# ALZHEIMER'S DETECTION IN MRI IMAGES: LEVERAGING RESNET - INTEGRATED CNN FOR ENHANCED ACCURACY

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**ABSTRACT: Alzheimer's disease possesses several challenges in the medical field due to its complexity and progressive nature. Alzheimer's disease is a progressive neuro logical disorder which effects the brain and causes memory loss, behavior and mood changes. In Advance stage it causes severe cognitive decline in brain. Because of early detection difficulty and misdiagnosis Alzheimer's constantly being a huge problem. To address this problem, we are introducing a concept using ResNet Integrated CNN method applying on MRI (Magnetic Resonance Imaging) images for getting high accuracy results for detection of Alzheimer's, this help to get quality of treatment in early stage for patient. Using ResNet makes the model to outstand by reducing the computation cost. By considering some factors in brain regions (Hippocampus, cortex, neurons) and ventricles enlargement, grey and white matter, functional changes like Blood flow, metabolism, and connectivity this clearly defines the stage of Alzheimer's and its progressive rate. In this article we are considering this factor to detect the disease with High accuracy and improve the quality of life to patient. By using quality datasets like ADNI (Alzheimer's Disease Neuroimaging Initiative) we achieved higher accuracy by applying advanced preprocessing.**

***Index terms*:** Alzheimer's disease, Magnetic Resonance Imaging, Conventional Neural Networks.

## I. INTRODUCTION

Alzheimer's Disease (AD) is a progressive neurodegenerative disorder that affects memory, thinking, and behavior. It is the most common cause of dementia, accounting for 60–80% of cases worldwide. Other factors, such as cardiovascular health, diabetes, head injuries, and lifestyle habits, may further increase the risk. Women are more likely than men to develop the disease, possibly due to hormonal and genetic differences. At the cellular level, Alzheimer's disease is characterized by abnormal protein deposits in the brain. These processes cause widespread brain shrinkage, particularly in regions responsible for memory, such as the hippocampus. This loss of synaptic connections and neurons underpins the progressive cognitive decline observed in patients. The symptoms of Alzheimer's typically develop slowly and worsen over time. Also play a role in managing symptoms and improving quality of life. In conclusion, Alzheimer's disease is a challenging and complex condition that affects millions worldwide. We are introducing a concept using ResNet Integrated CNN method applying on MRI (Magnetic Resonance Imaging) images for getting high accuracy results for detection of Alzheimer's, this help to get quality of treatment in early stage for patient. Using Resnet makes the model to outstand by reducing the computation cost. By considering some factors in brain

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**ResNet:** ResNet (Residual Networks) is a deep learning architecture is developed to address the challenges of training very deep neural networks It introduces residual learning through skip connections, allowing gradients to flow directly through the network without degradation which is widely used for image classification and feature extraction. Pre-trained on the ImageNet dataset including medical imaging applications like MRI-based Alzheimer's detection. Its ability to capture hierarchical spatial patterns through convolutional layers for detecting subtle changes like Hippocampus, cortex, neurons) and ventricles enlargement, grey and white matter in brain structures.

**CNN:** Convolutional Neural Networks (CNN's) are specialized deep learning models designed for image recognition and processing, making them ideal for analyzing medical images. CNNs operate through convolutional layers that scan input images, learning spatial hierarchies of features from low-level edges and textures to high-level anatomical structures.

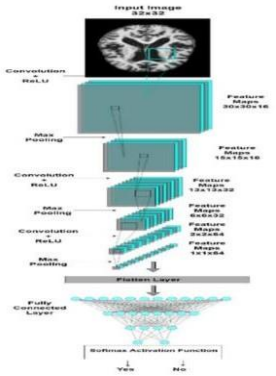


**Fig:1** – CNN Architecture

**ResNet integrated CNN:** The integration of ResNet and CNN layers creates a hybrid model that combines the pre-trained feature extraction capability of ResNet with the domain-specific adaptability of CNN layers. This approach has proven highly effective for analyzing MRI images from the ADNI (Alzheimer's Disease Neuroimaging Initiative) dataset. The workflow begins with ResNet extracting high-level features such as textures and shapes, which are further refined using additional CNN layers that emphasize subtle anatomical variations like Hippocampal atrophy and Cortical thinning. Fully connected layers can be classifying the images as either Alzheimer's - positive or healthy. Enhancements such as transfer learning, fine-tuning layers, data augmentation, and reduce training time and improve model. This integration achieves High accuracy in classifying MRI images for Alzheimer's Detection.

