

AI-Based Alzheimer's Disease Detection Using MRI Brain Images

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Abstract - Alzheimer's disease is a progressive neurodegenerative disorder that affects memory, thinking ability, and cognitive functions. Early diagnosis plays a crucial role in slowing disease progression and improving patient care. Traditional diagnostic procedures are often expensive, time-consuming, and dependent on expert analysis of medical imaging data. To overcome these limitations, this project proposes an intelligent Alzheimer's Disease Detection System using deep learning techniques and MRI brain image analysis. The proposed system utilizes the ResNet-50 convolutional neural network model for feature extraction and classification of Alzheimer's disease stages. MRI brain images are preprocessed using normalization, resizing, and augmentation techniques to improve prediction accuracy and model robustness. The system classifies MRI images into four categories: Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented. A Flask-based web application is integrated to provide a user-friendly interface for uploading MRI scans and obtaining real-time predictions along with confidence scores, heatmap visualization, and risk assessment. The proposed model demonstrates reliable performance in detecting Alzheimer's disease and supports early clinical diagnosis through automated analysis. Overall, the system is scalable, efficient, and suitable for healthcare applications involving neurological disease prediction and medical image analysis.

Keywords - Alzheimer's disease detection, MRI analysis, deep learning, ResNet-50, CNN, Flask framework, medical image classification, healthcare AI

I. INTRODUCTION

In recent years, artificial intelligence and deep learning technologies have significantly transformed the healthcare sector, especially in medical image analysis and disease diagnosis. Alzheimer's disease (AD) is one of the most common neurodegenerative disorders that affects memory, cognitive ability, and behavioral functions. The disease gradually damages brain cells and leads to severe dementia, affecting millions of elderly individuals worldwide. Early detection of Alzheimer's disease is essential for effective treatment, patient care, and slowing disease progression. Traditional diagnostic techniques for Alzheimer's disease

involve neurological examinations, cognitive tests, and manual analysis of MRI or PET scans by medical experts. These procedures are often expensive, time-consuming, and prone to human error. With advancements in machine professionals in accurate and early-stage disease detection. Deep learning models, particularly Convolutional Neural Networks (CNNs), have shown excellent performance in medical imaging applications due to their ability to automatically extract complex features from images. MRI brain scans provide valuable structural information regarding brain tissue degeneration and hippocampal shrinkage associated with Alzheimer's disease. By analyzing these patterns, deep learning models can classify different stages of dementia with improved accuracy and efficiency. This project proposes an intelligent Alzheimer's Disease Detection System using the ResNet-50 deep learning architecture and MRI brain image analysis. The system performs preprocessing operations such as normalization, resizing, and augmentation before feature extraction and classification. A Flask-based web application is developed to provide an interactive platform where users can upload MRI images and receive instant predictions, confidence scores, heatmap visualizations, and disease risk analysis.

II. LITERATURE SURVEY

The literature survey reviews existing research contributions related to Alzheimer's disease detection using machine learning and deep learning techniques. Various approaches such as CNNs, transfer learning, MRI-based classification, and radiomic analysis have been explored to improve diagnostic accuracy and early disease prediction.

- *Deep Radiomic Analysis of MRI Related to Alzheimer's Disease*

Published In: Multidisciplinary Rapid Review Journal, 2020

Authors: Ahmad Chaddad, Christian Desrosiers, Tamim Niazi

This study presents a radiomic-based MRI analysis

MRI images from the OASIS dataset were used to identify structural abnormalities associated with Alzheimer's disease progression. The research focused mainly on affected brain regions such as the hippocampus and amygdala, which are highly associated with memory loss and cognitive decline. Most of the existing systems focus on identifying structural abnormalities in brain regions such as the hippocampus, amygdala, and cortical areas that are highly affected during disease progression. The following studies provide important insights into MRI preprocessing.

- CNN entropy features achieved an AUC of 92.58%.
- Hippocampus and amygdala regions showed strong disease correlation.
- MRI texture analysis improved early-stage Alzheimer's detection.

