefore, it becomes substantial to recognize PD at earlier stages hence appropriate medication could offer prolonged existence for the patient by controlling the symptom. In the study, a novel algorithm called MGWO was developed on the conventional GWO that acts as a search technique for FS. GWO is a metaheuristic approach that is stimulated by hunting down behaviors of wolves. Gupta et al. [25] introduced a new optimized and improved version of crow search algorithm (OCSA) to increase the diagnoses of PD. The presented study is utilized to predict PD with 100% accuracy and assist individuals to have relevant medication at earlier stages. The efficiency of OCSA was evaluated for twenty benchmark datasets and the outcomes are compared to the original chaotic crow search algorithm (CCSA).

4. Performance Evaluation

This section examines the PD detection results of various models available in the literature.

Table 1 and Fig. 2 provide the PD classification outcomes of different models on HandPD spiral dataset [21-24]. The experimental results specified that the MGOA-KNN and MGWO-KNN models have reached poor classification outcomes whereas the MGOA-DT and OCFA models have shown slightly enhanced classification results. Followed by, the MGWO-RF, and MGWO-DT models have reported moderately closer classification performance. Although the MFOA-RF model has reached reasonable performance with $accu_y$ of 92.91%, DR of 97.89%, and FAR of 21.87%, the IFSO-DL model has shown maximum results with $accu_y$ of 93.30%, DR of 98.20%, and FAR of 8%.

Table 1 PD classification analysis of different approaches under HandPD spiral dataset

HandPD spiral			
Methods	$Accu_y$	**DR**	**FAR**
MGOA-KNN	75.59	85.26	53.12
MGOA-RF	92.91	97.89	21.87
MGOA-DT	88.97	94.73	28.12
MGWO-KNN	73.40	81.90	50.00
MGWO-RF	92.40	94.00	11.90
MGWO-DT	92.40	94.00	11.90
IFSO-DL	93.30	98.20	8.00
OCFA	89.25	90.32	27.92

