MJFAS
Malaysian Journal of Fundamental and Applied Sciences

RESEARCH ARTICLE

Early Diagnosis of Alzheimer's Disease using Convolutional Neural Network-based MRI

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Abstract Alzheimer's disease (AD) is a neurodegenerative ailment that causes cognitive deterioration due to changes in brain structure. Individuals usually see diagnostic symptoms after irreversible brain damage has occurred. In order to slow the course of the illness and enhance the quality of life for AD patients, early diagnosis is crucial. Recent advances in machine learning and scanning have made the use of these methods to detect AD in its earliest stages possible. This article uses deep learning using CNN methods to extract picture characteristics from ADNI (Alzheimer's Disease Neuroimaging Initiative) datasets to improve Alzheimer's disease diagnosis techniques. This descriptor will be used in conjunction with the CNN to categorize the illness and add new characteristics that are more accurate, quicker, and stable than the current features. In this process, an Alzheimer's detection System will be implemented to mitigate the adverse effects of data imbalance on recognition performance, and an integrated multi-depth architectural technology will be introduced to boost recognition quality. Using the suggested model of the convolution neural network (CNN) technique, classification accuracy results were obtained above 97%.

Keywords: Alzheimer's disease, dementia: MRI image, ADNI.

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Received: 3 Nov. 2022
Accepted: 11 April 2023

Introduction

Alzheimer's disease (AD) is a neurological disorder of a type of dementia that affects memory, behaviour, and ability to understand. That disease, that gradually destroys brain cells, resulting in memory and thought problems. In advanced stages, the ability fails to perform the most basic tasks the brain performs [1]. Structural Magnetic Resonance Imaging (MRI) and resting-state functional Magnetic Resonance Imaging (fMRI) are non-invasive techniques for analysing the anatomy of the brain, functional brain behaviour, and brain changes. Some of the early symptoms of Alzheimer's disease can be seen in imaging data contribute to delaying disease progression and help in obtaining necessary disease care. which must be used in combination with additional clinical knowledge outcomes to accurately classify the data [2]. There is a special technique for obtaining imaging sections of the human brain, where radioactive drugs are needed with MRI devices to obtain high-resolution results. It contributes to provide precise and timely diagnoses for Alzheimer's patients [3]. Figure 1 illustrates the stages of the development of Alzheimer's disease which are divided into three types which are, Non-Dementia, Mild Dementia, Very Mild Dementia and Moderate Dementia [4]. Figure 1 illustrates the stages of Alzheimer's disease with magnetic resonance imaging of the brain.

10.11113/mjfas.v19n3.2908

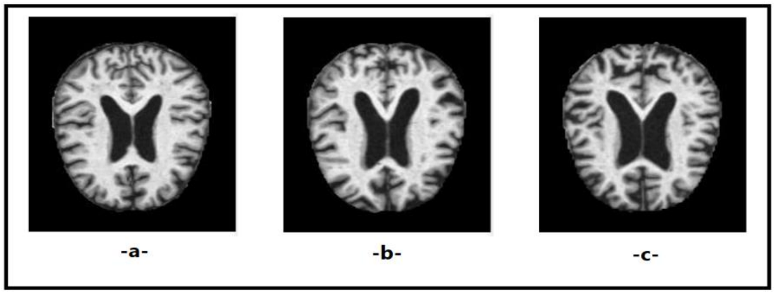

Figure 1. Alzheimer's disease stage (a: very mild dementia, b: mild dementia, and c: moderate dementia)

Despite the encouraging results achieved in all previous works, non-neglected weaknesses were noted in the previously proposed schemes. Previous research focused on one of the main advantages of diagnosing the disease [5]8,[6]. Yet, results accuracy depends on quality factor of entered data, and its effects on the results. More accurate results can be obtained by extracting the characteristics of the MRI images regarding the type of used data [7]. Ischemic-Stroke is a medical emergency, and early detection and action will help the patient recover quickly. the proposed scheme can help in the early diagnosis of many brain diseases such as stroke, to get the infected part out of the MRI slice of the brain and look at it [8].

