Chapter 3
Current Neuroinnovative Techniques With Machine Learning Algorithms in the Diagnosis and Classification of Neurodegenerative Diseases

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ABSTRACT

Neurodegenerative diseases are one of the most debilitating diseases associated with progressive neuronal dysfunction and protein accumulation. The increasing prevalence of Alzheimer's disease (AD), Parkinson's disease (PD), and amyotrophic lateral sclerosis (ALS) in population is leading to the development of neuroinnovative techniques for early recognition, classification and treatment. Various computer-aided software programs based on machine learning (ML) studies have been developed in recent decades in medical scope. ML is a branch of artificial intelligence that recognizes and models different data sets and algorithms. Different disciplines such as neural networks, support vector machines, Decision Trees, Random Forests, logistic regression, k-Nearest Neighbor techniques such as multi-layer perceptron, Neural Networks, Gaussian Mixture Models, and Boosting methods have been introduced

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in neurology. This section will discuss neuropathological and neuroradiological evaluation of AD, PD, and ALS, and ML-based modeling algorithms used in diagnosing and classification so far.

INTRODUCTION

Artificial intelligence (AI) is a branch of science based on computer-based activations in different scientific fields, and it has become widespread, especially in the last decade. AI has revolutionized the early diagnosis, classification, and treatment of diseases by creating various algorithms within the framework of acquired learning instructions (Oliver et al., 2021). Machine learning (ML) is a subdiscipline of AI and identifies different data sets by learning and checking them with acquired learning methods (Mosavi et al., 2019). In this respect, the most frequently used algorithms so far are neural networks, support vector machines (SVM), decision trees (DT), random forest (RF), logistic regression, and many more. Also, some others are subsections of the neural network, such as Goodfellow's generative adversarial network (GAN) (Goodfellow et al., 2020). Neurodegenerative diseases (NDDs) are characterized by pathological protein aggregation in the central and/or peripheral nervous system that causes synaptic and neuronal network dysfunction, abnormal proteostasis, cytoskeletal abnormalities, altered energy metabolism, DNA and RNA defects, neuronal cell death, and damage the structure of neural networks. The most common neurodegenerative diseases in society include Alzheimer's disease (AD), Parkinson's disease (PD), and amyotrophic lateral sclerosis (ALS). ML is involved in groundbreaking innovations in neurology, as in many medical disciplines, especially in computer-aided identification, monitoring, and management of symptoms associated with neurodegenerative movement disorders.

AD is one of the most common neurodegenerative diseases in society, and its main etiopathogenesis is the abnormal accumulation of amyloid-beta (Aβ) and tau in intra/extra neuronal structures, which are amyloid precursors. Extracellular Aβ plaques and hyper-phosphorylated tau forms intracellular NFT, which cause synaptic degeneration, and neuronal death follow, driving a neurodegenerative progression through various brain regions (Blennow et al., 2006; Wakhloo et al., 2022). ML is used to detect disease progression and differential diagnosis, for which various ML algorithms such as support vector machines (SVM), decision trees (DT), and ensemble models have been used so far (Dara et al., 2023).

PD is characterized by the pathogenic accumulation of alpha-synuclein, resulting in the loss of dopaminergic neurons in the substantia nigra pars compacta (Raina et al., 2020; Psol et al., 2021; Garg et al., 2022). It is known that progressive neuronal loss occurs long before clinical findings (Mahajani et al., 2021; Raina et al., 2021),

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