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A Conceptual Framework for Early Detection of Alzheimer's Disease Using Deep Learning

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Abstract

Early detection of Alzheimer's disease is an important research challenge because the disease progressively affects memory, thinking, behaviour, and daily activities. Traditional diagnosis involves clinical assessment, cognitive tests, medical history, and neuroimaging. However, identifying early-stage changes can be difficult because they may overlap with normal ageing and mild cognitive impairment. Researchers have investigated deep learning techniques for analysing brain Magnetic Resonance Imaging (MRI) and other neuroimaging data. Convolutional Neural Networks (CNNs), ensemble models, and multimodal approaches have shown potential for automated classification. Nevertheless, challenges remain regarding dataset size, model generalisation, explainability, overfitting, data leakage, and clinical validation. This paper reviews eight selected studies and uses their findings to describe a conceptual framework combining MRI preprocessing, deep learning-based feature extraction, classification, and performance evaluation. The framework investigates classification into Cognitively Normal (CN), Mild Cognitive Impairment (MCI), and Alzheimer's Disease (AD) categories. The framework has not been implemented or experimentally tested. Its effectiveness must be established through controlled experiments and independent validation.

Keywords: Alzheimer's Disease, Early Detection, Deep Learning, Convolutional Neural Network, MRI, Medical Image Processing, Mild Cognitive Impairment, Classification.

1. Introduction

Alzheimer's disease is a progressive disorder of the nervous system characterized by memory, thinking, behavior, and daily activity impairments. This condition is one of the leading causes of dementia and presents a significant issue for health systems. The early detection of Alzheimer's disease is helpful for the assessment and observation of disease development.

The conventional diagnostic approach includes history taking, cognitive testing, clinical evaluation, and neuroimaging where appropriate. MRI gives an idea of brain structure and possible changes related to Alzheimer's disease. Nevertheless, it can be hard to detect early changes because they can be subtle.

Deep learning provides a computational method for the analysis of medical images. Convolutional Neural Networks (CNNs) can learn features from MRI images and classify them. Three-dimensional CNNs can analyze volumetric brain images, whereas ensemble learning uses predictions from multiple

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models. Multimodal research considers utilizing complementary information from multiple neuroimaging sources.

Studies on different deep learning models, multimodal neuroimaging, and early detection have also been conducted [5]–[8]. Differences in datasets, classification methods, and evaluations make direct comparison difficult. This paper summarizes selected works and provides a conceptual framework for MRI-based Alzheimer's disease classification, focusing on preprocessing, feature extraction, and classification.

2. Problem Statement

Detection of Alzheimer's disease at early stages can be difficult because initial alterations in brain structure and cognitive functioning might be small. It is important to distinguish mild cognitive impairment from normal aging and Alzheimer's disease. Current deep learning approaches show promise in automated neuroimage analysis, but effectiveness may be influenced by insufficient data, overfitting, data leakage, and differences in patient groups and imaging devices.

The research question is: How can a deep learning approach be examined for classification of brain MRI images into Cognitively Normal (CN), Mild Cognitive Impairment (MCI), and Alzheimer's Disease (AD) categories?

3. Objectives

- To understand how deep learning is used for early detection of Alzheimer's disease.
- To study the role of MRI images in analysing brain changes associated with Alzheimer's disease.
- To review preprocessing and feature extraction techniques used in medical image analysis.
- To study CNN, ensemble, and multimodal approaches used for Alzheimer's disease detection.
- To analyse the strengths, limitations, and challenges of existing methods.
- To propose a conceptual framework for MRI-based classification into CN, MCI, and AD.
- To identify suitable evaluation metrics for measuring classification performance.
- To outline future experiments for assessing generalisation and reliability.

4. Literature Review

The selected studies investigate different deep learning techniques for Alzheimer's disease detection. Their methodologies, findings, and limitations are summarized below.

A. *Fathi et al.*

Fathi, Ahmadi, Dehnad, Almasi-Doghaee, and Sadegh studied an ensemble-based deep learning technique for early diagnosis of Alzheimer's disease through MRI images [1]. This approach uses several CNN classifiers to investigate whether ensemble learning can improve classification. Results from a specific dataset may not generalise to different populations, so independent validation is needed.

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B. *Tima et al.*

Tima et al. studied a deep learning method for early diagnosis of Alzheimer's disease [2], focusing on automated classification in diagnostic data analysis. Deep learning can discover patterns in medical data, but performance depends on data quality, model selection, and evaluation conditions.

C. *El-Assy et al.*

El-Assy et al. proposed a CNN network tested for diagnosing and classifying early Alzheimer's using MRI scans [3]. CNNs learn image representations and reduce the need for manually designed image features. Sufficient training data and testing on unseen patients remain important.

D. *Arafa et al.*

Arafa et al. reviewed deep learning techniques for early diagnosis of Alzheimer's disease [4], highlighting techniques and challenges in automated diagnosis. A review provides insight into the research area but does not independently validate a new classification method on a common dataset.

