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Convolutional Neural Networks Algorithm for Detecting Alzheimer's Disease

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ABSTRACT

The identification of Alzheimer's disease (AD) has become crucial in recent years due to the global increase in life expectancy. If mild cognitive impairment (MCI) occurs, it can progress to Alzheimer's disease and dementia because it permanently impairs the patient's mental ability. Many researchers have given this condition their undivided focus since, if caught early enough, it can be treated and its progression halted. Psychological examinations and biochemical tests are frequently used to diagnose the illness. The analysis of magnetic resonance imaging (MRI) scans, which are used to examine changes in the structure of the human brain, is one of the suggested methods for detecting Alzheimer's disease. The SPM (Statistical Parametric Mapping) toolbox is used in this study to preprocess brain MRI images before segmenting the brain's gray matter (GM) and feeding it into the convolutional neural network (CNN) algorithm. The ADNI (Alzheimer's Disease Neuroimaging Initiative) dataset is used in this paper. Based on the test's results, we could accurately distinguish the three groups of normal control (NC), Alzheimer's disease, and moderate cognitive impairment.

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Abbreviations

AD, Alzheimer's Disease; MCI, Mild Cognitive Impairment; GM, Gray Matter; CNN, Convolutional Neural Network; ADNI, Alzheimer's Disease Neuroimaging Initiative; NC, Normal Control; SPM, Statistical Parametric Mapping; PD, Parkinson's Disease; RBM, Restricted Boltzmann machine; AAL atlas, Automated Anatomical Labeling atlas

Introduction

The most significant kind of dementia and memory loss, Alzheimer's disease is a type of brain malfunction (1). In order to stop progression, early detection is crucial (2). The use of magnetic resonance imaging (MRI) of the brain is currently thought to be one of the finest methods for the early identification of Alzheimer's disease (3). Numerous investigations have been conducted to pinpoint regions linked to Alzheimer's (4, 5). The most visible sign of Alzheimer's illness is hippocampal loss (6). The number of hippocampus voxels, the cortex's thickness, and the structure of the hippocampus have all been studied (7). MRI scans with Voxel-based morphometry and the SPM (Statistical Parametric Mapping) toolbox are frequently used to make the diagnosis of Alzheimer's disease (8). The SVM algorithm is used in (9) to categorize Alzheimer's disease and healthy control. Support vector machine (SVM) is used by Rafieipour et al. (10) to identify Parkinson's disease (PD). Despite being widely used, SVM has come under fire for its subpar performance on raw data and the fact that design technology experts are required to extract instructional features. This method's dependence on manually created features is another drawback because it is unable to extract adaptive features. This research classifies data using deep learning methods to prevent this kind of issue. Deep learning algorithms' superior performance over other traditional classification techniques is its key selling point.

Due to its high efficiency, convolutional neural network (CNN) is one of the machine learning techniques that is widely used in feature extraction and image categorization (11). An artificial neural network designed for the processing and manipulation of multidimensional data, such as photographs, is known as a CNN. A structure meant to resemble the human visual system has been tried. CNNs, like other artificial neural networks, are composed of neurons that store weights and biases and, in later layers, offer a means of decision-making. Let's say we wish to classify photographs using all linked layers of regular neural networks. The amount of each buried layer will thus be enormous, and the updating procedure will be very long.

This network gives a structure that may be utilized to extract the greatest features from photos, setting it apart from other neural networks. There are numerous categorization algorithms, as indicated in (12). For huge data, the Convolution Neural Network technique is appropriate. A convincing deep learning model suitable for network data, such as RGB and magnetic resonance pictures, has been proven to exist in CNN. The application of CNN's has rapidly increased in a variety of industries as a result of AlexNet's exceptional achievement in natural picture categorization. To categorize facial emotions, Altaher et al. (13) used an ensemble multi-inception CNN model. They compared the outcomes to CNN, Deep Belief Networks, and the Restricted Boltzmann machine (RBM). The multi-inception ensemble CNN model outperforms the other models in terms of accuracy.