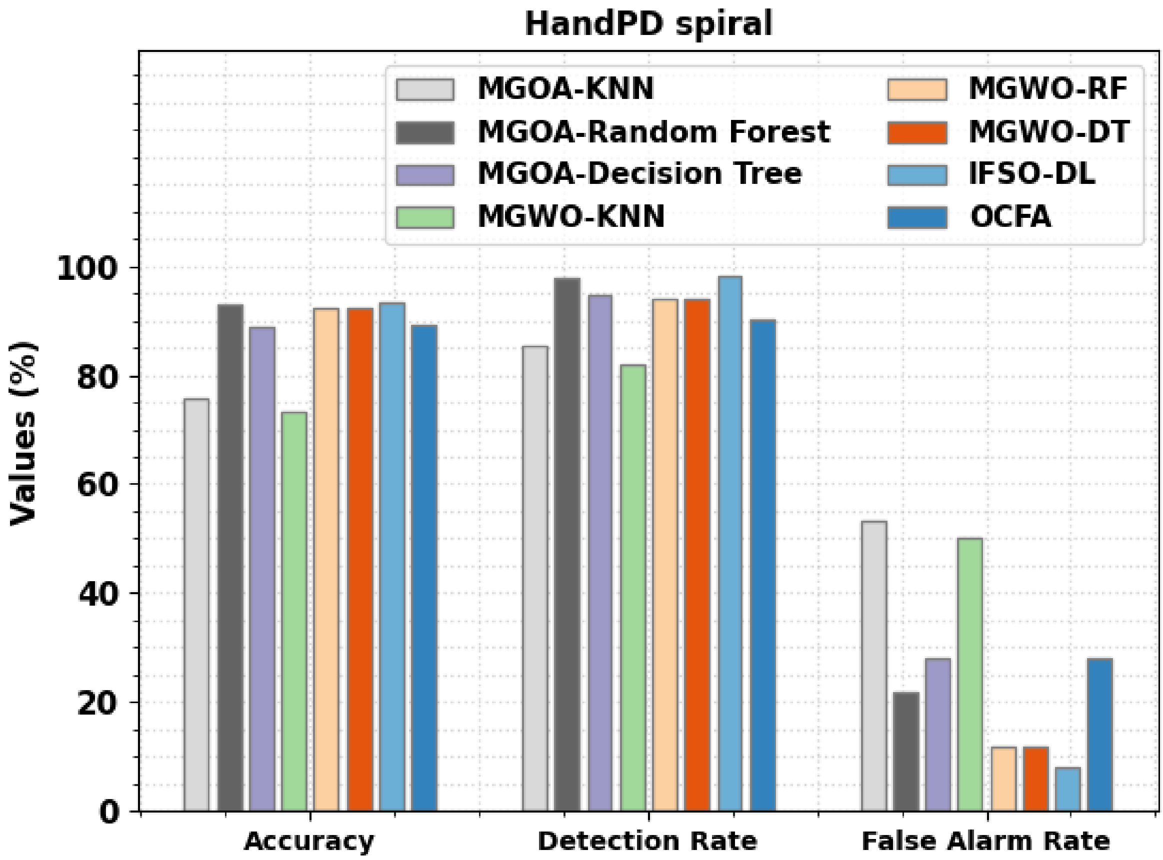

Fig. 2. PD classification analysis of different approaches under HandPD spiral dataset

Table 2 and Fig. 3 offer the PD classification result of distinct algorithms on HandPD meander dataset. The experimental outcomes that the MGOA-KNN and MGWO-KNN systems have attained worse classification outcomes whereas the MGOA-DT and OCFA models have demonstrated somewhat higher classification results. Afterward, the MGWO-RF and MGWO-DT approaches reported moderately closer classification performance. Eventually, the MFOA-RF system reached reasonable performance with $accu_y$ of 93.70%, DR of 100%, and FAR of 19.05%, the IFSO-DL algorithm has exhibited maximal results with $accu_y$ of 94%, DR of 100%, and FAR of 13.50%.

Table 2 PD classification analysis of different approaches under HandPD meander dataset

HandPD meander			
Methods	$Accu_y$	**DR**	**FAR**
MGOA-KNN	74.80	85.80	47.62
MGOA- RF	93.70	100.00	19.05
MGOA-DT	88.98	91.76	16.67
MGWO-KNN	72.80	85.80	60.00
MGWO-RF	93.00	99.10	22.20
MGWO-DT	88.00	92.00	22.20
IFSO-DL	94.00	100.00	13.50
OCFA	89.00	88.67	16.21