## A. PROBLEM STATEMENT

There are many challenges the development of effective machine learning models for detection and classification in Alzheimer's disease faces, such as overfitting due to limited datasets like ADNI, computationally expensive complex architectures, and inappropriate modeling of temporal progression. Besides these, models lack multi-modal imaging data integration, tend strongly towards binary classification instead of multi-class stage differentiation, and strongly depend on particular neural network architectures that hinder their generalization, scalability, and clinical applicability.

## B. RESEARCH GAPS

1. **Overfitting Dual Models:** Present dual models overfit, primarily because they are very complex and rely heavily on the number of parameters used. This affects the ability to generalize towards unseen data.
2. **Complex Models for Accuracy:** Good accuracy often comes with overcomplex models, which become

computational expensive and are hard to deploy in practice.

3. **Limited Inputs for Binary Classification:** Many studies focus only on binary classification (e.g., healthy vs. Alzheimer's), which limits the ability to identify intermediate stages such as Mild Cognitive Impairment (MCI).
4. **Unspecified Deep Learning Contributions:** Several deep learning models lack clarity in defining how specific architectural components contribute to Alzheimer's diagnosis.

## II. LITERATURE REVIEW

1. **Kevin de Silva, Holger Kunz (2024)**

   This article focus on develops a method in using CNN to predict the Alzheimer's Disease from only one central MRI slice using the dataset MIRIAD with an optimum configuration towards having high diagnosis accuracy with little computational load. It takes the point of achieving diagnostics workflow smoothing through its performance on short training and fast prediction time suitable for practical clinical applications.

2. **Maysam Orouskhani, Chengcheng Zhu (2022)**

   This article focus on paper addresses the challenges of diagnosing Alzheimer's Disease (AD) by deep learning, focusing on data scarcity and overfitting due to limited labeled MRI samples. It presents a novel deep triplet network inspired by the VGG16 architecture with a conditional loss function to enhance accuracy. Results on the OASIS dataset demonstrate superior performance over state-of-the-art techniques, highlighting the potential of deep triplet networks in advancing AD detection and addressing data limitations.

3. **Battula Srinivasa Rao (2023)**

   This article focus on addresses the need for early diagnosis of Alzheimer's Disease, the most common neurodegenerative condition among the elderly. This article addresses how MRI studies have provided significant information about anatomy and pathology and how recent innovations in CNN-based deep learning have improved significantly in segmentation and classification. It explores how CNN can be applied in the detection of AD, presents new techniques with open datasets, and puts forward a potential contribution towards early diagnosis and effective management of disease.

4. **Ahmed Khalid (2023)**

   This article focus on brings into focus Alzheimer's Disease as one of the major health challenges that require early detection to prevent irreversible brain damage. It discusses MRI analysis using deep learning techniques in order to process data in an efficient and accurate manner, dealing with complexities of distinguishing early stages of AD. Three FFNN methodologies combine features from GoogLeNet, DenseNet-121, and handcrafted techniques like DWT, LBP, and GLCM, achieving outstanding results with up to 99.7% accuracy. These results show the potential of combining deep learning with handcrafted methods in transforming AD detection and stage prediction.

5. **Amir Ebrahimi (2020)**

   This article focus on paper presents an innovative approach to detect Alzheimer's Disease (AD) with MRI by using transfer learning with 3D CNNs. Unlike 2D CNNs, 3D CNNs are able to capture spatial relations in MRI scans and increase the accuracy of diagnosis. The method has achieved outstanding performance metrics, such as 96.88% accuracy and 100% sensitivity, which shows the effectiveness of transfer learning in improving AD detection using 3D CNNs.

| S.No | Year | Author's | Article Title | Key Findings |
|---|---|---|---|---|
| 1. | 2024 | A.M. El-Assy | A novel CNN architecture for accurate early detection and classification of Alzheimer's disease using MRI data. | Dual models, overfitting. |
| 2. | 2023 | Ahmed Khalid | Automatic Analysis of MRI images for Early prediction of Alzheimer's disease stages Based on hybrid features of CNN and Handcrafted features. | Excellent accuracy, dependency on complex models. |
| 3. | 2023 | Iroshan Aberathne | Detection of Alzheimer's disease onset using MRI and PET neuroimaging. | Neuroimaging techniques lack detailed metrics. |
| 4. | 2023 | Kevin de Silva, Holger Kunz et.al | Prediction of Alzheimer's disease from magnetic resonance imaging using CNN. | Binary classification with input limitations. |
| 5. | 2023 | Battula Srinivasa Rao | A Review on Alzheimer's Disease Though analysis of MRI images using Deep learning techniques. | Unspecified deep learning, unclear specific contributions. |
| 6. | 2022 | Maysam Orouskhani, Chengcheng Zhu et.al | Alzheimer's disease detection from Structural MRI using Conditional deep triplet network. | Triplet network, margin sensitivity challenges. |
| 7. | 2020 | Amir Ebrahimi | Introducing Transfer Learning to 3D ResNet - 18 for Alzheimer's disease detection on MRI images. | High accuracy, dimensionality and overfitting challenges. |
| 8. | 2020 | Ahmad Waleed Salehi | A CNN model: Earlier Diagnosis and Classification of Alzheimer's disease using MRI. | Effective CNN, generalization and imbalance issues. |
| 9. | 2020 | Guilherme Folego | Alzheimer's disease detection Through Whole -Brain 3D-CNN MRI. | 3D data explored, complexity affects performance. |
| 10. | 2017 | Litjens | A Survey on Deep Learning in Medical Image Analysis | Deep learning revolutionizes medical imaging. |
| 11. | 2016 | He, K. et.al | Deep Residual Learning for Image Recognition | Solves vanishing gradients, enables depth. |

