MSc in Computational Cognitive Neuroscience

Goldsmiths UNIVERSITY OF LONDON

Generative AI in the Classification of Alzheimer's Disease

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Introduction

Alzheimer's Disease (AD)

AD is a neurodegenerative disorder, the leading cause of dementia, and has symptoms such as memory loss, cognitive decline and mood changes. 55 million people had dementia in 2019, and this is expected to rise to 139 million by 2050 (WHO, 2021). Early detection and classification are crucial for treatment. Diagnostic methods focus on brain scans (such as Magnetic Resonance Images, MRIs) and cognitive tests (Alzheimer's Society, 2023).

Artificial Intelligence & Medical Imaging

AI is increasingly used to analyse medical images, including for AD diagnosis, with promising results (M. Menagadevi et al., 2024). However, these methods require large datasets, not readily available in medical settings due to the quantity of available data and privacy concerns (Khan et al., 2023).

Generative AI

Generative Adversarial Networks (GANs) have been used to generate synthetic MRI images indistinguishable from real images by radiologists (Kazuhiro et al., 2018), This may be an important approach in tackling data concerns. Supplementing real datasets with synthetic images, and using generative AI to enhance image resolution, have both been shown to increase classification accuracy of an AI model (SinhaRoy & Sen, 2023).

Project Aims & Hypotheses

This project aims to validate the use of generative AI in improving accuracy of classification of stages of AD by a CNN (convolutional neural network). Generative AI is implemented in two ways: supplementing the dataset with synthesised data and enhancing image resolution. It is hypothesised that each of these will increase classification accuracy. The general approach is a replication of a 'Hybrid Deep Learning Framework' (SinhaRoy & Sen, 2023), but utilises a more advanced image generation model.

Methodology

Data

The data is from Kaggle, named 'ADNI_Extracted_Axial'. It consists of 2D axial MRI slices, processed from 3D MRIs sourced from ADNI (Alzheimer's Disease Neuroimaging Initiative). There are a total of 5154 images, split into 3 classes indicating the stage of Alzheimer's present: Cognitively Normal (CN), Mild Cognitive Impairment (MCI) and Alzheimer's Disease (AD).

Synthetic Image Generation (StyleGAN3)

NVIDIA's state-of-the-art image generation model (StyleGAN3) is used for generating synthetic MRIs with their appropriate class labels (CN, MCI, AD). Image quality will be assessed using Fréchet Inception Distance, which statistically compares the distribution of real and synthetic images. A sample of preliminary synthetic images can be seen in the workflow below.

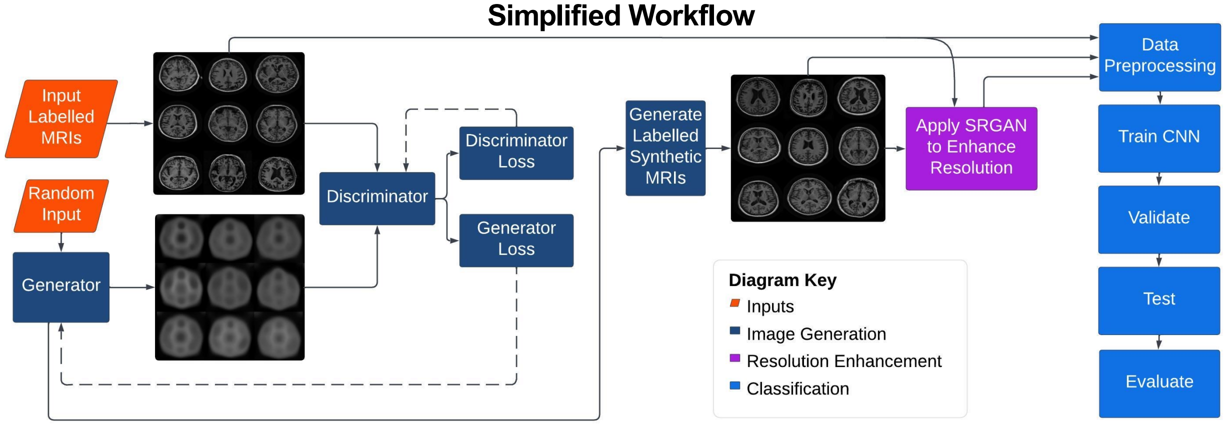
Resolution Enhancement (Super Resolution GAN)

A Super Resolution GAN (SRGAN) architecture (Ledig et al., 2016) is implemented to enhance image resolution. It has been pretrained on 1000 images from the DIV2K dataset, and then applied to both real and synthetic MRIs.

Classification (Convolutional Neural Network)

After preprocessing, data is split into training, validation and test sets. The CNN is then trained, validated and its classification accuracy is evaluated on the test set.

Simplified Workflow



Results

Results will take the form of an ablation study, removing different components of the system, and comparing the performance (judged by classification accuracy).

Example Results Table

Type	Accuracy (%)
Without StyleGAN3 & SRGAN	
Without StyleGAN3	
Without SRGAN	
With StyleGAN3 & SRGAN	

Limitations & Future Directions

2D MRI slices contain limited information:
Incorporate 3D MRIs and/or multimodal data.

No explanation for decisions limits medical use:
Develop Explainable AI models.

No Professional Feedback on Synthetic Images:
Collaborate with radiologists.

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