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Master's Thesis Project in Information Systems and Web:

A Deep Learning–Based Approach for Alzheimer's Disease Detection from Brain MRI Images Through Attention-Enhanced Convolutional Neural Networks

1. Description

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that leads to cognitive decline, memory impairment, and loss of functional abilities. Early detection of AD is crucial for timely clinical intervention and disease management. Magnetic Resonance Imaging (MRI) is widely used for analyzing structural brain changes associated with Alzheimer's disease, such as hippocampal atrophy and cortical thinning. In recent years, deep learning, particularly Convolutional Neural Networks (CNNs), has demonstrated strong potential in automatically extracting discriminative features from brain MRI images for disease detection [1]. However, conventional CNN models often focus on global image features and may fail to capture subtle, localized anatomical changes related to early-stage Alzheimer's disease. To address this limitation, recent studies have introduced attention-enhanced CNN architectures, which allow models to focus on the most informative regions of MRI images, leading to improved classification accuracy and interpretability [2]. Moreover, comprehensive reviews highlight that attention-based and hybrid deep learning models consistently outperform traditional machine learning and standard CNN approaches in MRI-based Alzheimer's disease detection tasks [3].

This project proposes the design and implementation of an attention-enhanced CNN framework for Alzheimer's disease detection from brain MRI images. The proposed approach aims to improve diagnostic performance by combining deep feature extraction with attention mechanisms that emphasize disease-relevant brain regions. The system will be trained and evaluated using publicly available MRI datasets, and its performance will be compared with baseline deep learning models.

2. Problem Statement

Despite significant advancements in deep learning for medical image analysis, accurate detection of Alzheimer's disease from MRI images particularly at early stages remains a challenging task. Several factors contribute to this challenge:

- First, structural brain changes in early Alzheimer's disease are subtle and highly variable across individuals, making them difficult to identify using traditional feature extraction techniques and standard CNN architectures [3,4]. Although CNNs can learn hierarchical representations, they may not sufficiently emphasize the most discriminative anatomical regions relevant to AD progression.
- Second, the high dimensionality and complexity of MRI data increase the risk of overfitting and reduce model generalizability across different datasets and imaging conditions. Recent studies emphasize the need for more robust architectures that can selectively focus on relevant features while suppressing irrelevant information [5].
- Third, there is a growing demand for model interpretability in clinical applications, where clinicians require insight into the regions of the brain that influence automated diagnostic decisions. Attention mechanisms have been shown to enhance both performance and interpretability by generating attention maps that highlight disease-related brain regions.

These challenges indicate the necessity of developing a deep learning-based approach that integrates attention mechanisms within CNN architectures to improve accuracy, robustness, and interpretability for Alzheimer's disease detection from brain MRI images.

3. Contributions

- Development of a convolutional neural network (CNN)–based model for the detection of Alzheimer's disease from brain MRI images.
- Implementation of basic MRI preprocessing steps, including image normalization, resizing, and data augmentation, to improve data quality and model performance.
- Incorporation of an attention mechanism to enhance the model's ability to focus on relevant brain regions associated with Alzheimer's disease.
- Performance evaluation of the proposed approach using standard classification metrics and comparison with a baseline CNN model.

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