The study concluded that deep radiomic feature extraction improves MRI-based Alzheimer's disease diagnosis and enhances early disease prediction accuracy.

- ***Alzheimer's Disease Detection by Using Deep Learning Algorithms***

Published In : IEEE Access, 2020

Authors: Suhad Al-Shoukry, Taha H. Rassem, Nasrin M. Makbol

This paper reviewed multiple deep learning approaches used for Alzheimer's disease diagnosis using MRI and PET imaging datasets. The study analyzed CNN-based architectures, preprocessing methods, and transfer learning techniques for automated disease classification. Public datasets such as ADNI and OASIS were reviewed to evaluate the effectiveness of deep learning models in detecting different dementia stages.

- CNN models outperformed traditional machine learning algorithms.
- MRI preprocessing improved feature extraction performance.
- Transfer learning reduced training complexity and improved accuracy.

The authors concluded that deep learning provides reliable and non-invasive solutions for Alzheimer's disease diagnosis and early-stage detection.

- ***Longitudinal Brain MRI Retrieval for Alzheimer's Disease Using Different Temporal Information***

Published In : IEEE Access, 2021

Authors : Katarina Trojchanec, Ivan Kitanovski, Ivica Dimitrovski

This research proposed a longitudinal MRI retrieval framework for Alzheimer's disease analysis using temporal MRI information collected at multiple time intervals. The study focused on monitoring disease progression by analyzing structural brain changes observed in MRI scans over time. MRI datasets from the ADNI database were used for experimentation and feature extraction. The authors compared cortical thickness features and volume-based MRI features to evaluate their effectiveness in disease retrieval

and classification tasks. Feature selection techniques and quality control methods were also implemented to improve retrieval efficiency and reduce MRI processing errors. The research demonstrated that integrating temporal MRI information improves disease monitoring, classification reliability, and progression analysis.

- Temporal MRI analysis improved disease retrieval accuracy.
- Volume-based MRI features outperformed cortical thickness features.
- Feature selection improved classification efficiency and reliability.

The study concluded that longitudinal MRI analysis provides meaningful insights for monitoring Alzheimer's disease progression and improving diagnosis accuracy.

- ***Early Prediction of Alzheimer's Disease Using Convolutional Neural Network***

Published In: Egyptian Journal of Neurology, 2022

Authors: Vijeeta Patil, Manohar Madgi, Ajmeera Kiran

This review paper analyzed different CNN architectures used for early Alzheimer's disease detection using MRI and PET scans. Multiple deep learning models including 18-layer CNN, VGG19, DenseNet169, and 3D-CNN were compared to evaluate disease classification accuracy. The study highlighted the importance of automated feature extraction and structural brain abnormality analysis. The proposed system was found to be useful for personalized treatment planning and long-term Alzheimer's disease assessment.

- 18-layer CNN achieved approximately 98% classification accuracy.
- CNN models effectively identified structural brain abnormalities.
- 3D-CNN improved visualization of affected brain regions.

The paper concluded that convolutional neural networks provide highly accurate and automated solutions for Alzheimer's disease diagnosis.

- ***Alzheimer's Disease Detection: A Deep Learning-Based Approach***

Published In: International Conference on Artificial Intelligence and Healthcare, 2023

Authors: Muhammad Wasim, Affan Alim, Waqas Ahmed

This research proposed a deep learning-based Alzheimer's disease detection system using 3D-CNN architectures and MRI brain scans. The study focused on automated feature extraction, MRI normalization, and disease classification using deep convolutional neural networks. MRI images from the ADNI1 dataset were converted from 3D format into 2D slices for training and evaluation.

MRI images from the ADNI1 dataset were preprocessed using normalization, brain extraction, and image enhancement techniques before classification. The study focused on automated feature extraction and dementia stage prediction using deep learning models. The proposed system utilized advanced preprocessing techniques including brain extraction and normalization to improve feature quality and reduce noise. The authors also compared ResNet50 and VGG16 architectures for evaluating classification performance and scalability. In addition, the paper highlighted several challenges faced in Alzheimer's disease prediction, including limited dataset availability, class imbalance, overfitting problems, and difficulties in detecting very early stages of dementia.

framework for Alzheimer's disease detection using texture, intensity, shape, and entropy-based CNN features extracted from MRI brain scans.