The Proposed Method and Results

This article seeks to differentiate between Alzheimer's disease (AD) and mild cognitive impairment (MCI). The ADNI (Alzheimer's Disease Neuroimaging Initiative) dataset (14) is used in this study. Figure 1 depicts sample scan slices from the ADNI dataset of AD, MCI, and also NC (normal control). We begin by converting 3D brain pictures into sagittal slices. The SPM toolbox is used in the subsequent phase to pre-process the slices, remove motion noise and noise brought on by scanner errors, and normalize all the pictures. We then divide the white matter, gray matter, and cerebrospinal fluid in the brain slices. In this article, the gray matter of the brain and the hippocampus are the main topics. The pictures of the gray matter of the brain are transformed into one-dimensional vectors in the final stage, and then the CNN algorithm is used to extract the feature. Figure 2 displays the algorithm in broad strokes.

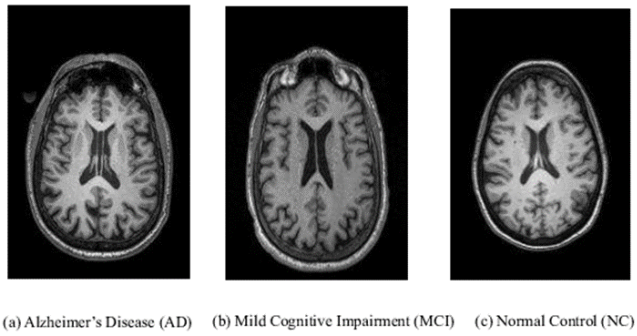

Figure 1. Sample scan slices from the ADNI Dataset of (a) Alzheimer's Disease (AD), (b) Mild cognitive impaiment (MCI), and (c) Normal control (NC) (14).

According to the findings, the hippocampus area of the brain is where there are the greatest differences between brain pictures of people with Alzheimer's disease and those of healthy controls.

As previously noted, the CNN algorithm is used to produce three kinds of segmented data: NC, AD, and MCI. In the final phase, we feed the segmented images of the brain to the CNN algorithm. Using raw data as an input, CNN models enable the system to recognize important traits and appropriately classify them. Without human assistance, classification results are generated automatically based on CNN's choice.

Figure 3 illustrates how the CNN algorithm processed data. We conducted the trials twice, once on the brain's entire gray matter and once just on the hippocampus that was removed from the segmentation area. The CNN algorithm's classification accuracy in both instances was greater than 99%.

Figure 4 displays how the photos associated with NC, AD, and MD were distinguished from one another in layer 4 of the CNN.

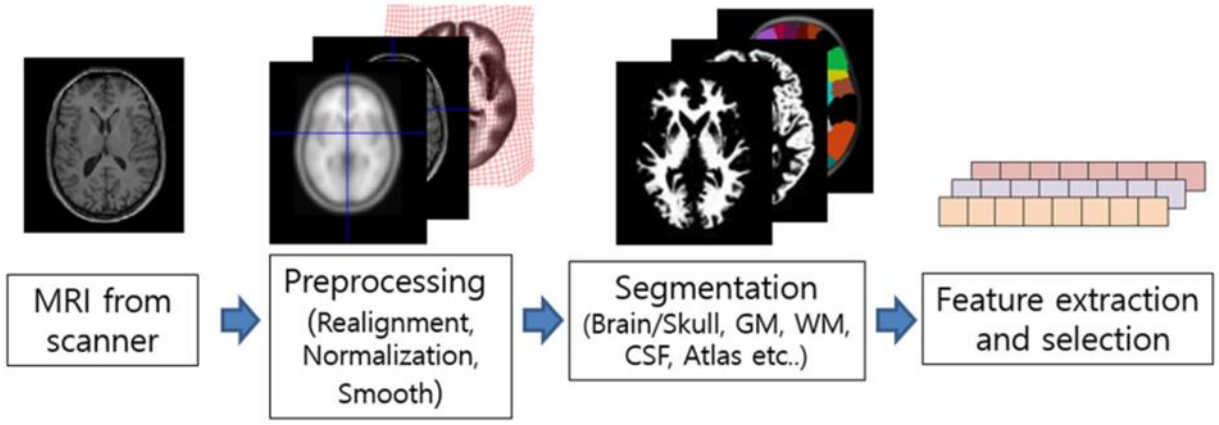

Figure 2. An overview of the proposed algorithm.

