**Title:** ***Using Deep Learning to Detect Alzheimer's Disease: A Neuroimaging-Based Approach***

## 1. Introduction

Alzheimer's Disease (AD) is a progressive neurodegenerative disorder that affects millions of people worldwide, leading to memory loss, cognitive impairment, and ultimately, loss of autonomy. Early diagnosis is crucial to slowing disease progression and improving the quality of life for patients and caregivers. However, traditional diagnostic methods, such as neuropsychological tests and clinical assessments, are often subjective and may not detect the disease in its early stages.

Recent advances in medical imaging and artificial intelligence (AI) have opened new possibilities for objective, early detection of Alzheimer's Disease. Deep learning, a subset of AI, has demonstrated strong potential in image classification and pattern recognition tasks. This proposal aims to explore how deep learning can be used to detect AD using neuroimaging data, particularly structural Magnetic Resonance Imaging (MRI) scans.

## 2. Research Problem

Current diagnostic techniques for Alzheimer's are either invasive (e.g., cerebrospinal fluid analysis) or rely heavily on clinical interpretation, which introduces variability. Although MRI provides rich structural data of the brain, manual interpretation is time-consuming and error-prone. There is a growing need for automated, accurate, and interpretable tools that can assist clinicians in diagnosing AD, especially in its early or mild cognitive impairment (MCI) stages.

## 3. Objectives

The primary objectives of this research are:

- To develop a deep learning model capable of detecting Alzheimer's Disease from structural MRI scans.
- To compare the performance of different deep neural network architectures, including Convolutional Neural Networks (CNNs) and Vision Transformers (ViTs).
- To evaluate the model's ability to classify between Normal Control (NC), Mild Cognitive Impairment (MCI), and Alzheimer's Disease (AD) groups.
- To explore the interpretability of the model using visualization techniques such as Grad-CAM.

## 4. Methodology

### 4.1 Dataset

The research will utilize publicly available datasets such as the Alzheimer's Disease Neuroimaging Initiative (ADNI), which provides high-resolution MRI scans of patients labeled as NC, MCI, and AD. Preprocessing steps will include normalization, skull stripping, and resizing to a standard input shape.

### 4.2 Model Development

We will experiment with multiple deep learning architectures:

- **CNN-based Models**: 3D CNNs are suited for volumetric data like MRI. Variants such as ResNet3D and DenseNet3D will be evaluated.
- **Transformer-based Models**: Vision Transformers (ViT) will be adapted for 3D medical imaging using attention mechanisms.
- **Hybrid Models**: Combinations of CNN and transformer components to capture both local and global features.

### 4.3 Training and Evaluation

- Models will be trained using stratified k-fold cross-validation.
- Performance will be assessed using accuracy, precision, recall, F1-score, and AUC-ROC.
- Interpretability will be ensured using Grad-CAM or occlusion sensitivity maps to highlight key brain regions.

## 5. Expected Outcomes

- A deep learning model with high classification accuracy for detecting Alzheimer's stages.
- Insights into brain regions most correlated with AD, improving clinical interpretability.
- A comparative analysis of CNNs vs. ViTs in neuroimaging tasks.
- A prototype of a decision-support tool that can be integrated into clinical workflows.

## 6. Significance of the Study

This research will contribute to the field of medical AI by demonstrating the feasibility and effectiveness of deep learning for neurodegenerative disease diagnosis. An accurate, automated model for AD detection will assist neurologists in early diagnosis and may pave the way for more personalized and timely treatment interventions.

## 7. Timeline

**Year 1:**
Conduct an in-depth literature review, define the research problem, and initiate preliminary data collection.

**Year 2:**
Develop and design the AI model, followed by training and testing using the collected data.

**Year 3:**
Perform comprehensive evaluation and interpretation of the results, and complete the final report and publication of findings.

## 8. References


1. Jack, C. R., et al. (2010). Hypothetical model of dynamic biomarkers of the Alzheimer's pathological cascade. *The Lancet Neurology*, 9(1), 119–128.
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4. Wang, S. H., et al. (2021). Alzheimer's Disease Classification via 3D ResNet and Radiomics. *Frontiers in Aging Neuroscience*, 13, 672430.