A Novel Multi-Modal Deep Learning Approach With Attention Mechanisms for Early Detection of Alzheimer's Disease

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Alzheimer's disease (AD) remains difficult to diagnose in its early stages. Current diagnostic approaches often miss subtle early symptoms, delaying intervention. In this research, a novel multi-modal deep learning (DL) framework with AI attention mechanisms was developed to improve early AD detection. MRI, apolipoprotein E (APOE) biomarkers, and clinical data from the Alzheimer's Disease Neuroimaging Initiative were used for this model. This multi-modal framework detects AD by capturing the best practices of a clinician by sieving through data and cross-referencing relationships. First, this approach utilizes a DL framework, rather than the current conventional ML approaches, to consistently extract features of each modality. Using a convolutional neural network (CNN), spatial features were extracted from the MRI. Multi-layer perceptron methods processed the genetic and clinical datasets. Then, two mechanisms, self-attention and cross-attention, were applied onto those feature sets to capture intra-modality and inter-modality relationships, enhancing the model's ability to identify subtle AD-related patterns. AD detection accuracy of 97.9% was achieved by this model, outperforming existing multi-modal and uni-modal models, which lack attention mechanisms. The statistical analysis found that with the DL approach, MRI brain structure integrity (BSI) measures and the APOE genotype features had high predictive statistical Shapley values (ranking top seven), while conventional ML approaches had significantly lower Shapley values (ranking bottom six). This study shows multi-modal's improved ability over uni-modal's for early detection of AD, demonstrates the usefulness of attention mechanisms, and reveals the importance of BSI measures and the APOE genotype in detecting AD.

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