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COMPARATIVE ANALYSIS OF PARKINSON'S DISEASE DIAGNOSIS SYSTEM

ROHIT LAMBA[1], TARUN GULATI, AND ANURAG JAIN

ABSTRACT. Parkinson's disease is a neurodegenerative disorder. Its progress in human body is so slow that its symptoms appear over time so its early diagnosis is not an easy task. This disease is diagnosed by general neurologists and movement order specialists by physical examination and review of patient's medical history. Unfortunately developing countries like India have limited resources and diagnosis of Parkinson's disease is a very challenging task. Changes in speech can be used as a measurable indicator for early detection of this disease. This paper presents an insight into the different decision support systems for Parkinson disease diagnosis using speech signals.

1. INTRODUCTION

Parkinson's disease is the second most common neurodegenerative disorder after Alzheimer's disease. Around seven to ten million people in world are suffering from this disease as per the report of the World Health Organization (WHO). The main cause of Parkinson's disease is the lack of dopamine in substantia nigra. Dopamine is a brain chemical that work as a neurotransmitter produced by neurons [1]. When these neurons begin to damage or dies in substantia nigra, results in less production of dopamine which is the main cause of motor deficiency or the start of Parkinson in a person. The reason behind the

[1]*corresponding author*

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impairment of these neurons is still unknown [2]. Parkinson's disease cannot be cured but early diagnosis and appropriate treatment will improve symptoms.

2. Symptoms of Parkinson's Disease

Each patient has different symptoms of this disease and over time the symptoms are very mild and unnoticeable. The initial symptoms of parkinson's disease are motor and non-motor symptoms. Motor symptoms include radykinesia, rigidity, tremor and postural instability (loss of balance) and nonmotor symptoms include psychiatric symptoms, sleep sickness, sensory impairment, and dysautonomia (autonomic dysfunction) [3, 4]. Parkinson's patients normally suffer from change in handwriting, change in speech, tremor, slowed movement (bradykinesia), impaired posture and balance.

3. Parkinson's Disease Risk Factors

The most common risk factors of this disease are:

(i) **Age**
Parkinson's disease usually develops in older people around sixty, but it can develop before the age of fifty also [4].

(ii) **Gender**
Parkinson's disease can affect both women and men but men are having more chances to develop this disease. However, the ratio of Parkinson's disease patients between men and women is 3:2 [4, 5].

(iii) **Ethnicity and Race**
Ethnicity is also a risk factor in Parkinson disease. It has been observed, the Hispanic ethnic origin persons more suffered from Parkinson as compared to non-Hispanic Whites, blacks and Asians. Dark skin peoples have less risk of developing Parkinson as compared to white skin people.

(iv) **Family History and Genetics**
If a person's parents or siblings have Parkinson's disease, they may be almost twice as likely to develop Parkinson's disease.

(v) **Environmental Causes**
Several studies have also provided evidence that environmental factors such as exposure to pesticides, agricultural chemicals, working with

heavy metals, solvents, and detergents may be the cause of Parkinson's development.

(vi) **Head Trauma**
A person who has experienced a brain trauma injury is likely to develop Parkinson's disease.

4. Need of Decision Support System for Parkinson's disease diagnosis

Health is the first priority of every person in all countries around the world. But due to limited medical support and resources, decision support system (DSS) designed especially for disease diagnosis gaining momentum. Parkinson's disease is still non-curable and the life of the patient suffering from this disease is adversely affected. The best solution to deal with this disease is early diagnosis which is not easy. There is scope to create a clinical decision support system for the diagnosis of Parkinson's disease that will provide accurate and reliable results.

5. Comparative Analysis of Different Decision Support Systems for Parkinson's Disease Diagnosis

The various Parkinson's disease diagnosis systems using speech signals proposed by researchers are discussed in this section.

Sakar, C.O. et al. [6] proposed a model for classification of Parkinson's disease diagnosis in which feature extraction was done by Tunable Q-factor wavelet transform and minimum redundancy-maximum relevance (mRMR) method was used for feature selection. Different ensemble classifiers were used with voting and stacking.

Nissar, I et al. [7] proposed an ensemble machine learning approach for Parkinson's disease detection using voice-based signals. The author's main focus is to analyze the effect of MFCC and TQWT features for PD Detection. The mRMR and Recursive Feature Elimination (RFE) feature selection methods were used. Eight different classifiers are used for analyzing the results.

Tuncer, T. et al. [8] proposed a novel method for detection of Parkinson disease using vowels. The preprocessing of data was done by minimum average

maximum tree and by relief-based feature selection method 50 most discriminative features were extracted and fed into eight different classifiers for classification of Parkinson disease.

Gunduz, H. et al. [9] proposed two frameworks to classify Parkinson's disease using speech signals based upon Convolutional Neural Networks (CNN). UCI Parkinson's disease Classification Data Set was used in this study. Leave One Out Validation method was used in this paper and results show the second framework outperforms with 86.9% accuracy.