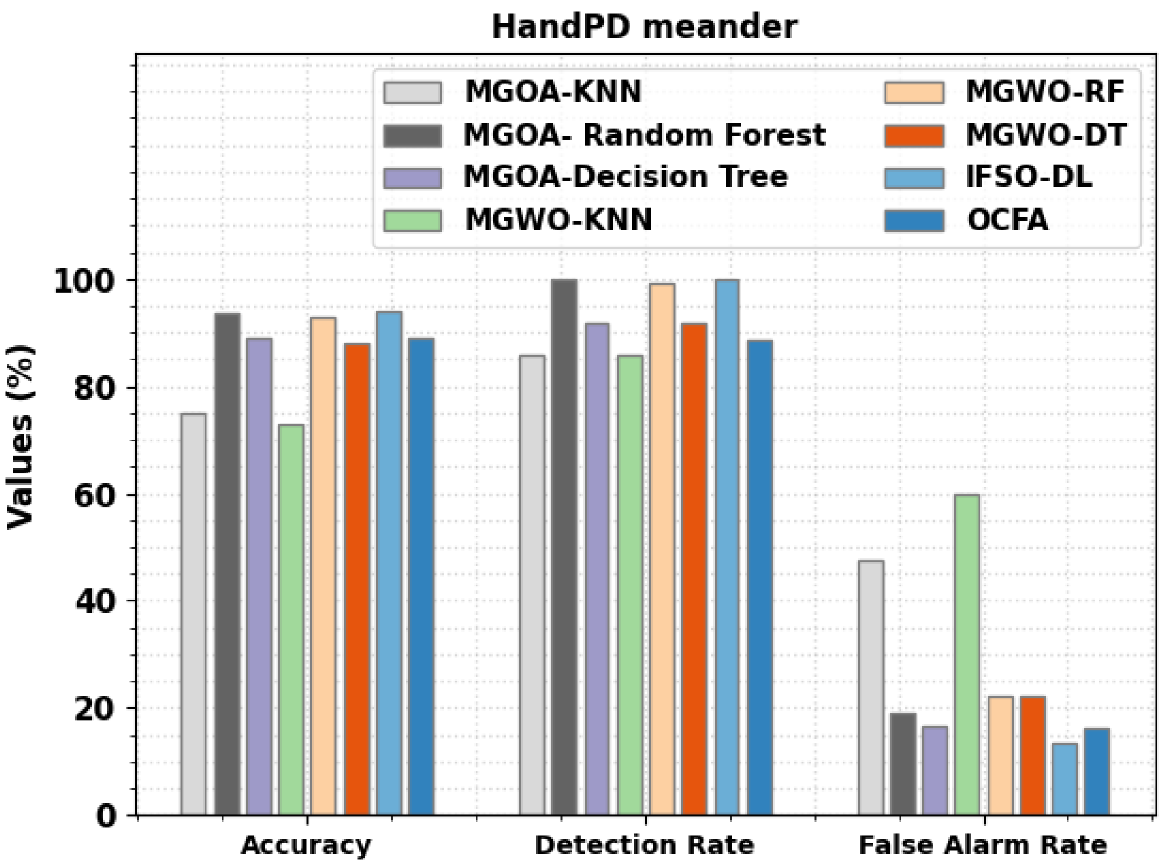

Fig. 3. PD classification analysis of different approaches under HandPD meander dataset

Table 3 and Fig. 4 define the PD classification outcome of different algorithms on Speech PD dataset. The experimental outcomes revealed the MGOA-KNN and MGWO-KNN models have achieved least classification results whereas the MGOA-DT and OCFA systems have shown somewhat enhanced classification results. Meanwhile, the MGWO-RF and mGWO-DT methodologies have reported moderately closer classification performance. Moreover, the MFOA-RF algorithm has reached reasonable performance with $accu_y$ of 94.87%, DR of 100%, and FAR of 22.22%, the IFSO-DL system has demonstrated higher outcomes with $accu_y$ of 95.30%, DR of 100%, and FAR of 18.50%.

Table 3 PD classification analysis of different approaches under Speech PD dataset

Speech PD			
Methods	$Accu_y$	**DR**	**FAR**
MGOA-KNN	89.74	96.67	30.00
MGOA-RF	94.87	100.00	22.22
MGOA-DT	84.61	90.00	30.00
MGWO-KNN	91.80	97.40	30.00
MGWO-RF	93.90	100.00	30.00
MGWO-DT	89.80	94.90	30.00
IFSO-DL	95.30	100.00	18.50
OCFA	87.00	87.33	29.68