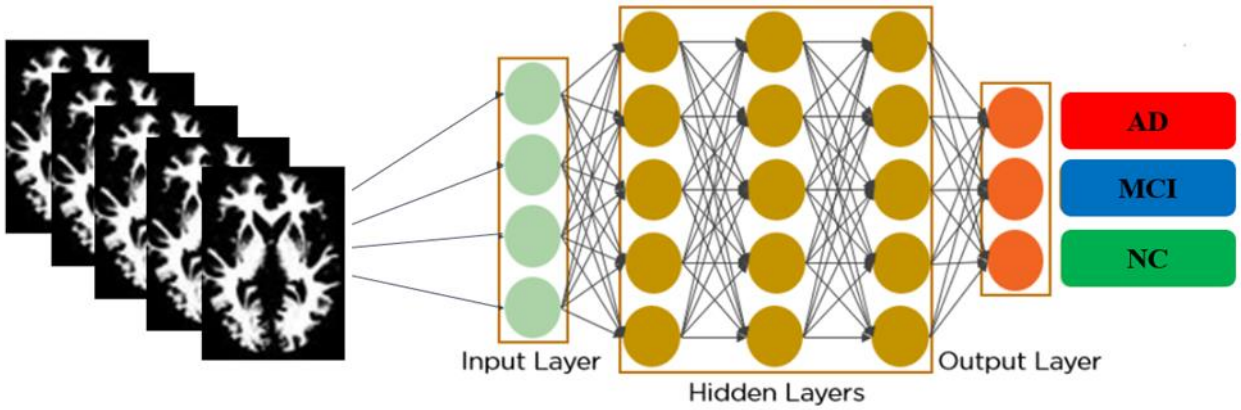

Figure 3. Data classification by convolution neural network algorithm.

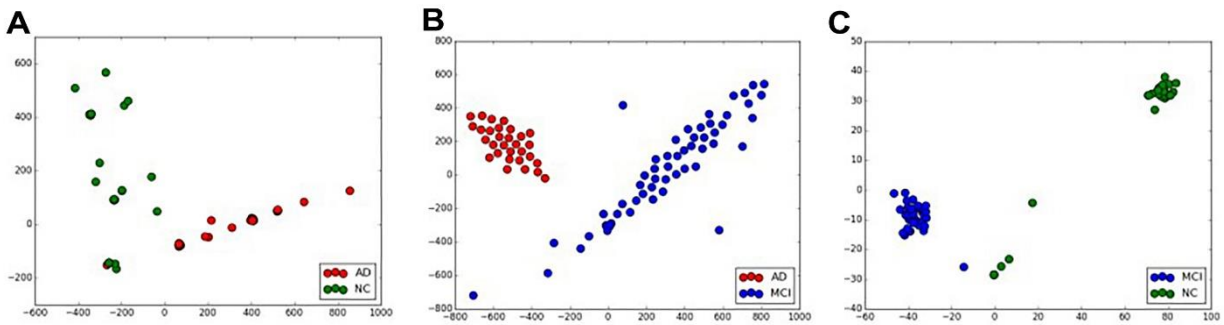

Figure 4. (A) Classification of AD vs. NC, (B) Classification of AD vs. MCI, (C) Classification of MCI vs. NC.

Conclusion

Brain scan characteristics are categorized to make an early diagnosis, which is crucial for both treating and preventing Alzheimer's. The traits must accurately reflect the underlying alterations in physical brain structures brought on by AD, such as changes in hippocampal shape, cortical thickness, and brain volume. With the help of a CNN that can pick up general information from the SPM toolkit, this study aims to forecast the onset of Alzheimer's disease. In this study, we initially used the SPM toolbox to pre-process three-dimensional brain magnetic resonance images from the ADNI dataset. As a result, the photos were cleaned of noise. Following that, we categorized the collected brain slices into three categories: white matter, gray matter, and cerebrospinal fluid using the MNI AAL (automated anatomical labeling) atlas to arrange the pictures in the same coordinate system. Using the SPM toolbox, we also segmented the hippocampus area of the brain's gray matter. After which a one-dimensional vector representing these qualities was created and supplied as input to the CNN algorithm. According to the test's results, we were able to accurately identify the three groups into NC, AD, and MCI. This study introduced a novel method for predicting Alzheimer's disease based on structural brain MRI scans that performs better than several of the most effective predictors available right now. It may be wise to look into quantum networks and algorithms from an information perspective when machine learning and quantum technologies with increasing complexity develop as papers

Declaration

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Conflicts of interest/Competing interests
The author declares no conflict of interest.

Authors' contributions
ZB designed the study concept, collected and interpreted the data and drafted the manuscript.

Ethics approval
Not applicable.

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