Chapter 1
Bio-Inspired Algorithms: Devices for Diagnosis and Treatment of Parkinson's Disease

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ABSTRACT

Parkinson's disease (PD) is a common neurodegenerative disorder with a high prevalence rate in the geriatric population, and more than 10 million people are afflicted with this disease worldwide. Striatal dopamine deficiency and intracellular inclusions containing aggregates of alpha-synuclein are the neuropathological signs caused by neuronal loss in the substantia nigra. PD causes motor and nonmotor symptoms. A diagnostic test or medical tool that is reliable for Parkinson's disease is not yet available. Thus, the diagnosis of PD is primarily based on clinical symptoms. Optimized bio-inspired algorithms are the novel and heuristic approach for diagnosis and treatment of Parkinson's disease. In this chapter, various bio-inspired algorithms are discussed such as optimized cuttlefish algorithm, optimized grasshopper algorithm, wolf search algorithm, crow search algorithm, and ant-lion algorithm. Other useful approaches include bionics institute rigidity device, sawtooth waveform-inspired pitch estimator (SWIPE), brain stimulation therapies, and bioinspired nanomedicine.

INTRODUCTION

Parkinson's disease is a common neurodegenerative disorder with prevalence to 4% of the population over 80 and with 160/100000 in western europe (davie, 2008). The driving sources of disability around the world are neurological disorders and the predominance of Parkinson's disease is expanding more

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quickly than other neurological disorders (armstrong & okun, 2020). Parkinson's disease is associated with a loss of cells in the substantia nigra and James Parkinson was the first person to describe the cognitive syndrome- parkinson's disease in *an essay on the shaking palsy* in 1817 (jankovic, 2008). Carlsson and colleagues discovered dopamine as a putative neurotransmitter at lund, sweden in 1957 (jankovic, 2008). Deficiency of dopamine in the striatum (as a result of degeneration of dopaminergic neurons in the substantia nigra) and intracellular inclusions containing aggregates of alpha-synuclein called lewy bodies are the common neuropathological sign of pd (poewe, et al., 2017). The loss of dopaminergic terminals in the basal ganglia, is crucial for onset of motor symptoms (simon, tanner, & brundin, 2020).

Parkinson's disease manifests itself as a combination of motor as well as non-motor symptoms. Motor symptoms comprise of physical features such as tremors, ataxia, slowness, stiffness in limb movements and postural imbalance (dauer & przedborski, 2003). The non-motor symptoms are heterogeneous in nature, impacting several organ systems, such as gastrointestinal and genitourinary systems (armstrong & okun, 2020). Constipation, hyposmia, orthostatic hypotension and urogenital dysfunction are some of the non-motor symptoms which are the significant part of parkinson disease. Bradykinesia, hypokinesia, and akinesia are variety of symptoms including decreased voice volume, normal facial expression paucity, and drooling, decreased stride length during walking and decreased size and speed of handwriting (dauer & przedborski, 2003). Epidemiologic studies suggest that constipation is associated with an increased risk of parkinson disease and this often appears years prior to the appearance of significant motor symptoms (hopfner, et al., 2017). There are many disorders that can have at least some of these clinical symptoms and this clinical syndrome is known as *parkinsonism*. The disorders in which parkinsonism is a prominent part are called as *parkinsonian disorders* and the examples are parkinson's disease, progressive supranuclear palsy, multiple system atrophy, corticobasal degeneration and vascular parkinsonism (williams & litvan, 2013) (dickson, 2012).

There are two forms of parkinson disease, i.e., familial, which is hereditary in origin, and sporadic (idiopathic), which develops from gene-environment interactions. Familial form accounts for 10–15% of reported pd cases whereas, remaining 85-90% cases are sporadic ones. There are seven genes which have been identified for familial pd. These are; alpha-synuclein (snca), glucocerebrosidase (gba), parkin rbr e3 ubiquitin protein ligase (park2), leucine-rich repeat kinase 2 (lrrk2), parkinson protein 7 (park7), vacuolar protein sorting-associated protein 35 (vps35), phosphatase and tensing homolog-induced kinase 1 (pink1), these genes have been used to research for possible early detection methods for pd along with their specific metabolites and pd-associated biomarkers. Early diagnosis of pd is very crucial as almost 70% of neuronal death has occurred by the time actual symptoms of the disease are manifested. The genotypes of humans are unique and therefore, individuals exposed to same environmental factors are also affected varyingly, leading to diverse phenotypes of the disease. The combined impact of genetic and environmental factors leads to structural alterations in dna, which may affect the occurrence of human disease. Pesticides and heavy metals are known to increase pd by altering genes linked to familial pd (park1, lrrk2, pink1) causing oxidative stress, mitochondrial dysfunction and deterioration in protein degradation (ball et al., 2019). Drug induced parkinsonism is also a common etiology in many elderly patients. Nearly 40% of patients on drug therapy with conventional antipsychotics like chlorpromazine or haloperidol exhibit extrapyramidal side effects which include parkinsonism-like symptoms due to dopaminergic blockade in the nigrostriatal region (shin & chung, 2012).

The study of the bionic functions, biological structures, and organizational principles found in nature with modern technologies has led to the development of numerous mathematical and metaheuristic algorithms based upon the knowledge transferring process from life form to human technologies. Output of

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