Chapter 5

Neural Network: Transforming the Diagnosis and Treatment of Neurological Diseases

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ABSTRACT

The accelerating global prevalence of neurological diseases such as Alzheimer's, Parkinson's, epilepsy, stroke, and multiple sclerosis has created an urgent demand for advanced technologies that can improve diagnostic precision, treatment personalization, and long-term patient outcomes. This chapter explores the transformative role of neural networks—computational systems inspired by the structure and function of the human brain—in revolutionizing the diagnosis, treatment, and management of neurological disorders. Beginning with foundational principles in deep learning, including key architectures like convolutional neural networks, recurrent neural networks, and long short-term memory networks, the chapter outlines how these models process complex, high-dimensional neurological data. Practical applications are examined across neuroimaging analysis, signal interpretation, and brain-computer interface systems, showcasing their ability to detect early disease markers, predict therapeutic responses, and support neurorehabilitation.

1. INTRODUCTION

Neurological diseases represent one of the most pressing health challenges of the 21st century, with their global burden increasing at an alarming and unprecedented

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rate. Disorders such as Alzheimer's disease, Parkinson's disease, epilepsy, stroke, and multiple sclerosis not only account for significant mortality and morbidity but also exert profound psychological, social, and economic tolls on patients, families, and healthcare systems alike. These conditions are frequently chronic, progressive, and incurable, often requiring long-term care and continuous monitoring (Dias-Carvalho et al. 2024). According to the World Health Organization, neurological disorders are now the leading cause of disability-adjusted life years and the second leading cause of death globally, reflecting the sheer scale and complexity of the problem. In addition, the worldwide growing life expectancy and aging population will contribute to this burden in the coming decades, which further emphasizes the need for development of more precise, scalable and proactive healthcare interventions (Oladapo et al., 2024).

Traditional diagnostic tools and therapeutic models, while invaluable, often fall short in detecting early disease stages, tailoring treatment plans to individual needs, or adapting to the dynamic nature of disease progression. These limitations have catalyzed a shift toward more data-driven, technology-enhanced approaches (Torri et al., 2024). In recent years, the healthcare sector has begun integrating advanced computational tools, particularly those powered by artificial intelligence, to address these gaps and elevate the standard of care. Neural networks—computational systems modeled after the structure and function of the human brain—are among the most promising of these tools. However, neural networks can learn very complex patterns from extremely large and diverse datasets and make highly accurate predictions, catch small anomalies and adapt to new data in ways a regular algorithm cannot (Tsiara et al. 2025).

Their application in neurology has been especially transformative, as the field inherently involves large volumes of complex, multimodal data, including neuroimaging, electrophysiological recordings, clinical narratives, genetic information, and behavioral assessments. Neural networks are uniquely equipped to process this data with high dimensionality and variability, offering new possibilities for early detection of disease, personalized treatment optimization, and continuous patient monitoring (Liao et al. 2024). By analyzing neuroimaging scans, signals, and other data sources, these models can identify disease signatures that precede clinical symptoms, monitor treatment efficacy over time, and predict future disease trajectories with impressive precision. In addition, neural networks enable the creation of intelligent clinical decision support systems, brain computer interfaces, patient specific therapeutic strategies, and improve neurological care on an individualized and responsive basis (Mahadevan et al. 2024).

This chapter aims to provide a comprehensive overview of the transformative role of neural networks in the diagnosis, treatment, and management of neurological diseases. It begins by establishing the foundational concepts and architectures

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