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Study on Neurodegenerative Disease Detection using Deep Neural Networks

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***Abstract—**This article provides a comprehensive re- view of the use of deep learning techniques in the study of neurodegenerative disease detection and high- lights their importance in addressing the emerging health challenges of these diseases. The study inves- tigates the creation and implementation of a com- plex deep learning model within an accessible web application, with the potential to reshape diagnostic practices. Through the utilization of cutting-edge ma- chine learning methodologies, the model demonstrates the capability for accurate and early identification of Alzheimer's disease, thereby enabling personalized treatment strategies and forecasting of disease progres- sion. These advancements not only improve patient well-being but also contribute to a more profound understanding of the disease's trajectory and potential treatment options. Finally, this review highlights the importance of ongoing research on deep learning in the study of neurodegenerative disease detection and their potential to impact patient outcomes..*

I. Introduction

As the world's population ages, the devastating neuro- logical disease Alzheimer's presents an increasing health threat. For successful intervention and better patient outcomes, Alzheimer's disease identification must occur as soon as possible A subclass of deep neural networks (DNNs), Convolutional neural networks (CNNs), have become a potent tool in the fight for an early diagnosis of Alzheimer's disease in recent years. This review fo- cuses on the novel usage of CNNs for Alzheimer's disease early detection, which has the potential to completely change the way we approach this difficult condition[2]. As the world's population ages, the devastating neurological disease Alzheimer's presents an increasing health threat. For successful intervention and better patient outcomes, Alzheimer's disease identification must occur as soon as possible. Convolutional neural networks (CNNs), a sub- class of deep neural networks (DNNs), have become a po- tent tool in the fight for an early diagnosis of Alzheimer's disease in recent years. This review focuses on the novel usage of CNNs for Alzheimer's disease early detection, which has the potential to completely change the way we approach this difficult condition. The main role of this review is to examine the most recent advancements, difficulties, and possibilities in using CNNs to detect Alzheimer's disease[1]. This covers the technical aspects of model architecture, feature extraction, preprocessing,and data acquisition. We will also talk about practical and ethical issues like patient privacy, data security, and the legal framework for incorporating CNN-based diagnostic tools into Alzheimer's treatment. Through an exploration of the current challenges and limitations, this review aims to pave the way for future research and development, ultimately enhancing the lives of individuals affected by Alzheimer's disease through earlier and more accurate diagnoses. The integration of CNNs into Alzheimer's dis- ease detection represents a promising pathway toward providing newfound hope and improved care for those grappling with this complex neurodegenerative condition. In summary, this review seeks to illuminate the pioneer- ing application of Convolutional Neural Networks in the early detection of Alzheimer's disease. By examining the most recent advancements and considering the broader implications of this technology, we aim to contribute to a future where timely and precise diagnoses offer a lifeline to individuals and families affected by Alzheimer's disease.

II. Literature Survey

Dementia, including Alzheimer's disease, is a major health problem worldwide, with an increasing incidence among the elderly. Early diagnosis and intervention are critical to improving patient outcomes and quality of life.Recent advances in medicine, especially MRI scans, are promising in detecting biomarkers associated with Alzheimer's disease, such as amyloid [3]. Amyloid is a protein that accumulates in the cells of Alzheimer's pa- tients and is considered a hallmark of the disease. Various studies have explored different approaches for Alzheimer's disease detection using MRI data. A classification method using 3D structural MRI data was proposed [1]. Linguistic

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deficits and biomarkers were utilized to predict probable Alzheimer's disease [2]. Multimodal deep learning models were investigated for early detection of Alzheimer's disease stages [4]. Deep learning techniques were applied for diagnostic classification and prognostic prediction using neuroimaging data [5]. An ensemble system of deep convolutional neural networks was developed for Alzheimer's disease diagnosis using brain MRI analysis [6]. A classification method for Alzheimer's disease detection using MRI images was proposed [7]. An approach focused on detecting anatomical landmarks for fast Alzheimer's disease diagnosis [8]. A deep learning approach was proposed for early detection of Alzheimer's disease [9]. In summary, the

advancements in medical imaging and machine learning techniques offer promising avenues for early detection and intervention in Alzheimer's disease, ultimately leading to improved patient outcomes and quality of life [10].

