Different Classification Approaches for Early Detection of Parkinson's Disease

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Abstract

Parkinson's disease is perhaps the most well-known neurodegenerative disorder that mainly occurs due to the loss of dopamine-producing neurons and consists of motor/non-motor symptoms. The progression of the symptoms is often varying from one person to another to the diversity of the disease. The condition causes a huge burden both on those affected, as well as their families. Accurate diagnosis is critical and challenging but still, no specific diagnostic process is available. The computer-aided diagnosis techniques of signalling and imaging processing are very helpful in the prediction and classification of PD. This review gives a brief description of different methods of classification for early detection and also highlights the most profitable research directions by focusing on continuous monitoring patterns of daily activities, interactions, and routine that may provide the data on status changes, clinical management, and controlling self-correction.

Keywords: Parkinson's disease, Signalling & Imaging processing, Computer aided techniques

1 Introduction

Parkinson's disease is a chronical progressive neurodegenerative disease, impacting an estimated ten million people worldwide. After Alzheimer's disease, PD is the second most neurological problem [1] and mainly occurs due to prominent loss of substantia nigra's dopamine neurons (part of the basal ganglia in the brain) showed the presence of abnormal accumulation of alpha-synuclein (aSyn) (an intercellular protein) [2]. The lost dopamine neurons create the problem of movement actions controlling the body. Basically, PD has two types of symptoms: Motor symptoms (bradykinesia, shaking, rigidity, and postural instability problems) and Non-motor symptoms (autonomic, sensory, sleep, and neuropsychiatric types dysfunctions) [3].

There is no precise cause found but many researchers think that genetic, environmental, and some other factors play a crucial role in PD [4]. Sometimes manifestations of PD do not appear abruptly that starts with mild and progress slowly. Basically, there are 5 stages of PD which can be measured using Hoehn and Yahr (HY) scale [5].

- **Stage 1:** Postural, walking and facial expressions all changed.
- **Stage 2:** Walking problems and bad postures may be noticeable.
- **Stage 3:** Loss of balance and slow movement. Falling is more common.
- **Stage 4:** The patient couldn't live alone
- **Stage 5:** Hallucinations and delusions may occur.

HY scale rating is based on present observations of PD. So, another measuring way of PD is Movement Disorder Society-Unified Parkinson's Disease Rating Scale. This MDS-UPDRS rating scale provides the modified version of Unified PD Rating Scale (UPDRS) scores and also a complete analysis of PD manifests. It divided into four sub-scales with having sixty-five times [6], each one has ranged from 0–4. 0 shows normal and 4 means severity.

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PD can't be relieved however treatment gives symptomatic benefit still no treatment has been proved to slow disease progression [7] but medications can help control in manifestations. The role of chemical messengers is played by common drugs (such as Levodopa, dopamine agonists, etc.). Medicines typically increase the quality of the life of the patient, but it relies on the condition of patients and in critical cases, it often does not work. As the prevention of PD is not possible due to unknown reason of cause but early diagnosis can slow down the progression of disease [8]. There are a lot of ways to diagnose PD by using computer aided based techniques that assist the doctors and also provided remote monitoring.

This systematic review offers a comparative overview for the collection of work carried out within the framework of various classification techniques and effective searches in IEEEXplore, PubMed, Elsevier's sciencedirect.com, Springer, MPDI, ACM, Nature, Hindawi, and other major publications. The following steps followed for the systematic review paper: Section 2 demonstrates the analysis approach, Section 3 covers the various methods of classification using signalling and imaging computer-aided techniques that affect the quality of life. Finally, in conclusion, the overall review analysis has been addressed in section 4.

2 Review Methodology

We have divided our study into six subcategories based on the motor/non-motor symptoms, nature, and data source, the most researched by researchers. These distinct subcategories of classification include two categories: 1. Signalling processing (voice-based, wearable-based, non-wearable-based, handwriting-based, EEG-based) and 2. Imaging processing. Various keywords were searched to classify papers based on each symptom, such as Parkinson's disease + speech, Parkinson's disease + machine learning, Parkinson's disease + tremor, Parkinson's disease + accelerometer, Parkinson's disease + neuroimaging, Parkinson's disease + (SPECT, MRI etc.) and many others in Google Scholar.

2.1 Classification Methods

2.1.1 Voice based

One of the main issues that arise in Parkinson's patients is speech disturbance (dysphonia). About 70 percent-90 percent of individuals are known as having PD dysphonia. In general, PD patients have a low-volume voice with an expression-less consistency [9]. Due to a shift of accent, an unexpected blast, long stops, and a lot more problems, it is difficult to understand. In the early diagnosis of PD, several deep learning and machine learning classification techniques based on voice patterns will support [8]. It also offers a minimal-cost, non-invasive diagnostic solution, as it is easy to gather information using a microphone (headset-based/smartphone-based). As a consequence, a great deal of work based on voice designs has been performed. For analysts, various databases are available to work on. Some of them are public, some of them are personal.

