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Detection of Alzheimer's Using Convolutional Neural Network

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***Abstract*: Alzheimer's disease is a neurodegenerative disease that usually starts slow and progressively worsens. Early detection of Alzheimer's can help us prevent deterioration of the tissue damage in the brain. In this paper, a detailed analysis on detection of Alzheimer's disease using various Convolutional Neural Network (CNN) architectures in Machine Learning (ML) is shown. This disease causes people to suffer from memory loss and unusual brain tissue damages. Several ML models have been used by researchers for detection of Alzheimer's. Analyzing Magnetic Resonance Imaging (MRI) scans is a very useful and common practice for the diagnosis of Alzheimer's disease. ML is used to help the computers to train on the large and complicated datasets and detect the presence of Alzheimer's disease in brain MRI. In today's world Deep Learning techniques have successfully brought change in numerous fields including medical image analysis. We propose a deep CNN for Alzheimer's disease using MRI scan data sets. Our model identifies Alzheimer's disease in its different stages using different CNN architectures to obtain efficiency and accuracy for early-stage diagnosis of Alzheimer's disease.**

***Keywords*: Neurodegenerative disease, Convolutional Neural Network, Machine Learning, Magnetic Resonance Imaging, Deep Learning, Medical image analysis, CNN architectures.**

1. Introduction

Alzheimer's disease (AD) is a progressive neurological disorder that affects memory, thinking ability, and behavior, eventually interfering with daily activities. It is one of the most common causes of dementia among the elderly population. Early diagnosis of Alzheimer's disease is crucial, as timely medical intervention can help slow disease progression, improve quality of life, and assist patients and caregivers in planning appropriate care. However, traditional diagnostic methods are often time-consuming, expensive, and dependent on expert clinical evaluation, which can lead to delays and inaccuracies in early-stage detection.

With the rapid advancement of medical imaging and artificial intelligence, deep learning techniques—particularly Convolutional Neural Networks (CNNs)—have shown great potential in automating the analysis of brain MRI scans. CNN-based models can effectively learn complex patterns and features from medical images, making them suitable for detecting subtle structural changes in the brain associated with different stages of Alzheimer's disease.

This project focuses on developing an efficient and accurate CNN-based system for the early prediction and classification of Alzheimer's disease using MRI scans. By leveraging advanced deep learning architectures such as DenseNet121, VGG19, and ResNet50, the proposed system aims to improve classification accuracy and reduce misclassification, especially in early stages like Non-Demented and Very Mild Demented cases. The system is designed to support multi-level classification and provide reliable predictions that can assist medical professionals and patients in early diagnosis and decision-making.

2. Literature Survey

Alzheimer's disease (AD) is a progressive neurodegenerative disorder and a leading cause of dementia worldwide. It poses a significant challenge to healthcare systems due to its increasing prevalence, high treatment costs, and the lack of a definitive cure. Early and accurate diagnosis of AD is essential for effective disease management and for slowing cognitive decline. In recent years, advancements in artificial intelligence, particularly Convolutional Neural Networks (CNNs), have enabled automated and reliable analysis of medical imaging data, making them highly suitable for Alzheimer's disease detection. This literature survey reviews existing research and methodologies that employ CNN-based techniques for AD detection and classification.

A. Introduction

Alzheimer's disease primarily affects memory, cognitive function, and behavior, gradually impairing an individual's ability to perform daily activities. Due to overlapping symptoms with other neurological disorders and subtle changes in early stages, accurate diagnosis remains challenging. Traditional diagnostic approaches rely heavily on clinical assessments and expert interpretation of brain imaging, which can be subjective and time-consuming. The motivation for using CNNs in AD detection arises from their ability to automatically learn hierarchical features from medical images and achieve high accuracy in classification tasks. This literature survey provides an overview of CNN-based approaches, imaging modalities, datasets, evaluation metrics, and future research directions in AD detection.