- 3D-CNN achieved 78.07% classification accuracy.
- MRI normalization improved feature extraction quality.
- The proposed model effectively classified dementia stages.

The study concludes that autoencoder reconstruction analysis provides an efficient and explainable approach for deepfake forensics, making it suitable for lightweight deployment in mobile devices and edge-based verification systems.

III. PROPOSED METHODOLOGY

The proposed Alzheimer's Disease Detection System consists of MRI image acquisition, preprocessing, feature extraction, disease classification, and result visualization modules. The system architecture is designed to provide accurate, automated, and real-time Alzheimer's disease prediction using deep learning techniques.

FLOWCHART OF THE SYSTEM

The flowchart represents the overall working architecture of the proposed Alzheimer's Disease Detection System. It illustrates the complete workflow starting from MRI image upload to final disease classification and result generation. The system is designed to automate the process of detecting Alzheimer's disease stages using deep learning and medical image analysis techniques.

Initially, the user uploads MRI brain scan images through the web interface developed using the Flask framework. The uploaded MRI images are then sent to the data acquisition module, where the system collects and validates the input images for further processing. After data acquisition, image preprocessing operations such as resizing, normalization, noise reduction, and enhancement are performed to improve image quality and standardize the input data for the deep learning model.

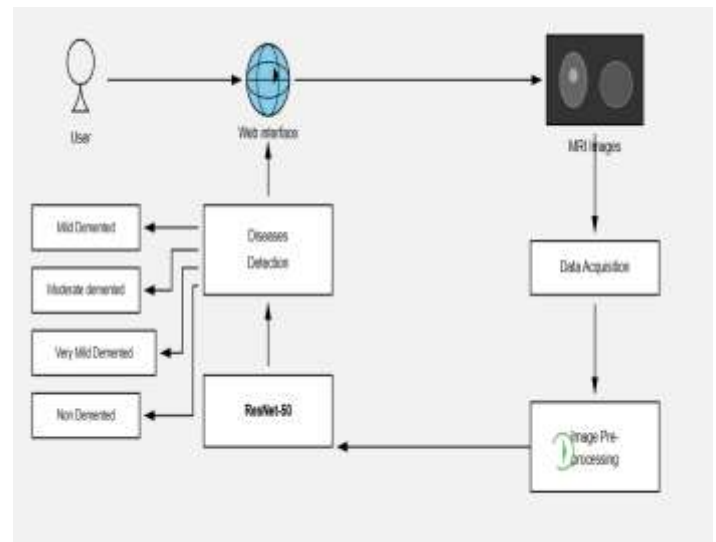


Fig: Data Flow Diagram

• Data Acquisition

MRI brain images are collected from publicly available datasets such as OASIS, ADNI, and Kaggle. The datasets contain labeled MRI scans representing four disease categories: Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented.

• Image Preprocessing

Preprocessing is performed to improve image quality and standardize input data. Operations such as image resizing, normalization, grayscale conversion, noise reduction, and augmentation are applied before training the deep learning model.

• Feature Extraction Using ResNet-50

The preprocessed MRI images are passed through the ResNet-50 convolutional neural network architecture. ResNet-50 utilizes residual learning and deep feature extraction techniques to identify structural abnormalities associated with Alzheimer's disease.

IV. IMPLEMENTATION

The implementation of the Alzheimer's Disease Detection System was carried out using Python, TensorFlow, Keras, OpenCV, and Flask. MRI images were collected from OASIS and Kaggle datasets and divided into training, validation, and testing sets. Preprocessing operations including normalization, resizing, and augmentation were applied to improve model generalization and reduce overfitting. The ResNet-50 architecture was employed as the core deep learning model for feature extraction and classification. Transfer learning was utilized by freezing initial convolutional layers and training custom classification layers on MRI datasets. The Adam optimizer and categorical cross-entropy loss function were used during training to improve convergence and prediction accuracy. The backend of the system was implemented using the Flask framework, enabling smooth communication between the user interface and the deep learning model. Users can upload MRI images through the web interface, after which the system preprocesses the image, performs inference using the trained model.