2.1.2 Handwriting

The other problem in PD is, for example, little, crowded handwriting, smaller handwriting phase with time, handwriting abnormality usually referred to as Micrographia. Handwriting is also warped because of hand tremors [10]. So, from handwriting models, tremors can also be measured. Handwriting Exam (HE)-dependent diagnosis is one of the quick and non-invasive ways in which PD patients are detected early [11]. Spiral Archimedes, meanders, and alphabets are the most commonly known handwriting templates. Informational data may also be taken from the smart-pen in the form of signals. In the study of signals for classification purposes based on handwriting models, there is still a lot of promise. As compared to conventional classification models, the fine-tuned models perform better. In order to enhance the accuracy of the classification of PD, deep learning models have also been explored to extract distinctive features.

2.1.3 Wearable devices

In general, PD patients experience multiple motor symptoms such as tremors, bradykinesia, dyskinesia, stooped posture, imbalanced gait, fear of falling, rigidity, etc. [12]. With the aid of the HY Scale and UPDRS scale, physicians\clinicians subjectively calculate these manifestations. The HY scale performs PD patient staging, while the UPDRS scale offers scores of suitable features. But both these scales are based on observations and questionnaire-based, which suffers from the problem of inter-rater inconsistency and lack of correlation between patient and observer. With the aid of certain wearable instruments, these problems can be reliably estimated and related to various sensors such as the Accelerometer (Accl), Gyroscope (Gyro), Magnetometer (Mag), Goniometer Telemeters, and several more [8]. When compared to an arbitrary clinical-based measurement with UPDRS scores, the estimation depending on these sensors is more precise. This system may also provide PD patients with remote tracking data that can support specialists in delivering customized care.

2.1.4 Non-wearable devices

In the past, mainly 3D depth infrared cameras were used for video exams, force plates were used for gait and freezing investigation, but these instruments were massive, invasive and costly. By the growth, wearable devices emerged that were lightweight, minimal effort, and easy to work with. There was a downside to the intrusive design of these items, regardless of the various points of interest presented by wearable devices. Minimum commitment by non-wearable devices offers great solutions to classify PD patients with little or no invasion to solve this issue. Kinect Sensors, smartphones, video cameras, leap motion controller, and others are part of these systems. Without any additional burden, video records observe motor gestures such as FT, PSH, HM, and cameras catch facial expressions such as blank expressions with less smiling and blinking [13]. These instruments can aid patients with PD develop their physical and psychological skills. With the support of these non-invasive, non-wearable devices, remote control is also possible. It may also be found that the most common activity for considering the signs of FoG and bradykinesia is the TUG test [14].

2.1.5 EEG based

Cognitive impairments also cause PD patients to suffer. These cognitive impairments will give a lot of evidence on how the condition progresses, what patient medications entail. EEG signals may be used to identify PD patients from HC as an important biomarker [15]. Compared to HC, it has been shown that PD patients exhibit distinctive EEG samples. By studying REM (Rapid Eye Movement) Behaviour Disorder (RBD) and IH patients, this can be achieved. Data is often obtained for a period ranging from 5 min to 30 min in the resting state. In order to find the optimal number of channels for the detection of PD [8], work should be performed on channel optimization. While limited studies on EEG have been discovered, most of the extraction of the feature is done with FFT. To further improve the performance of the system, other feature extraction methods should be explored.

2.1.6 Neuroimaging based

Investigation of brain imaging in patients with Parkinsonism has the potential to increase the precision of differential diagnosis [16]. Demographic results, MRI, f-MRI, SPECT, DATSCAN, PET, LFP images, UPDRS scale, HY scale, Mini-Mental State Check, ESS (sleep ratings), UPSIT (olfactory scores) and many more are clinical tests of Parkinson's disease. Different forms of photographs may be used as biomarkers to recognise visual impairments in Parkinson's patients, such as MRI, f-MRI, SPECT [16]. The role of neuroimaging in PD [2].

- The application of neuroimaging to improve diagnostic accuracy, timeliness, and reliability.

- Objective control of disease progression.
- Evaluation of "disease-modifying" drugs intended to slow disease development by interfering with the reasoning processes involved in chronic neuronal failure or replacing cells containing dopamine.
- Planning and assessment of deep brain stimulation methods for surgical candidates.

Medical tests callaborate with multiple scales can act as a way of forecasting UPDRS ratings, tracking patients with PD remotely, and detecting the magnitude of MS/NMS. This involves multivariate and multimodal knowledge that can further slowdown development. The PPMI (Parkinson Progression Markers Initiative) database acts as a reference database providing multivariate data that can be used to classify the association between symptoms for robust PD classification.

3 Conclusion

The neurological condition is Parkinson's disease. Patients, therefore, suffer from numerous MS/NMS effects. Scientific approaches for measuring Parkinson's disease signs, i.e. the scale of UPDRS and the scale of HY, are arbitrary in nature and suffer from the issue of inter-rater inconsistencies. Computer-based diagnostic system is, thus, important for PD detection and prediction. In addition, there is no treatment for this condition and the new research relies on the analysis of signals and imaging based on computer-aided techniques. By splitting the study into 6 separate sub-categories depending on the symptom, form, and data source, a comparative analysis was performed. This paper gives a summary of the strategies of PD classification which also needs a lot of early studies.

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