III. Classification Algorithms

In this project, we use neuroimaging data, specifically MRI scans, to develop a state-of-the-art deep learning model, a Convolutional Neural Network (CNN),[6] for the early detection of neurodegenerative diseases, with an emphasis on Alzheimer's disease. The goal is to precisely diagnose Alzheimer's disease in addition to determining the proportion of affected individuals with severe Alzheimer's disease. In order to do this, we will first gather a comprehensive and well-annotated dataset of MRI scans, which will include pictures of people with Alzheimer's disease at different stages of the disease's progression as well as clinical data that will provide specific details about the severity of the illness. Our model's main component, the CNN, will identify complex patterns and features from the MRI scans. To speed up the training process, transfer learn- ing—which makes use of pre-trained CNN models—will be taken into consideration. Following extensive training, the model ought to be able to offer quantitative forecasts that show the proportion of each person's Alzheimer's severity. Because of this special feature of quantification, patients can receive care that is specific to their particular disease stage, enabling more timely and personalized intervention and treatment. The field of diagnosing neurodegenerative diseases could undergo a revolutionary change if this CNN-based model is developed successfully. It might result in more effective treatments, earlier interventions, and an overall improvement in the quality of life for those with Alzheimer's and other neurodegenerative diseases.

A. Data Collection and Preprocessing

The creation of detailed and carefully collected data on MRI scans forms the basis of this project. This re- source should include images of Alzheimer's patients in various stages of the disease. It should also include general medical information that may indicate the severity of the disease, such as cognitive tests and other medical information.Preliminary information is an important step in preparing MRI scans for modeling. This involves normalizing pixel values, resizing images to standard format, and possibly using reliable data to increase the diversity of the dataset[8]. In addition, comparison of the MRI scan and medical records should be done together.

B. Model Architecture

Convolutional neural networks (CNNs) are deep learn- ing network architectures that derive their knowledge directly from data. CNNs are especially helpful for object recognition in images by identifying patterns. They can also be very useful in the classification of non-image data, like time series, signal, and audio data.

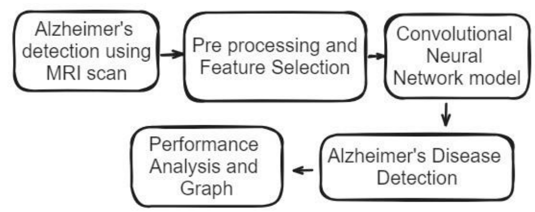

Fig. 1: Architecture of proposed Alzheimer's disease Prediction System

*1) **Kernel or Filter or Feature Detectors**:* The core of a convolutional neural network is essentially a filter used to extract features from images.
Formula = [i-k]+1
k : Size of kernel , i : Size of input

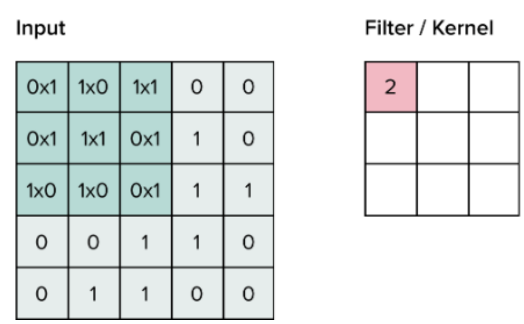

Fig. 2: Filter

*2) **Stride**:* A filter parameter of neural network know as stride.It will take one step at a time, as we completed step 1. The next two pixels will be skipped in order to take value if we give stride.
Formula = [i-k/s]+1
S: Stride , k : Size of kernel

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*3) **Padding**:* The word “Padding” refers to the pixels that the CNN core adds to the image during processing and is related to the connection between neural net- works.each new pixel value added to the CNN will be zero if we set padding to zero. When we scan the image using filters or kernels, its size will be reduced. We should not do this in order to remove the bottom part of the image while maintaining its size. Therefore we increase the size of the image by a few pixels.

