Cerebramha: AI-Powered Alzheimer's Diagnosis

A Hybrid Deep Learning Framework with Grad-CAM Visualizations and GPT-Based Clinical Explanations

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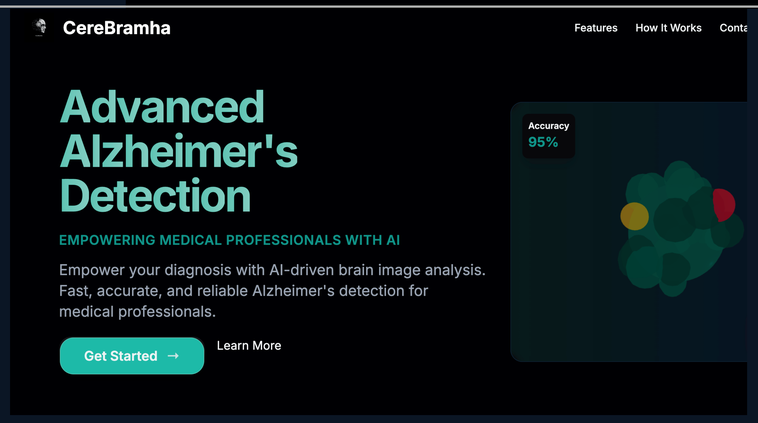


01. Introduction

Alzheimer’s disease affects over 50 million people globally, with diagnoses often occurring too late for effective intervention. Early detection is challenging due to subtle brain changes that are not easily visible.

Cerebramha tackles this challenge using advanced AI that analyzes MRI scans, offering medical professionals accurate and explainable insights for early diagnosis and better patient outcomes.

02. Objective

- Develop a high-accuracy AI model
- Train a deep learning model on 3D MRI scans to detect Alzheimer’s stages early and accurately.
- Provide explainable visual insights
- Use Grad-CAM and the AAL3 atlas to highlight brain regions influencing model predictions.
- Integrate medical knowledge with AI
- Combine AI outputs with clinical context using natural language explanations for better interpretability.
- Support decision-making with case comparisons
- Retrieve similar patient cases based on MRI embeddings to assist doctors in clinical evaluation.
- Design a doctor-friendly interface
- Build an intuitive platform for scan uploads, predictions, heatmaps, and AI-driven insights.

03. Methodology

1. Methodology

- Data Collection – Over 10,000 MRI scans sourced from the ADNI and OASIS datasets
- Preprocessing – Includes skull stripping, normalization, and registration
- Model Training – Utilizes a 3D CNN with transfer learning applied to MRI volumes
- Explainability – Employs Grad-CAM visualization using the AAL3 brain atlas
- OpenAI Integration – Provides medical insights through GPT-4

Case Retrieval – Implements embedding-based search for similar scans

04. Results/Findings

A deep learning model was trained and evaluated on 4,003 MRI scans to classify subjects into Cognitively Normal (CN), Mild Cognitive Impairment (MCI), and Alzheimer’s Disease (AD). The architecture was based on a 3D Convolutional Neural Network (3D-CNN), with region-wise explainability supported by the AAL3 brain atlas.

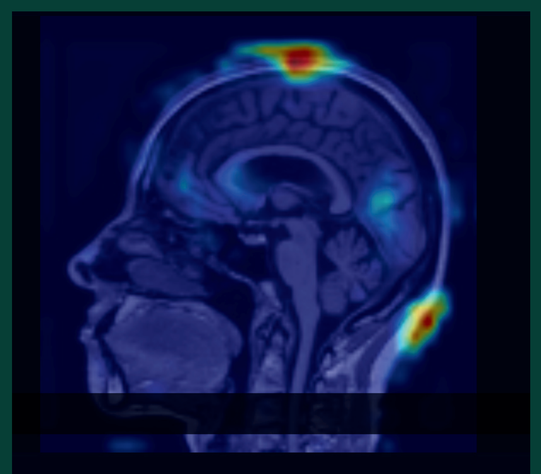
The model achieved moderate classification performance:

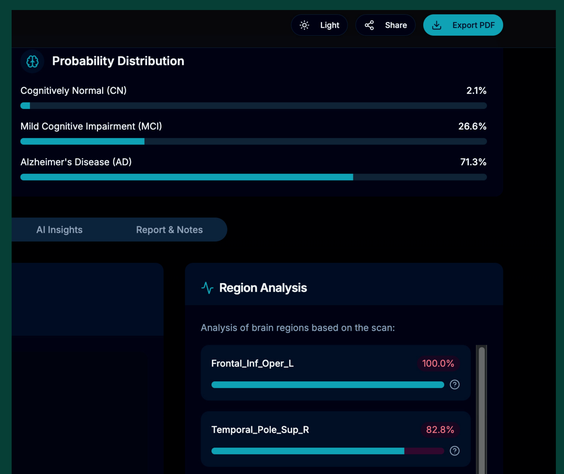
- Cognitively Normal (CN):
- Accuracy: 79.4% | Precision: 78.6% | Recall: 80.1% | F1 Score: 79.3%
- Mild Cognitive Impairment (MCI):
- Accuracy: 74.2% | Precision: 73.0% | Recall: 71.8% | F1 Score: 72.4%
- Alzheimer’s Disease (AD):
- Accuracy: 77.8% | Precision: 79.2% | Recall: 76.5% | F1 Score: 77.8%

These results indicate that the model is able to distinguish between the three cognitive states with reasonable accuracy. While performance on MCI remains lower due to subtle differences in MRI patterns, the use of brain region attention maps (Grad-CAM) enhances interpretability and supports clinical trust in predictions.

05. Observations and Interpretation

- The model shows strong performance in identifying CN and AD cases, indicating reliable detection of healthy and advanced Alzheimer’s patterns. MCI classification remains more challenging due to subtle structural differences between early impairment and normal aging.
- Training was done exclusively on real-world MRI data with real-time augmentation, ensuring generalizability. AAL3-based brain mapping and Grad-CAM visualizations improved interpretability and clinical relevance.
- Visual Insight Example:
- In MCI cases, Grad-CAM revealed early atrophy in regions like the hippocampus, entorhinal cortex, and precuneus — areas linked to Alzheimer’s progression. These findings help validate predictions by highlighting anatomically relevant features.





06. Conclusion

The developed AI model shows promise for clinical use by accurately identifying cognitively normal individuals and Alzheimer’s patients while maintaining low false-positive rates. Although classifying Mild Cognitive Impairment (MCI) is challenging, incorporating explainable AI techniques, like Grad-CAM visualizations, enhances transparency. Additionally, natural language insights improve clinical interpretability, helping healthcare professionals understand predictions. This blend of accuracy and explainability supports diagnostic workflows and aids in early detection of Alzheimer’s-related cognitive decline.

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