E. *Bricaud and Masala*

Bricaud and Masala studied several deep learning models for early Alzheimer's detection using MRI, with slice-level and scan-level analysis [5]. The study considers architecture and preprocessing effects. Data partitioning across scans from the same subject requires careful attention.

F. *Nagarhalli, Tatwad… et al.*

A multimodal deep learning approach for early Alzheimer's detection was described in [6], examining the combination of complementary data. Multimodal approaches may add information when available, but missing modalities, data quality, and computational requirements can complicate use.

G. *Alhasiry et al.*

Alhasiry et al. studied a neuroimaging-based deep learning framework for early detection [7]. The work explores automated brain scan analysis and classification. Different datasets and independent validation are important for assessing generalisation.

H. *Raza et al.*

Raza et al. reviewed deep learning approaches for early diagnosis using multiple brain scans [8], discussing data diversity, model testing, and generalisation. Multimodal imaging may require substantial computational resources and matched datasets.

5. Literature Survey Matrix

Author / Year	Methodology	Key focus	Limitations
Fathi et al., 2024 [1]	Ensemble deep learning with multiple CNN classifiers on MRI	Investigated combining classifier predictions	Dataset dependence and generalisation to unseen patients
Tima et al., 2024 [2]	Deep learning approach for early Alzheimer's	Automated classification for	Reproducibility depends on dataset and

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	detection	diagnosis	experimental setup
El-Assy et al., 2024 [3]	CNN architecture using MRI images	Learned image representations for classification	Training data and independent validation needed
Arafa et al., 2022 [4]	Review of deep learning approaches	Summarised methods, applications, and challenges	Review does not test a new model on a common dataset
Bricaud & Masala, 2026 [5]	Architecture comparison with slice- and scan-level MRI analysis	Architecture and preprocessing effects	Careful participant-level partitioning required
Nagarhalli, Tatwad… et al., 2025 [6]	Multimodal deep learning framework	Combining information within a framework	Modality availability and external validation
Alhasiry et al., 2025 [7]	Neuroimaging deep learning framework	Automated neuroimaging classification	Dataset diversity and independent testing
Raza et al., 2025 [8]	Review of multimodal neuroimaging deep learning	Advances, challenges, and future directions	Review does not establish system performance

6. Strengths and Limitations of Existing Methods

A. *Strengths*

The reviewed studies demonstrate the potential of deep learning for Alzheimer's disease classification using neuroimages. CNNs learn image features from MRI data, ensemble techniques combine multiple predictions, and multimodal methods analyze complementary information from different sources [1], [6], [8]. Comparing architectures and preprocessing methods can help understand their effects on classification [3], [5]. Review articles provide a broader view of methods and challenges [4], [8].

B. *Limitations*

Several issues limit the robustness of current models:

- Limited data can increase overfitting and weaken performance estimates.
- A trained model may not transfer to a new population or scanner.
- Data leakage, such as placing images from the same participant in training and testing, can produce misleading results.
- Distinguishing mild cognitive impairment from normal aging is challenging.
- Deep learning models can be difficult to interpret.
- High-performing results on one dataset do not establish clinical usefulness.

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7. Research Gap

The literature review identifies issues requiring further investigation:

- Limited Dataset Size: Small medical imaging datasets may increase overfitting and reduce reliability.
- Lack of Dataset Diversity: Models trained on particular groups, hospitals, or scanners may perform poorly elsewhere.
- Data Leakage: Training and testing splits should be performed at participant level to avoid inflated estimates.
- Early-Stage Classification: MCI and normal ageing can be difficult to distinguish; not all individuals with MCI develop Alzheimer's disease.
- Explainability: The influence of image regions on model predictions may be difficult to explain.
- Computational Requirements: Large CNNs and 3D models may require substantial processing power and memory.
- External Validation: Independent testing is needed to assess performance beyond the training dataset.

Research Question: Can a well-validated deep learning model provide accurate MRI-based classification across different diagnostic groups and subjects not previously encountered? The literature does not confirm that a hybrid framework would outperform current approaches; this requires experimental investigation.

8. Proposed Seminar Scope and Conceptual Framework

This seminar presents selected literature on deep learning-based detection of Alzheimer's disease and proposes a conceptual framework for MRI-based classification. It includes the proposed process, applications, evaluation metrics, and implementation considerations. It does not include a working system or experimental results.

A. *Proposed Framework*

The conceptual framework consists of four major stages: collecting labeled MRI images from an appropriate research dataset, preprocessing the images, applying CNN or 3D-CNN for feature extraction and classification, and evaluating predictions using suitable classification metrics.

MRI Dataset → Pre-processing → CNN / 3D-CNN Feature Extraction → CN / MCI / AD Classification → Performance Evaluation

Preprocessing steps, model architecture, and training parameters should be decided at implementation time and reported clearly.