## III. METHODOLOGY

### A. OBJECTIVES

1. **Integrating Attention Mechanism:** Focus the model to sensitive regions, for instance the hippocampus and cortex regions while introducing attention mechanisms which makes a model sensitive to some specific features but insensitive to the margin.
2. **Generalization Improvisation through Transfer Learning:** By using ResNet50's pre-trained weights, fine-tuned on Alzheimer's-specific data, to enhance model adaptability and improve performance on smaller or imbalanced datasets.

3. **Class Imbalance Resolution:** To overcome class imbalance we apply data augmentation techniques and weighted loss functions to address class imbalance, ensuring fair representation of all disease stages in the learning process.
4. **Handle Binary and Multi-Class Tasks:** To overcome binary classification we develop the model so that it can handle binary (Healthy vs. Alzheimer's) as well as multi-class classification, depending on the type of application or dataset required.
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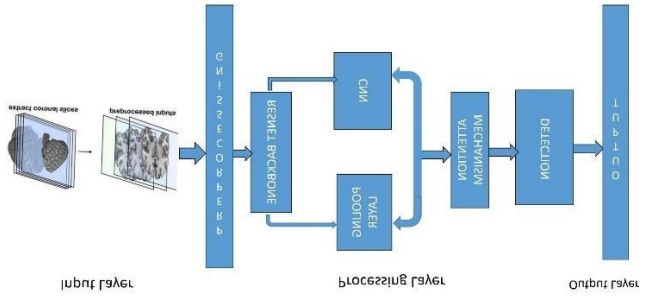

**Fig:2** - Architecture of Alzheimer's Detection in MRI Images: Leveraging ResNet - Integrated CNN for Enhanced Accuracy

1. **Input Layer:**
   - **About Datase (ADNI)**
   - ADNI provides Alzheimer's data in Nifti or DICOM format which is 3D volumetric data. It becomes slightly difficult to work directly on the 3D data, hence the given dataset was created for easy implementation of the image processing algorithms.
   - This dataset consists of 2D axial images extracted from the ADNI baseline dataset which consisted of Nifti images. It consists of 3 classes, i.e. AD (Alzheimer's Disease), CI (Mild Cognitive Impaired) and CN (Common Normal) subjects.
   - The images have been extracted from the ADNI Baseline dataset (NIFTI format) which consisted of 199 instances.
2. **Processing Layer:**
   - **ResNet:**
   - Deep Feature Extraction: ResNet captures complex spatial patterns indicative of Alzheimer's, such as hippocampal atrophy and cortical thinning.
   - Handling MRI Data: It processes MRI scans effectively, allowing for the analysis of volumetric data. Prevents Overfitting: Residual connections help avoid overfitting, improving generalization and performance on unseen data
   - Multi-Class Classification: It can classify different stages of Alzheimer's, aiding in tracking disease progression.
   - Integration with Multi-Modal Data: ResNet's adaptability enables the integration of MRI with other modalities, enhancing diagnosis.
   - Transfer Learning: Pre-trained models can be fine-tuned on Alzheimer's datasets, improving model accuracy with limited data.
   - **Conventional Neural Networks:**
   - CNN refines and processes spatial and structural patterns identified by ResNet, emphasizing critical regions like the hippocampus and cortex.
   - Pooling layers reduce feature map sizes while retaining salient information, enhancing computational efficiency.

- CNN predicts the presence or stage of Alzheimer's (e.g., mild, moderate, severe) by analyzing extracted features and aggregating them through fully connected layers

- CNN can handle and merge data from multiple imaging modalities, such as MRI for better diagnostic accuracy.