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B. Alzheimer's Disease and Imaging Modalities

Alzheimer's disease is clinically characterized by memory loss, impaired reasoning, and changes in behavior. Diagnostic criteria often include cognitive tests, patient history, and neuroimaging findings. Among imaging modalities, Magnetic Resonance Imaging (MRI) is widely used due to its ability to capture detailed structural changes in the brain, such as hippocampal atrophy and cortical thinning. Positron Emission Tomography (PET) is another imaging technique used to identify metabolic and amyloid-related changes in the brain. These imaging modalities provide valuable biomarkers that support the detection and staging of Alzheimer's disease.

C. Convolutional Neural Networks

Convolutional Neural Networks are a class of deep learning models specifically designed for image analysis. CNNs consist of convolutional layers for feature extraction, pooling layers for dimensionality reduction, and fully connected layers for classification. Key concepts such as weight sharing and local receptive fields allow CNNs to efficiently process high-dimensional image data. Activation functions like ReLU introduce non-linearity, enhancing model learning capability. Popular CNN architectures such as VGGNet, ResNet, and DenseNet have demonstrated superior performance in various image classification tasks, including medical imaging applications.

D. CNN-based Approaches for AD Detection

Several studies have explored the use of CNNs for detecting Alzheimer's disease from brain MRI scans. Researchers have employed both custom-built CNN models and transfer learning approaches using pre-trained architectures such as VGG19, ResNet50, and DenseNet121. These models have shown promising results in classifying different stages of Alzheimer's disease, including Non-Demented, Mild Cognitive Impairment, and Demented cases. Preprocessing techniques such as skull stripping, normalization, resizing, and data augmentation are commonly applied to improve image quality and enhance model performance. Comparative studies indicate that deeper architectures with residual or dense connections often achieve higher accuracy and better generalization.

E. Datasets and Evaluation Metrics

Publicly available datasets such as the Alzheimer's Disease Neuroimaging Initiative (ADNI) and Kaggle MRI datasets are widely used in CNN-based AD detection research. These datasets provide labeled MRI scans across different stages of Alzheimer's disease. Model performance is typically evaluated using metrics such as accuracy, sensitivity, specificity, and Area Under the Receiver Operating Characteristic Curve (AUC-ROC). These metrics help assess the reliability, robustness, and clinical relevance of the proposed models.

F. Challenges and Future Directions

Despite significant progress, CNN-based AD detection faces several challenges, including limited labeled data, class imbalance, and variations in imaging protocols. Overfitting and lack of model interpretability also remain concerns in clinical adoption. Future research directions include the use of multimodal data fusion, explainable AI techniques, ensemble learning, and larger, more diverse datasets to improve robustness and reliability. Additionally, optimizing models for early-stage detection remains a key focus area.

G. Conclusion

This literature survey highlights the effectiveness of Convolutional Neural Networks in detecting and classifying Alzheimer's disease using medical imaging data. CNN-based approaches have demonstrated high accuracy and potential for early diagnosis, outperforming traditional methods in many cases. However, addressing existing challenges and improving generalizability is essential for real-world clinical deployment. Continued research and technological advancements are expected to further enhance the role of deep learning in Alzheimer's disease detection and diagnosis.