• Dataset Description :

The proposed Alzheimer's Disease Detection System was trained and evaluated using benchmark MRI datasets such as OASIS, ADNI, and Kaggle Alzheimer MRI datasets. These datasets contain labeled MRI brain scans categorized into four stages: Non Demented, Very Mild Demented, Mild Demented, and Moderate Demented. The datasets provide structural brain information required for detecting dementia-related abnormalities and improving classification accuracy.

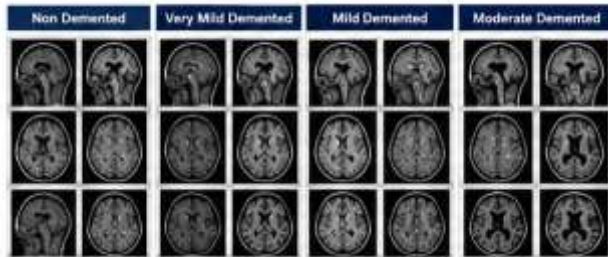


Fig a: MRI Dataset Collection

• Image Pre-processing :

Image preprocessing plays a crucial role in improving MRI image quality and enhancing the performance of the deep learning model. Raw MRI brain scans often contain noise, intensity variations, low contrast, and unwanted background regions that may reduce classification accuracy. To overcome these issues, several preprocessing operations were performed before feeding the images into the ResNet-50 model.

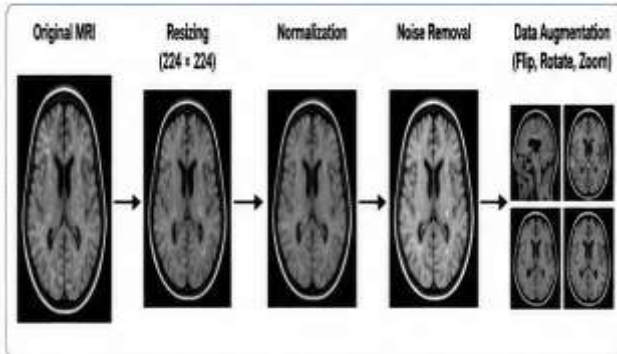


Fig b: MRI Image Pre-processing Pipeline

• Model Building

The proposed Alzheimer's Disease Detection System utilizes the ResNet-50 Convolutional Neural Network architecture for automated MRI feature extraction and disease classification. ResNet-50 is a deep residual learning model consisting of 50 layers that enables efficient training of deep neural networks while avoiding vanishing gradient problems through residual connections.

Transfer learning techniques were applied using pretrained ImageNet weights to improve training efficiency and reduce computational complexity. The initial convolutional layers of the network were frozen to preserve learned low-level features, while fully connected classification layers were customized and trained using Alzheimer's MRI datasets. The model learns important structural abnormalities, tissue degeneration patterns, and spatial features associated with different stages of dementia.

