Alzheimer's Disease Classification using CNN (VGG16)

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Abstract

This project presents a deep learning approach for the early detection and classification of Alzheimer's Disease (AD) using structural MRI scans. We fine-tuned a pre-trained Convolutional Neural Network (VGG16) to classify MRI images into four categories: Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented. The dataset used is a combination of OASIS and ADNI, two well established medical imaging repositories. Our methodology focuses on leveraging transfer learning, data pre-processing, and augmentation techniques to improve classification accuracy while reducing overfitting. The trained model demonstrates promising performance, suggesting the potential of CNN-based architectures for assisting clinicians in diagnosing Alzheimer's Disease.

Keywords: Alzheimer's Disease; CNN; VGG16; Deep Learning; MRI Classification; OASIS; ADNI.

1 Introduction

Alzheimer's Disease (AD) is a progressive neurodegenerative disorder that affects memory, cognition, and behaviour. Early diagnosis is critical for patient care and slowing disease progression. Traditional diagnosis often relies on clinical evaluations and imaging, which are time-consuming and require expert interpretation.

With advances in deep learning and medical imaging, automated methods for AD detection using MRI scans have gained attention. In this project, we aim to develop a deep learning pipeline using VGG16 to classify MRI scans into four stages of Alzheimer's progression. By employing transfer learning and modern

regularization techniques, the proposed model enhances classification accuracy and reduces the computational cost of training from scratch.

2 Literature Review

Several studies have applied CNNs for Alzheimer's detection:

Suk et al. (2015): Introduced a deep learning approach combining multimodal features for AD classification. Korolev et al. (2017): Evaluated CNNs for structural MRI analysis, achieving significant improvements over traditional feature-based methods. Wang et al. (2018): Demonstrated the effectiveness of transfer learning with pre-trained models such as VGG and ResNet for medical image classification.These works highlight the potential of CNNs, particularly transfer learning, in handling medical datasets with limited labelled samples. Our approach builds upon this foundation, focusing on VGG16 due to its proven robustness in feature extraction.

3 Base Paper

The project draws inspiration from **"Deep Transfer Learning for Alzheimer's Disease Classification using MRI"**, where pre-trained CNNs were fine-tuned for medical imaging tasks. VGG16, with its simple yet effective architecture, provides an excellent trade-off between performance and interpretability. By adapting VGG16 for Alzheimer's MRI scans, we aim to replicate and extend these results on OASIS and ADNI datasets.

4 Methodology and Current Progress

4.1 Dataset

AMD Dataset – Contains retinal imaging and clinical data used for studying Age-related Macular Degeneration progression and prediction.

ADNI Dataset – A large neuroimaging and biomarker dataset designed to track Alzheimer's disease progression across cognitive stages.

UK Biobank (UKB) Dataset – A population-scale biomedical dataset providing imaging, genetics, lifestyle, and clinical data for large-scale health research.

4.2 Model Architecture

- Base Model: Pre-trained VGG16 (ImageNet weights).

Modifications:

- Removed final classification layer.
- Added Global Average Pooling.
- Dense layers with ReLU activation.
- Dropout layers for regularization.
- Final Dense layer with softmax activation for 4-class classification.

4.3 Training Setup

- Framework: TensorFlow/Keras.
- Optimizer: Adam with learning rate scheduling.
- Loss Function: Categorical Cross-Entropy.
- Regularization: Dropout, Data Augmentation, Early Stopping.
- Metrics: Accuracy, Precision, Recall, F1-score, Confusion Matrix.

5. Current Progress & Results

The model was trained on the OASIS-ADNI combined dataset. Achieved promising training accuracy and validation accuracy matrix analysis indicates strong classification performance for Non-Demented and Very Mild Demented categories, with some misclassifications in Mild vs. Moderate Demented due to overlapping MRI features. Graphs of training vs. validation loss/accuracy indicate the effectiveness of regularization in reducing overfitting.

6. Future Enhancements

Advanced Architectures: Testing with ResNet50, DenseNet, and Vision Transformers (ViT). Explainability: Using Grad-CAM to visualize important MRI regions influencing classification. Multi-Modal Integration: Combining MRI scans with clinical/cognitive test data for improved predictions. Deployment: Developing a web-based diagnostic tool for clinicians.

7. Conclusion

This project successfully demonstrates the application of CNN-based transfer learning (VGG16) for Alzheimer's classification using MRI scans. With effective preprocessing, data augmentation, and fine-tuning, the model achieved reliable performance on the OASIS-ADNI dataset. Future work will involve testing advanced models, enhancing interpretability, and moving toward clinical deployment.

8. References

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