➢ **Attention Mechanism:** The attention mechanism focuses on the most relevant brain regions in MRI scans, such as the hippocampus and cortex, which are critical for Alzheimer's diagnosis. By assigning higher weights to these regions, it improves the model's ability to detect subtle patterns associated with the disease progression.

➢ **Detection:** Binary detection classifies MRI scans into two categories: healthy and Alzheimer's disease. This simplifies the diagnostic task, focusing on distinguishing affected individuals from the healthy population for early intervention.

## IV. RESULTS & DISCUSSIONS

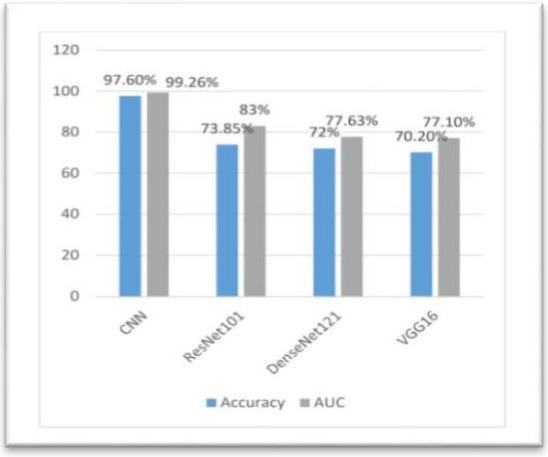


**Fig:3** – Comparision Graph

- We can see that many research papers indicate that CNN was the most accurate at 97.60 while VGG16 was the least accurate at 70.20. In addition, ResNet101 and DenseNet121 attained an accuracy of 73.85 and 72 percent respectively. Going further, we take CNN and integrated with ResNet to get good result with less time complexity and High accuracy. By taking subsets at different stages of AD, we have achieved Multi Modal Classification where we classified AD into Mild Demented, Moderate Demented, Non Demented, Very Mild Demented. We have taken 2D axial images for training the Model.

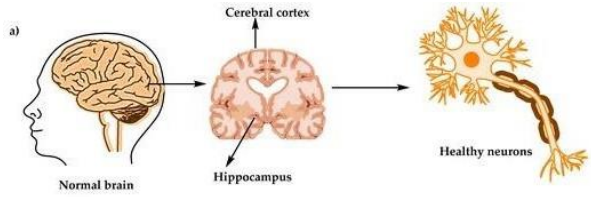


**Fig: 4** – Non - demented scenario

- AD has been considered a multifactorial disease associated with several risk factors such as increasing age, genetic factors, head injuries, vascular diseases, infections, and environmental factors (heavy metals, trace metals, and others). The underlying cause of pathological changes in Alzheimer's disease (Aβ, NFTs, and synaptic loss) is still unknown.

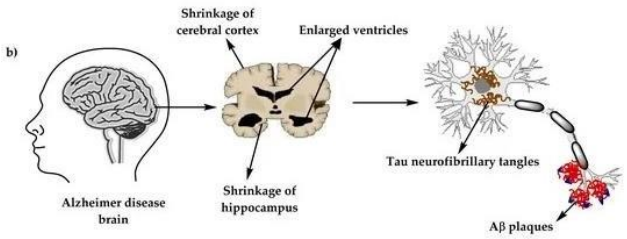


**Fig: 5** - Demented scenario

- There are two types of neuropathological changes in AD which provide evidence about disease progress and symptoms and include: positive lesions (due to accumulation), which are characterized by the accumulation of neurofibrillary tangles, amyloid plaques, dystrophic neurites, neuropil threads, and other deposits found in the brains of AD patients. In addition to negative

lesions (due to losses), that are characterized by large atrophy due to a neural, neuropil, and synaptic loss.

## V. CONCLUSION

From our Model ResNet integrated CNN we conclude that we have increase Detection accuracy and overcome some limitations which are helpful for Early diagnosis of Alzheimer's they are Decrease Time Complexity, Decrease Computational Cost, Multi Modal Classification, progressive analysis. The proposed ResNet-integrated CNN model provides a powerful solution for detecting Alzheimer's disease by effectively processing 3D MRI data with enhanced residual connections. It captures complex spatial and temporal features while incorporating multi-modal imaging data like MRI for improved accuracy. Techniques like data augmentation, transfer learning, and weighted loss functions help address overfitting and class imbalance, ensuring reliable performance. The model's scalability and computational efficiency make it suitable for real-world applications. With its ability to classify multiple disease stages, this approach supports early diagnosis and better clinical decision-making, offering significant potential for improving Alzheimer's detection and treatment.

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