This paper we provide more accurate classification based convolutional neural network algorithms to extracting feature for brain condition using MRI images from ADNI (Alzheimer's Disease Neuroimaging Initiative) is a multi-center research with the ultimate goal of bettering clinical trials for the diagnosis, treatment, and eventual prevention of Alzheimer's disease (AD) [9].

Data Collection

The Alzheimer's Disease Neuroimaging Initiative (ADNI) provided the MRI image data we used since it is publicly available online (http://www.loni.ucla.edu/ADNI) and has been well structured and processed. T1 and T2 MRI images acquired on 1.5T and 3T scanners are part of the ADNI database. ADNI has also converted the picture file to Neuroimaging Informatics Technology Initiative standards for data anonymization (Nifti). To test our method, we used a 256x256x170 voxel version of the baseline ADNI-1 dataset acquired from a 1.5T Tesla scanner and processed with Magnetization Prepared- RApid Gradient Echo (MP-RAGE). We selected 6400 ADNI images, with 3200 images for NC, 2240 images for MCI, 896 images for MC and 64 images for AD. Table 1 shows our ADNI dataset's demographic distribution.

Table1. Demographic data of ADNI dataset

Data	NC	MCI	MC	AD
Number of instances	3200	2240	896	64

Deep Learning

Advances in deep learning, and in particular the deep learning sub-field, have led to the creation of algorithms that can analyse digital pictures to make diagnoses with a level of accuracy comparable to that of trained medical professionals. Despite their proven success, deep learning systems still have several issues, are susceptible to cognitive and technological biases, such as bias created by utilizing inadequate data or a diverse dataset to train an algorithm [10]. Accurate results in the diagnosis of illnesses and other areas benefit greatly from the use of deep learning algorithms because of their capacity to extract characteristics and a high-precision classification [11] as shown in Figure 2.

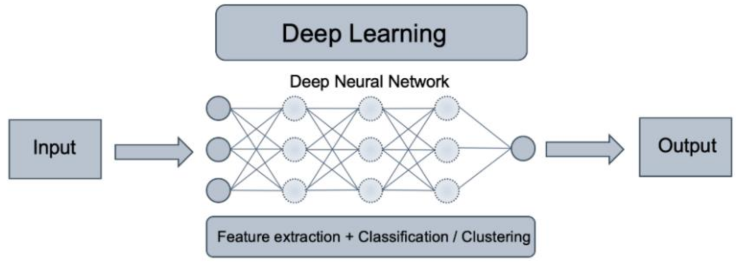

Figure 2. Deep learning architecture

Deep Learning (DL) is a part of the machine learning approach that involves the processing of information that employs deep networks [12]. In 1943, McCulloch and Pitts termed DL as 'cybernetics'[13]. Gradually, DL garnered interest amongst researchers due to its capability as well as characteristics to imitate the manner in which the brain processes information before making decisions. DL has been designed to process information either through supervised or unsupervised approaches, in which learning is conducted on representations and multi-layered features [14]. Several breakthroughs associated with DL have been reported, in terms of enhancing solutions and solving problems, with the help of highly advanced computation models. Since DL can perform learning on multi-layered representations, it is superior in deriving outcomes from sophisticated problems. In this sense, [15] DL is considered to be the most advanced approach for processing and capturing data abstraction in several layers. Such characteristics make DL an optimum approach for studying and analyzing gene expression data. Since DL can learn multi-layered representations, this makes it a versatile strategy to get accurate results more quickly. The multi-layered representation component forms a part of the overall architecture of deep learning [18, 16].

DL and ML vary in terms of performance based on data quantity. DL is ineffective for a learning dataset that has low dimensionality, as it needs data with high dimensionality to conduct comprehensive learning [17].

Convolutional Neural Network (CNN)

An artificial neural network known as a convolutional neural network (CNN) may be used to isolate certain characteristics in a dataset. When compared to other network models, CNN's weight allocation is more straightforward because it relies on a singular feature mapping, [18] which enables reduction of overall weights. These characteristics have added to the widespread popularity of CNN in field pattern recognition [19].

