A Comparative Study of Convolutional Neural Networks and Transformer-based models for Medical Image Classification

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PROBLEM DEFINITION

Alzheimer's disease is a neurodegenerative condition that causes memory impairment, especially in older individuals, and currently has no cure. Due to a large number of patients, it is not feasible to manually diagnose the disease in a timely and efficient manner. Although various diagnostic procedures are available, mistakes during the diagnosis process are common due to time constraints and the complexity of the disease. Thus, there is a pressing need for a precise and timely diagnosis of Alzheimer's disease. Our proposed project compares various deep learning-based medical imaging methods for diagnosing and classifying Alzheimer's disease at different stages.

METHODS AND MODELS

For our given problem, we will use three different deep learning models, our problem outlines itself as a fully-supervised classification problem, and our models will be implemented as such in PyTorch. We initially preprocess the dataset as per the requirements of our models. First, we will implement the ubiquitous AlexNet architecture that will serve as a baseline performance for the project. Our second model will be a custom deep neural network employing CNNs and RNNs to build a CNN - LSTM model for latent feature extraction. Lastly, with the growing popularity of the Transformer architecture, we will reimplement this model and adapt it to our problem. We will then evaluate all three models to determine the best one. We expect the CNN - LSTM model to perform ever-so-slightly better than its counterparts.

DATASET

For the scope of the project, we focus on the classification of Alzheimer's Disease from the Magnetic Resonance Imaging modality. The dataset contains MRI scans with four different stages of Alzheimer's disease and can be classified into No dementia, Very Mild Dementia, Mild Dementia, and Moderate Dementia. The dataset contains 6400 MRI images, including 896 images showing. Mild Dementia, 64 showing Moderate Demented (64 images), 3200 scans showing No Dementia, and 2240 images from patients suffering from Very Mild Dementia. The total dataset is 29 MB, and all the images are black and white with a size of 128x128 pixels.

COMPUTATIONAL RESOURCES

Deep Neural Networks require a significant amount of computational power due to their intensive nature, making it necessary to have sufficient resources available for training the models on the image dataset. So we will use a system with 32 GB RAM, a cuda-based GPU, and a high-power CPU for computation.

METRICS AND EVALUATION

In order to make the model evaluation and comparison easier, we will use popular classification metrics. First, accuracy will provide a naturally interpretable and easily comparable metric. Since our dataset is imbalanced, accuracy alone is insufficient to evaluate performance. Therefore, in order to get a better performance evaluation, we will measure the F1-Score. Lastly, we use the AUROC of our model and perform hyperparameter tuning to further validate performance and for ease of comparison.