Chapter 2
Decoding Alzheimer's AI-Powered Biomarker Analysis for Diagnosis and Monitoring

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ABSTRACT

Alzheimer's disease (AD) necessitates early diagnosis and monitoring for effective management. This study introduces AlzNet, an AI-powered algorithm combining convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to analyze cerebrospinal fluid (CSF) biomarkers—amyloid-beta (Aβ42), total tau (t-tau), and phosphorylated tau (p-tau181). Leveraging data from 500 participants (200 AD, 150 mild cognitive impairment (MCI), 150 healthy controls) from the Alzheimer's Disease Neuroimaging Initiative (ADNI), AlzNet demonstrated high accuracy (92.5%), sensitivity (90.3%), specificity (94.7%), and AUC-ROC (0.96)

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in differentiating between AD, MCI, and controls. Notably, it identified lower Aβ42 and elevated t-tau and p-tau181 levels as significant markers. AlzNet's non-invasive, cost-effective approach and its potential to facilitate early detection and continuous monitoring of AD underscore its clinical utility. Future research will explore its validation across diverse populations and enhance real-time monitoring capabilities.

INTRODUCTION

Alzheimer's disease (AD) stands as one of the most prevalent neurodegenerative disorders, affecting millions worldwide and posing significant challenges to healthcare systems globally (Bazarkbekov et al., 2024). Characterized by progressive cognitive decline, memory loss, and behavioral changes, AD not only diminishes the quality of life for affected individuals but also places immense emotional and financial burdens on families and caregivers (Qiu & Cheng, 2024). As populations age, the prevalence of AD continues to rise, underscoring the urgent need for effective diagnostic and monitoring tools to better manage this debilitating condition.

Alzheimer’s Disease: Understanding the Challenge

The hallmark neuropathological features of AD include the accumulation of extracellular amyloid-beta (Aβ) plaques and intracellular neurofibrillary tangles (NFTs) composed of hyper phosphorylated tau protein (Vimbi et al., 2024). These pathological changes lead to neuronal dysfunction, synaptic loss, and ultimately, neurodegeneration. Clinically, AD progresses through distinct stages, beginning with subtle cognitive impairments, such as forgetfulness and mild cognitive impairment (MCI), before advancing to more severe dementia. As shown in Table 1 effects of Alzheimer’s Disease.

Table 1. Effects of Alzheimer’s Disease

Domain	Effects of Alzheimer's Disease
Cognitive Function	Memory loss, difficulty in problem-solving, confusion
Behavioral Changes	Mood swings, depression, anxiety, social withdrawal
Physical Health	Impaired movement, difficulty swallowing, weight loss
Daily Living Skills	Difficulty in completing familiar tasks, disorientation
Communication	Trouble with language, repeating questions, losing train of thought
Sleep Patterns	Insomnia, night wandering, disrupted sleep cycles

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