The document reading system utilizes a Convolutional Neural Network (CNN) that was trained in tandem with a probabilistic model that included linguistic restrictions. This technology was already processing about 10% of all U.S. cheques by the late 1990s. In the future, Microsoft used several different optical handwriting detection and character recognition systems that were based on convolutional neural networks [20]. In the early 1990s, CNNs were employed as an experiment for object detection in natural images, including hands and faces [21]. The Figure 3 illustrate the generic structure for convolution neural network.

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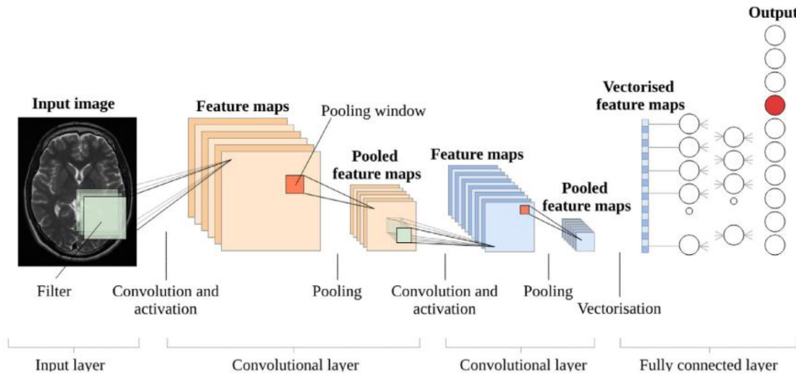

Figure 3. A Convolutional Neural Networks Architecture

Meanwhile, Tao *et al*. [22] proposed deep learning for assessing photos of biological components, which incorporated transfer learning and multiple tasks learning. However, Krizhevsky *et al*. [23] proposed a CNN-based DL algorithm with claimed results that surpassed the state-of-the-art ML approaches. The suggested study did exceptionally well in the visual identification task, earning the researcher's high marks.

Proposed Method

In this paper, investigated the various model architectures. CNN model is configured once data collection and features extracted are complete. The convolutional structure with completely linked layers was the one they assumed to be the most common. This sort of structure is well-suited to the multi- and high-dimensional data seen in things like 2D graphics and genetic data. For assessing the improvements made by increasing the CNN depth, the researchers designed the proposed CNN layer configurations using the Krizhevsky principles [24].

Learning representative characteristics of data that make it easier to retrieve valuable information for the next learning assignment is known as representation learning (Lan, *et al*., 2019). Because of deep learning's great performance, representations acquired by deep neural networks have outperformed handcrafted features on most learning tasks [25].

Deep learning Models are layered structures with various layers that learn different functions (hierarchical representations of layered features). To get the final output, these layers are eventually connected to a last layer (usually a completely connected layer in the case of classification).

A neural network is made up of layers of interconnected computational units called neurons. The data enters the network from an input layer, which is followed by one or more opaque layers that convert the data as it goes through, and eventually an output layer that generates the neural network's predictions [26]. By detecting trends in a series of labelled training results, the network is trained to make useful predictions, and the outputs are compared to the individual labels using an analytical function. During preparation, the network's parameters – the power of and neuron – are fine-tuned before the network's trends provide accurate predictions for the training data. The network will then be used to make observations about new, unknown data, i.e., generalize to new data, until the trends have been learned. Figure 4 illustrates the structure of the proposed method of classifying Alzheimer's disease.

