Chapter 10
Exploiting Image Processing and AI for Neurological Disorder Diagnosis:
A Focus on Alzheimer's and Parkinson's Diseases

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ABSTRACT

The diagnosis and management of neurological disorders, particularly Alzheimer's and Parkinson's diseases, rely heavily on advanced medical imaging techniques. Neuroimaging modalities such as magnetic resonance imaging (MRI), positron emission tomography (PET), and single-photon emission computed tomography (SPECT) play a critical role in revealing structural and functional changes in the brain associated with these diseases. This review explores how image processing techniques and artificial intelligence (AI), including machine learning and deep learning, are revolutionising the diagnosis of Alzheimer's and Parkinson's. By leveraging these technologies, significant improvements in early detection, disease progression tracking, and personalised treatment strategies have been achieved. This paper aims to provide a comprehensive overview of current AI-driven approaches, their applications in neuroimaging, and their potential to advance the understanding and treatment of these neurological disorders.

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1. OVERVIEW OF NEUROLOGICAL DISORDERS

Brain sickness refers to any condition that affects the structure, function, or chemistry of the brain, leading to disruption of normal activities. The brain is a complex organ that regulates almost all bodily activities, including cognition, memory, emotion, motor skills, and sensory perception. Brain dysfunction may profoundly affect both physical and mental health. Neurological illnesses can be categorized based on their genesis and effects. The remainder of this paper is organized as outlined below.

a. Neurodegenerative Disorders
b. Cerebrovascular Disorders
c. Central Nervous System Infections and Inflammation
d. Traumatic Brain Injuries (TBI)
e. Neoplasms of the Brain
f. Epilepsy and Seizure Disorders
g. Psychological Disorders
h. Neurodevelopmental Disorders
i. Autoimmune Neurological Disorders
j. Metabolic Neurological Disorders
k. Degenerative Motor Neuron Disorders

Diverse neurological disorders may exhibit unique symptoms that render early diagnosis and intervention essential for symptom management and disease progression. This discourse pertains only to neurodegenerative disorders, specifically Alzheimer’s and Parkinson's diseases.

2. OVERVIEW OF ALZHEIMER'S AND PARKINSON'S DISEASES

Alzheimer's and Parkinson's diseases are prevalent neurodegenerative disorders that mostly affect the elderly; however, they differ in their symptoms, progression, and underlying mechanisms.

Alzheimer's disease (AD) is characterized by progressive decline in cognitive function and memory deficits. It is the primary cause of dementia and affects millions of people worldwide. In Alzheimer's disease, aberrant protein accumulation, such as beta-amyloid plaques and tau tangles, impairs neuronal transmission and ultimately results in cell death. Preliminary symptoms frequently encompass memory impairments and challenges with routine activities that progressively deteriorate. As the disease advances, patients may encounter confusion, alterations in personality, and challenges in language and decision-making.

Parkinson's disease (PD) mostly affects motor functions. The disease results from the gradual deterioration of dopamine-producing neurons in the brain, especially in the substantia nigra. Dopamine is essential for fluid coordination and balanced muscular actions. As dopamine levels diminish, individuals with Parkinson's disease have tremors, stiffness, bradykinesia, and postural instability. Non-motor symptoms, including cognitive impairment, sadness, and sleep difficulties, may also manifest. The precise etiology of neuronal death in Parkinson's remains unclear. Nonetheless, genetic and environmental variables are anticipated to significantly influence the outcomes.