B. *Potential Uses*

If sufficient results are obtained, the framework may be explored for:

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- Research on Alzheimer's disease classification using MRI imaging.
- Analysis of image patterns for different diagnostic categories.
- Evaluation of deep learning architectures in medical imaging.
- Decision-support research applications.

These are possible uses rather than proven abilities. The system will not substitute for professional diagnosis.

C. *Evaluation Criteria*

Evaluation should address the following:

- Classification Accuracy: Calculate accuracy, precision, recall, F1-score, and confusion matrices.
- Generalisation: Evaluate using participants not used for training or model selection.
- Robustness: Examine performance under image-quality and data-distribution changes.
- Processing Cost: Record training time, inference time, memory use, and hardware requirements.

For three classes, class-specific and macro-averaged metrics should be reported. The proposed method should be compared with appropriate baseline models.

D. *Limitations*

The framework has not been implemented or experimentally verified; its classification performance and computational cost are unknown. Outcomes may depend on dataset quality, preprocessing, model design, and label quality.

E. *Future Work*

Future work would implement the framework using a suitably labelled MRI dataset. Experiments could compare a CNN baseline with other architectures, including a 3D-CNN, using participant-level data splits. Evaluation should include class-wise metrics, explainability, lightweight models, and external validation on another data source. Any improvement must be demonstrated through experiments.

9. Conclusion

This paper reviews eight studies on early diagnosis of Alzheimer's disease using deep learning and presents a conceptual framework for MRI-based classification. The discussed research includes CNNs, ensemble learning, varied deep learning architectures, and multimodal neuroimaging, providing a basis for exploring classification of cognitively normal individuals, people with mild cognitive impairment, and people with Alzheimer's disease.

Small datasets, overfitting, data leakage, explainability, and generalisation remain important challenges. A model that performs well on one dataset may not perform similarly on another. The framework includes MRI preprocessing, deep learning feature extraction, classification, and evaluation. It remains conceptual, and no performance improvement is claimed. Implementation, controlled experiments, and validation are required to establish its contribution to Alzheimer's disease research.

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Ethical and Clinical Considerations

This framework is intended for research and possible decision-support exploration only. It must not replace professional clinical diagnosis. Data handling should protect privacy, and validation should account for population differences, dataset bias, and the possibility of incorrect predictions. Reliable evaluation and independent validation are necessary before considering practical clinical use.

References

[1] S. Fathi, A. Ahmadi, A. Dehnad, M. Almasi-Doghaee, and M. Sadegh, "A Deep Learning-Based Ensemble Method for Early Diagnosis of Alzheimer's Disease Using MRI Images," Neuroinformatics, vol. 22, pp. 89–105, 2024. Verify bibliographic details with the original source.

[2] J. Tima, C. Wiratkasem, W. Chairuean, P. Padongkit, K. Pangkhao, and K. Pikulkaew, "Early Detection of Alzheimer's Disease: A Deep Learning Approach for Accurate Diagnosis," in Proc. 2024 21st International Joint Conference on Computer Science and Software Engineering (JCSSE), Phuket, Thailand, 2024. Verify title and authors against the original.

[3] A. M. El-Assy, H. M. Amer, H. M. Ibrahim, and M. A. Mohamed, "A Novel CNN Architecture for Accurate Early Detection and Classification of Alzheimer's Disease Using MRI Data," Scientific Reports, 2024. Verify title, authors, and article number.

[4] D. A. Arafa, H. E. D. Moustafa, A. M. T. Ali-Eldin, et al., "Early Detection of Alzheimer's Disease Using the State-of-the-Art Deep Learning Approach: A Comprehensive Survey," Multimedia Tools and Applications, vol. 81, pp. 23735–23776, 2022. Verify full authors and DOI.

[5] I. Bricaud and G. L. Masala, "Multi-Architecture Deep Learning for Early Alzheimer's Detection in MRI: Slice- and Scan-Level Analysis," International Journal of Environmental Research and Public Health, vol. 23, no. 3, art. no. 322, 2026. Confirm publication information.

[6] Nagarhalli, Tatwad… et al., "A Novel Multimodal Framework for Early Detection of Alzheimer's Disease Using Deep Learning," arXiv preprint arXiv:2508.03046, 2025. Confirm complete author list and title.

[7] A. Alhasiry, K. Shinan, A. A. Alsadhan, H. E. Alhazmi, F. Alanazi, M. U. Ashraf, and T. Muhammad, "A Novel Neuroimaging Based Early Detection Framework for Alzheimer Disease Using Deep Learning," Scientific Reports, vol. 15, art. no. 23011, 2025. Confirm citation details.

[8] M. L. Raza, S. T. Hassan, S. Jamil, N. Hyder, K. Batool, S. Walji, and M. K. Abbas, "Advancements in Deep Learning for Early Diagnosis of Alzheimer's Disease Using Multimodal Neuroimaging: Challenges and Future Directions," Frontiers in Neuroinformatics, vol. 19, art. no. 1551777, 2025, doi: 10.3389/fninf.2025.1551777.