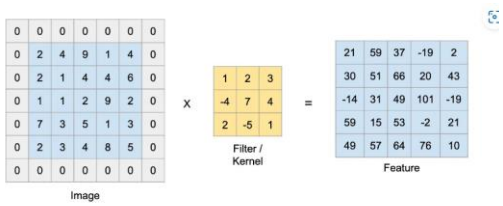

Fig. 3: Padding

***Pooling**:* Convolutional neural networks use convolutional techniques to help the network identify features by expanding the features extracted by convolutional filters regardless of their location in the image.

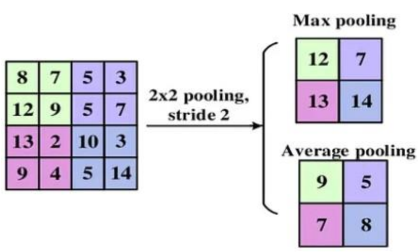

Fig. 4: Pooling

***Flatten**:* All 2D arrays obtained from joint maps are flattened into a long, regular linear vector. Fully connected process takes the flattened matrix as input to analyze the image

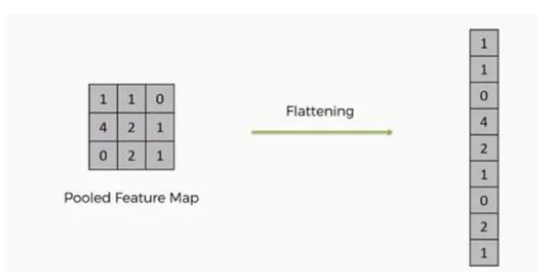

Fig. 5: Flatten

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A. Layers used to build CNN

Convolutional neural network perform better with im- age, speech, or audio signal inputs than other types of neural networks. There are three main categories of layer in them.

*1) **Convolutional layer**:* This layer is first used to extract different features from the input image. In this layer, we use kernel operations or filters to remove features from the input image.

*2) **Pooling layer**:* This layer aims to minimize com- putational expenses by shrinking the convolved feature mapThis can be done by reducing the coupling between layers and making each map unique on its own. There are different types of integration depending on the device. Max pooling and average pooling are available.

*3) **Fully-connected layer**:* Two different layers con- nects neurons by the Fully Connected (FC) layer, which also includes the weights and biases. These layers make up the final few layers of a CNN architecture and are typically positioned before the output layer.

B. Dropout

A Dropout layer is another feature that CNNs are known for. The Dropout layer is a mask that preserves all other neurons unaltered while nullifying some neurons’ contributions to the layer.

C. Activation Function

The decision to activate the neuron is determined by its activation function. This means that during the prediction process, input neurons will determine their importance to the network. There are many optimization functions, including ReLU, tanH, Softmax, and Sigmoid, functions. Everyone has their own goals[4].

1) **Sigmoid** - For binary classification in CNN model.
2) tanH – The tanh and Sigmoid functions are similar. The only difference is the symmetry around the origin. In this example, the value range is -1 to 1.
3) **Softmax** – The final activation function of the neural network is often used in multinomial logistic regression to normalize the network output to a probability distribution on the desired data.
4) **RelU** – The main advantage of using the ReLU function over other functions is that it does not activate all neurons at the same time.

IV- CONCLUSION

In conclusion, the development of a deep learning model for early neurodegenerative diseases detection, such as Alzheimer, using neuroimaging data and its integration into a web application is a significant and promising un- dertaking. This project holds the potential to revolutionize the way we approach the diagnosis and management of neurodegenerative disease Alzheimer. By combining ad- vanced machine learning methods techniques with user- friendly web interfaces, the model can provide early and accurate detection, precise prediction of disease severity, and personalized care for individuals at risk. This not only improves patient outcomes but also contributes to a deeper understanding of the disease’s progression and potential avenues for treatment

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