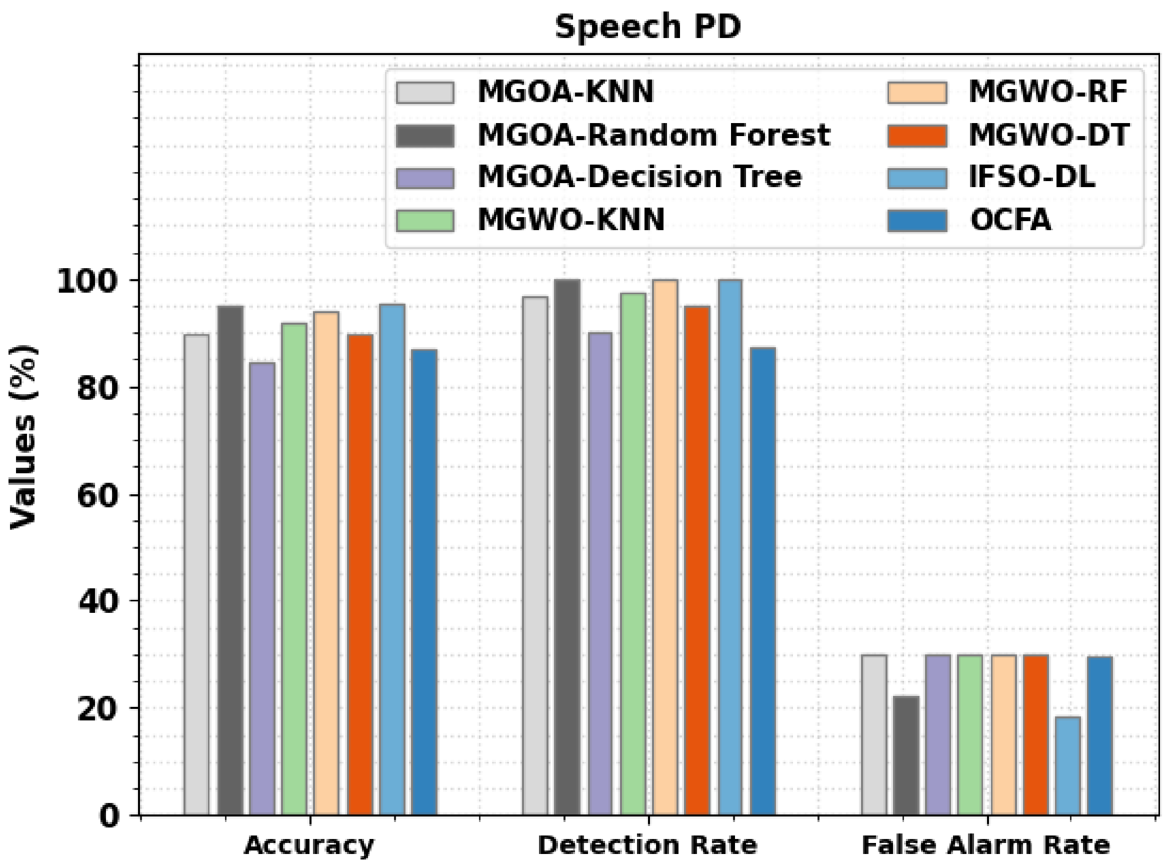

Fig. 4. PD classification analysis of different approaches under Speech PD dataset

Table 4 and Fig. 5 demonstrate the PD classification result of different approaches to Voice PD dataset. The experimental outcomespointed out that the MGOA-KNN and MGWO-KNN approaches have attained lesser classification outcomes whereas the MGOA-DT and MFOA-RF techniques have outperformed slightly superior classification results. Afterward, the MGWO-RF and mGWO-DT methodologies reported moderately closer classification performance. But, the OCFA method has reached reasonable performance with $accu_y$ of 94%, DR of 93.84%, and FAR of 0.87%, the IFSO-DL system has shown enhanced results with $accu_y$ of 100%, DR of 100%, and FAR of 0%.

Table 4 PD classification analysis of different approaches under Voice PD dataset

Voice PD			
Methods	$Accu_y$	**DR**	**FAR**
MGOA-KNN	91.82	83.51	0.91
MGOA-RF	100.00	100.00	0.00
MGOA-DT	100.00	100.00	0.00
MGWO-KNN	85.80	80.30	8.10
MGWO-RF	100.00	100.00	0.00
MGWO-DT	100.00	100.00	0.00
IFSO-DL	100.00	100.00	0.00
OCFA	94.00	93.84	0.87

Fig. 5. PD classification analysis of different approaches under Voice PD dataset

5. Conclusion

Existing works are mainly based on feature selection with ML based PD classification models. Since numerous works existed in the literature, this paper concentrated on a detailed performance validation of different PD classification models. The recently developed feature selection with data classification models using ML and DL for PD classification is examined. In addition, the performance analysis of different PD classification models is made using benchmark dataset and the results are inspected interms of different measures. A detailed comparative study is also made to notify the betterment of the reviewed models. In future, we plan to develop hybrid metaheuristic with DL based PD classification models for enhanced detection rate.

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