3. Methodology

Fig. 1. System use case diagram

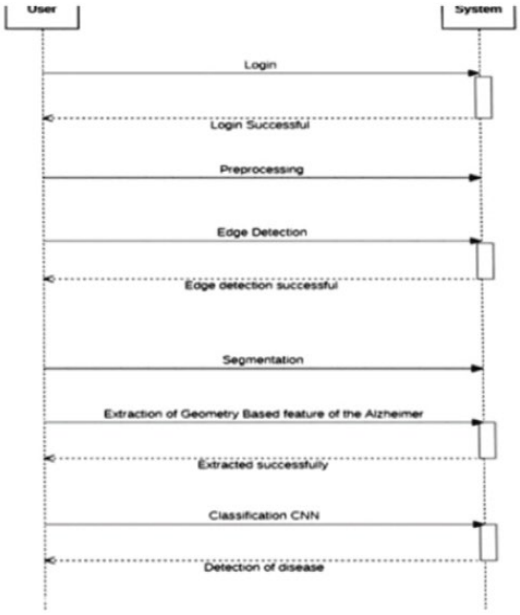

Fig. 2. Sequence diagram

Table 1

Test Case ID	Test Scenario	Pre conditions	Test Steps	Expected Results	Actual Results	Status: Pass/Fail
1	Non-Demented	Load model and preprocess the image	Select the image	Non-Demented	Non-Demented	Pass
2	Mild Demented	Load model and preprocess the image	Select the image	Mild Demented	Mild Demented	Pass
3	Very Mild Demented	Load model and preprocess the image	Select the image	Very Mild Demented	Very Mild Demented	Pass
4	Mild Demented	Load model and preprocess the image	Select the image	Mild Demented	Mild Demented	Pass
5	Non-Demented	Load model and preprocess the image	Select the image	Non-Demented	Non-Demented	Pass
6	Non-Demented	Load model and preprocess the image	Select the image	Non-Demented	Non-Demented	Pass
7	Mild Demented	Load model and preprocess the image	Select the image	Mild Demented	Mild Demented	Pass
8	Moderate Demented	Load model and preprocess the image	Select the image	Moderate Demented	Non-Demented	Fail
9	Non-Demented	Load model and preprocess the image	Select the image	Non-Demented	Non-Demented	Pass
10	Mild Demented	Load model and preprocess the image	Select the image	Mild Demented	Mild Demented	Pass

4. Results

In this project, three different CNN Algorithms have been used, i.e., DenseNet121, VGG19, ResNet50. These are there accuracies respectively,

VGG19: 88.86%

ResNet50: 92.89%

DenseNet121: 93.25%

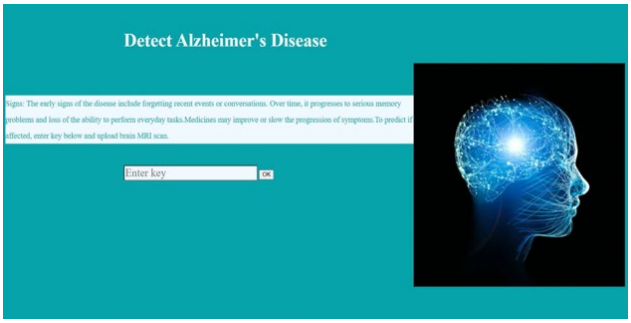

Fig. 3.

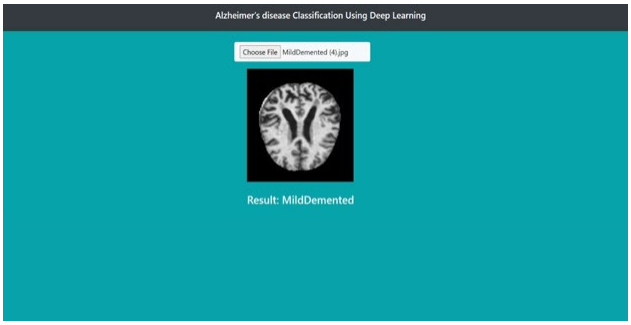

Fig. 4.

Accuracy achieved by using DenseNet121 – 93.25%.

5. Conclusion and Future Scope

In conclusion, the detection of Alzheimer's disease using convolutional neural networks (CNNs) holds great promise in the field of medical imaging analysis. By influencing the power of CNNs to extract relevant features from brain images, it is possible to develop accurate and efficient systems for Alzheimer's detection. However, it is important to note that designing an effective Alzheimer's detection system is a complex task that requires careful consideration of various factors, including data quality, model architecture, and evaluation metrics. Furthermore, the ethical implications and privacy concerns must be addressed when deploying such a system in a real-world setting. With continued research, advancements in deep learning techniques, and access to large and diverse datasets, CNN-based approaches for Alzheimer's detection have the potential to contribute significantly to early diagnosis and intervention, leading to improved patient outcomes and a deeper understanding of the disease. Future work including the usage of data from other modalities like PET, fMRI can be used to improve the performance.

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