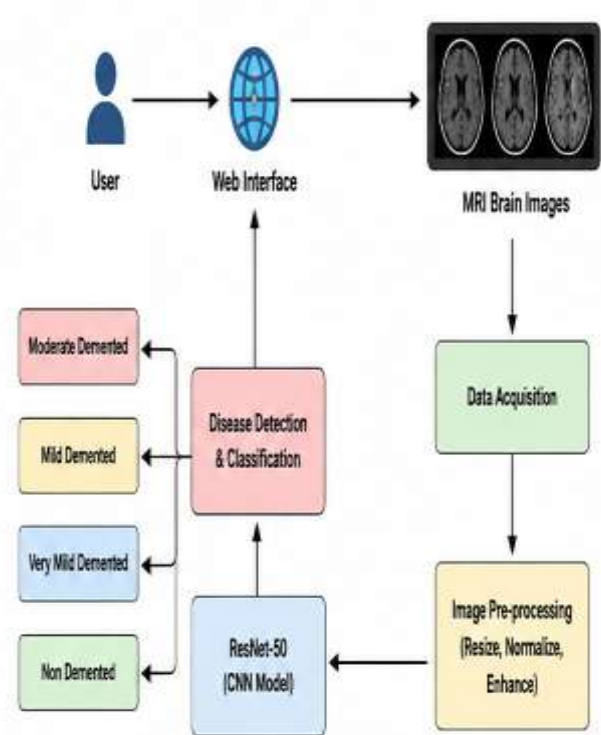


Fig c: Flowchart of Alzheimer's Disease Detection System

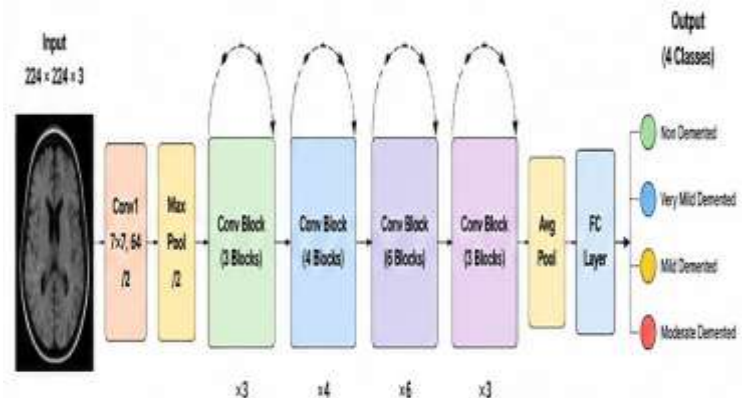


Fig d: ResNet-50 Model Architecture

V. CONCLUSION AND FUTURE SCOPE

The proposed Alzheimer's Disease Detection System successfully integrates deep learning techniques and MRI brain image analysis for accurate disease prediction. The ResNet-50 CNN architecture effectively extracts complex spatial features from MRI scans and classifies different stages of Alzheimer's disease with improved accuracy and efficiency.

The integration of confidence scores, heatmap visualization, and risk assessment enhances system interpretability and reliability. The Flask-based web application provides a simple and interactive platform for uploading MRI images and obtaining real-time predictions. The developed system can assist healthcare professionals in early diagnosis and support clinical decision-making processes.

FUTURE SCOPE

i. Multi-Modal Data Integration

Future enhancements can integrate MRI, PET scans, EEG signals, and cognitive assessment data into a unified framework. Combining multiple modalities can improve disease prediction accuracy and provide better understanding of neurological changes associated with Alzheimer's disease.

ii. Real-Time Alzheimer's Disease Detection

The system can be expanded to support real-time MRI analysis in hospitals and diagnostic centers. This would enable faster clinical decision-making and immediate disease assessment for patients.

iii. Explainable Artificial Intelligence (XAI)

Future work can incorporate Explainable AI techniques such as Grad-CAM and attention visualization methods to highlight affected brain regions responsible for predictions. This will improve transparency and increase trust among healthcare professionals.

iv. Mobile and Cloud-Based Deployment

A lightweight mobile application or cloud-based platform can be developed to provide remote Alzheimer's disease detection services. This would support telemedicine and improve accessibility for rural healthcare systems.

v. Integration with Hospital Information Systems

The system can be integrated with Electronic Health Record (EHR) systems and hospital databases for automated patient data management and streamlined clinical workflows.

vi. Continuous Learning and Model Updating

Future systems can implement automated retraining mechanisms using newly available MRI datasets. Continuous learning will help maintain high prediction accuracy as medical imaging data evolves.

vii. Enhanced Risk Assessment and Recommendation System

Advanced risk prediction modules can be incorporated to generate personalized treatment suggestions, cognitive improvement recommendations, and disease progression analysis for patients..

viii. Detection of Multiple Neurological Disorders

The proposed framework can be extended to detect additional neurological disorders such as Parkinson's disease, brain tumors, and dementia-related conditions using similar deep learning architectures and medical imaging techniques.

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