Promoting Equity: A Novel GAN-Based Framework for Improved MRI-Based Alzheimer's Diagnosis Utilizing Multiple Deep Learning Architectures

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Alzheimer’s disease (AD) is a progressive neurodegenerative disorder characterized by cognitive decline severe enough to interfere with daily activities. Current diagnostic methods, such as neuropsychological assessments, achieve an accuracy below 80%, indicating significant room for improvement. Magnetic resonance imaging (MRI), which reveals characteristic brain shrinkage in AD patients, presents a promising opportunity for machine learning to enhance diagnostic accuracy. This study leverages a ResNet50-based convolutional neural network (CNN) for MRI-based AD diagnosis, initially achieving an F1 score of 89%. More importantly, this research introduces a novel generative adversarial network (GAN)-based framework for more accurate AD diagnosis. Following data pre-processing, AG-GAN selected the largest imaging site as a reference domain, conforming images from three other sites to similar image parameters and effectively reducing scanner-specific variability. Subsequently, the CycleGAN generated additional synthetic images to address data scarcity and enhance training robustness. This systematic GAN-based integration significantly improved diagnostic performance, yielding an F1 score of 96.1%. The proposed methodology addresses critical challenges in multi-site MRI datasets, promoting equitable diagnosis by reducing performance disparities caused by scanner variability, limited data availability, and imbalanced datasets. As the first research project to propose a GAN-based framework to enhance AD diagnosis, these findings underscore the transformative potential of integrating deep learning with GAN-based harmonization and augmentation, improving AD diagnostic reliability and accessibility, particularly benefiting underfunded medical clinics and research facilities.

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