Classification of Alzheimer's Disease Stages Using Graph Neural Network and Structural Brain Network

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Abstract: Alzheimer's disease (AD) is a progressive neurodegenerative disorder marked by cognitive decline, advancing through stages such as mild cognitive impairment (MCI) and severe AD. Accurate early diagnosis is crucial for effective treatment and improved patient outcomes. Recent research has increasingly explored the use of neuroimaging and machine learning for AD diagnosis, yet challenges remain, including data variability, the need for large and diverse datasets, and the complexity of brain structures. This study addresses these challenges by employing a weighted graph neural network (WGNN) combined with structural brain network data derived from diffusion MRI. Unlike previous methods that use binary networks, our approach utilizes a weighted brain network, which captures the varying strengths of connections between brain regions, providing a more nuanced representation. The WGNN model leverages advanced techniques such as graph convolution and pooling to analyze these weighted brain networks. We trained and evaluated our WGNN on a comprehensive dataset from the Alzheimer's Disease Neuroimaging Initiative (ADNI), including 112 AD, 116 NC, and 130 MCI subjects. Our WGNN achieved an impressive classification accuracy of 0.91, effectively distinguishing between cognitively normal (NC), MCI, and AD stages. This performance highlights the model's effectiveness as a diagnostic tool, demonstrating its potential to significantly enhance early diagnosis and enable personalized treatment strategies. By offering a reliable and automated system for AD classification, our WGNN approach represents a significant advancement in improving patient management and treatment outcomes. This work underscores the powerful impact of integrating weighted graph representations and deep learning techniques for Alzheimer's disease detection.

Keywords: Alzheimer's disease, Weighted graph neural network, Structural brain network, Classification, Mild cognitive impairment

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