Polat, K et al. [10] present a novel hybrid approach for early detection of Parkinson's disease using speech signals. UCI Data Set was first preprocessed by using the Synthetic Minority Over-Sampling Technique. The classification was done by random forest classifier and the accuracy achieved by the proposed hybrid method was 94.89%.

Olivares, R.et al. [11] proposed an optimized BAT Algorithm for diagnosis of Parkinson's disease intending to increase the accuracy and reduces the loss. The data was split into an 80%-20% ratio for training and validation. The result shows that the proposed algorithm achieved 96.74% accuracy with 3.27% minimum loss.

Solana-Lavalle, G. et al. [12] proposed a pre-diagnosis tool for early diagnosis of Parkinson's disease by using fewer vocal features to increase classification accuracy. According to the author, this is the first time Eight to twenty features have been selected by wrapper features subset selection method with kNN, MLP, SVM, and RF classifiers.

Yaman, O et al. [13] proposed a statistical pooling method for the detection of Parkinson's disease with the help of vowels. RelifF method was used for selecting the top-weighted features. For classification SVM and kNN algorithms were used and obtained 91.25% and 91.23% accuracy receptively.

Lahmiri, S et al. [14] consider voice disorder patterns for the diagnosis of Parkinson's patients. 8 different pattern ranking techniques for feature selection and a nonlinear SVM classifier were used to distinguish between healthy and Parkinson's disease patients.

Xiong, Y. et al. [15] presented Parkinson's disease classification method using deep feature extraction technique from speech data. The feature selection was done by Adaptive Grey Wolf Optimization Algorithm. The classification was

done by using eight different supervised classifiers LR, SVM, RF, NB, GBM, LDA and decision tree.

Almeida, J.S. et al. [16] presented a Parkinson disease detection method using speech signal. Two channels acoustic cardioid and Smartphone were used to record audio signals. By using different features extraction techniques, 144 features were extracted and categorized into 18 feature subsets and then classification was done by four classifiers kNN, MLP, OPF and SVM.

Gupta, D. et al. [17] proposed a system for diagnosis of Parkinson disease patients intending to increase the accuracy by selecting fewer features. An optimized cuttlefish algorithm was used for the selection of features and kNN and decision tree classifiers were used for classification.

6. Issues and Challenges for Parkinson's Disease Diagnosis

Many tests are required for diagnosis of Parkinson patients in medical domain. Based on medical history, symptoms, and physical examination, a primary care physician may examine patients. Then diagnosis by a neurologist requires imaging tests such as MRI, SPECT and PET scans. Creating a Parkinson's disease diagnosis model is not an easy task. The researcher must have knowledge of machine learning algorithms as well as a basic understanding of Parkinson's disease such as symptoms and risk factors. Major issues and challenge faced by researchers for Parkinson disease diagnosis is discussed in this section:

(i) **Imbalance Dataset**
Many researchers have faced class imbalance problem. If in the dataset, the records belong to person having disease is more or less than the records of healthy persons then there is a mismatch between two classes. The machine learning model trained by imbalance dataset will not perform well.

(ii) **Feature Selection**
It is a process of selecting important and relevant features either by manually or automatically. Almost all researchers have used different feature selection method to create reduced feature subset which increases the performance and reducing complexity.

(iii) **Scaling**
Attributes in the dataset may have continuous and discrete values that

should be converted into same scale. Different scaling methods may be used to bring all the attribute value to same scale for performance enhancement.

(iv) **Similar Symptoms**
Other neurological disorders also have similar symptoms to Parkinson's disease. It is therefore not easy to identify whether a particular symptom is of Parkinson's disease or any other disease.

(v) **Risk Factor Identification**
Several risk factors have been observed by many researchers, identifying risk factors related to Parkinson's disease is a challenging task.

(vi) **Validation Method**
Different validation methods have been used by the researcher such as k-Fold Cross validation, Leave one person out validation method and train and test split method. Selection of validation method depends upon the type of data used.

(vii) **Performance Matrices**
Researcher have used different performance measures such as Accuracy, Sensitivity, specificity, F-1 Score, Area under the curve and some have used only accuracy and loss. So selection of performance measure is also challenging.

7. Conclusion and Future Scope

Parkinson's disease is non-curable, so if detected in its early stages, its effects in humans can be controlled. The proper medication, balanced diet and exercise can lower effect of Parkinson. This study is focused on the early diagnosis of Parkinson's disease by speech signals. There is no universal feature selection method and classifier for the medical dataset. For finding the best results one has to try different methods. Various researchers have shown different decision support system for Parkinson disease diagnosis, still there is a scope of improving the accuracy in it. Basis on the findings obtained from the work done by researchers, a decision support system will be proposed by the authors in near future.