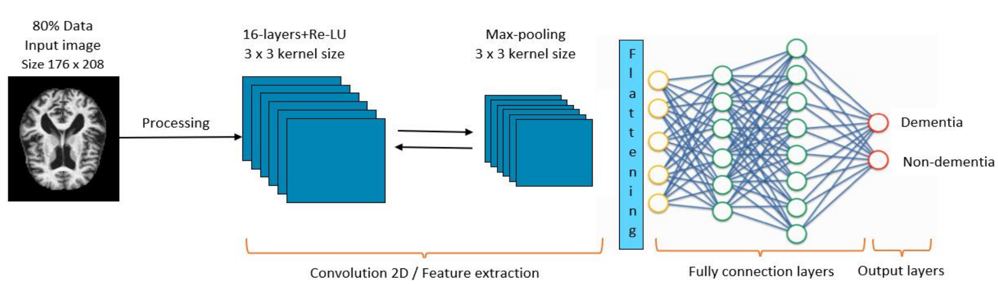

Figure 4. Proposed Convolution Neural Network model

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Result and Discussion

This section includes the results of the proposed method for identifying Alzheimer's disease (AD) and staging the disease as described in the previous section to verify the strength of the proposed method. The proposed model was implemented multiple times using the standard ADNI dataset.
The data is fed into neural networks based on CNNs, which extract features and classify multiple stages of Alzheimer's disease [28]. The Alzheimer's Disease Neuroimaging Initiative (ADNI) dataset has been used in several studies [29] for AD classification. The complete network was trained using the MSI MP75 CPU system with 16 GB memory.

Table 2. Details of Training accuracy, validation losses, and validation accuracy

Accuracy	Val_loss	Val_accuracy
0.977	0.089	0.97

The deep learning models in this thesis were all developed with a Tensorflow backend and implemented in Python using the Keras deep learning library. Because of its architecture, ease of use, and a large number of supporting libraries, Keras was chosen as the machine learning library of choice. Preliminary experiments using the cross-shaped convolutional neural network Brain-Net CNN [30] to identify functional connectivity datasets were carried out, and although the code behind this implementation was extensively examined, all of the studies discussed here used an altered architecture in Keras that used vertical filters instead [30-32].

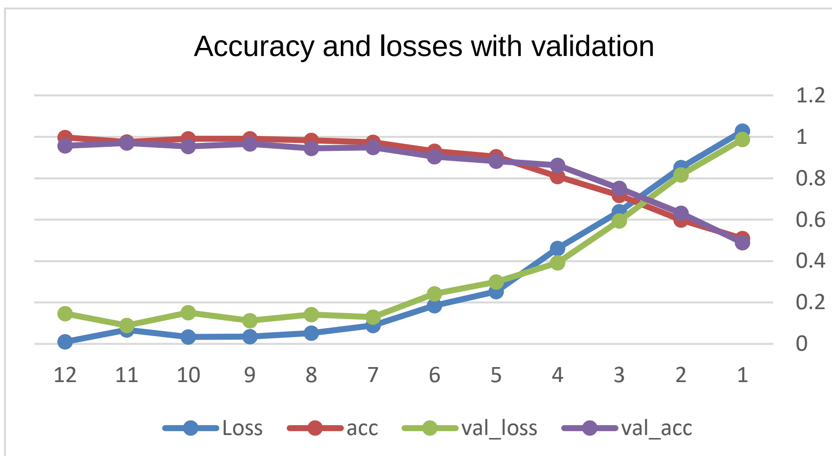

Figure 5. Graphical trends of accuracy and losses vs. val_accuracy and val_losses

Conclusion

Through the proposed method, MRI data from ADNI dataset was trained, the data was divided into 80% for training and 20% for testing. The results showed a clear progress in accuracy, the convolutional neural network algorithm extracts the features of images automatically, which contributes to obtaining better classification accuracy. The trained two-dimensional image set was 176 * 208 in size, the convolutional neural network was randomly trained at 15 epochs where testing accuracy of 0.977 was obtained as shown in table 2 and Figure 5 that show accuracy and loss in the training stage, the number of losses was 0.101 and the validation loss 0.089 and the validation accuracy was 0.975 after that apply image tested and get the results.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

Acknowledgment

This work is part of a research project, supported by the Ministry of Higher Education, Malaysia, and the University of Technology Malaysia. Also supported by Imam Ja'afar Al-Sadiq University, Baghdad, Iraq.

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