REFERENCES

[1] B. E. RILEY, S. J. GARDAI, D. EMIG-AGIUS, M. BESSARABOVA, A. E. IVLIEV, B. SCHULE, J. ALEXANDER, W. WALLACE, G. M. HALLIDAY, J. W. LANGSTON, , S. BRAXTON: *Systems-based analyses of brain regions functionally impacted in Parkinson's disease reveals underlying causal mechanisms. PLoS One*, **9**(8) (2014), 33–44.

[2] F. N. EMAMZADEH, A. SURGUCHOV: *Parkinson's disease: biomarkers, treatment, and risk factors*, Frontiers in neuroscience, **12** (2014) 612–620.

[3] R. F. PFEIFFER: *Non-motor symptoms in Parkinson's disease*, Parkinsonism and related disorders, **22** (2016), 119–122.

[4] T. A. ZESIEWICZ, Y. BEZCHLIBNYK, N. DOHSE, S. D. GHANEKAR: *Management of Early Parkinson Disease*, Clinics in geriatric medicine, 2019.

[5] P. C. LEAL, L. S. LINS, A. M. DE GOIS, M. MARCHIORO, J. R. SANTOS: *Commentary: evaluation of models of Parkinson's disease*, Frontiers in neuroscience, **10** (2016), 283.

[6] C. O. SAKAR, G. SERBES, A. GUNDUZ, H. C. TUNC, H. NIZAM, B. E. SAKAR, M. TUTUNCU, T. AYDIN, M. E. ISENKUL, H. APAYDIN: *A comparative analysis of speech signal processing algorithms for Parkinson's disease classification and the use of the tunable Q-factor wavelet transform*, Applied Soft Computing, **74** (2019), 255–263.

[7] I. NISSAR, D. RIZVI, S. MASOOD, A. MIR: *Voice-Based Detection of Parkinson's Disease through Ensemble Machine Learning Approach: A Performance Study*, EAI Endorsed Transactions on Pervasive Health and Technology, **5**(19) (2019), 111–123.

[8] T. TUNCER, S. DOGAN, U. R. ACHARYA: *Automated detection of Parkinson's disease using minimum average maximum tree and singular value decomposition method with vowels*, Biocybernetics and Biomedical Engineering, **40**(1) (2020), 211–220.

[9] H. GUNDUZ: *Deep Learning-Based Parkinson's Disease Classification Using Vocal Feature Sets*, IEEE Access, **7** (2019), 115540–115551.

[10] K. POLAT: *A Hybrid Approach to Parkinson Disease Classification Using Speech Signal: The Combination of SMOTE and Random Forests*, 2019 Scientific Meeting on Electrical-Electronics and Biomedical Engineering and Computer Science (EBBT) (2019), 1–3.

[11] R. OLIVARES, R. MUNOZ, R. SOTO, B. CRAWFORD, D. CARDENAS, A. PONCE, C. TARAMASCO: *An Optimized Brain-Based Algorithm for Classifying Parkinson's disease*, Applied Sciences, **10**(5) (2020), 1827.

[12] G. SOLANA-LAVALLE, J. C. GALAN-HERNANDEZ, R. ROSAS-ROMERO: *Automatic Parkinson disease detection at early stages as a pre-diagnosis tool by using classifiers and a small set of vocal features*, Biocybernetics and Biomedical Engineering, **40**(1) (2020), 505–516.

[13] O. YAMAN, F. ERTAM, T. TUNCER: *Automated Parkinson's disease recognition based on statistical pooling method using acoustic features*, Medical Hypotheses, **135** (2020), 109483.

[14] S. LAHMIRI, A. SHMUEL: *Detection of Parkinson's disease based on voice patterns ranking and optimized support vector machine*, Biomedical Signal Processing and Control, **49** (2019), 427–433.

[15] Y. XIONG, Y. LU: *Deep Feature Extraction From the Vocal Vectors Using Sparse Autoencoders for Parkinson's Classification*, IEEE Access, **8** (2020), 27821–27830.

[16] J. S. ALMEIDA, P. P. REBOUCAS FILHO, T. CARNEIRO, W. WEI, R. DAMASEVICIUS, R. MASKELIUNAS, V. H. C. DE ALBUQUERQUE: *Detecting Parkinson's disease with sustained phonation and speech signals using machine learning techniques*, Pattern Recognition Letters, **125** (2019), 55–62.

[17] D. GUPTA, A. JULKA, S. JAIN, T. AGGARWAL, A. KHANNA, N. ARUNKUMAR, V. H. C. DE ALBUQUERQUE: *Optimized cuttlefish algorithm for diagnosis of Parkinson's disease*, Cognitive systems research, **52** (1028), 36–48.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
MAHARISHI MARKANDESHWAR (DEEMED TO BE UNIVERSITY)
MULLANA, AMBALA, HARYANA, INDIA
E-mail address: rohitlamba14@mmumullana.org

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
MAHARISHI MARKANDESHWAR (DEEMED TO BE UNIVERSITY)
MULLANA, AMBALA, HARYANA, INDIA

VIRTUALIZATION DEPARTMENT, SCHOOL OF COMPUTER SCIENCE
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
DEHRADUN, INDIA