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INVESTIGATION ON EARLY RECOGNITION OF ALZHEIMER'S AILMENT BY MEANS OF DIFFERENTKINDS OF NEURAL NETWORK ARCHITECTURE

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ABSTRACT

Alzheimer's disease (AD) is an irreversible, progressive neurological brain disorder which abolishes brain cells producing an individual to mislay their memory, mental functions and ability to continue dailyactivities. Diagnostic symptoms were experienced by patients typically at later stages after irreversible neural damage occurs. Recognition of Alzheimer's disease is challenging because sometimes the signs that distinguish AD MRI data, can be found in MRI data of normal healthy brains of older people. Eventhough this disease is not completely curable, earlier detection can support for suitable treatment and to avoid permanent damage to mind tissues. Age and genetics are the extreme risk factors for this disease. This paper valuations the latest reports on AD detection based on diverse types of Neural Network Architectures.

Keywords: Alzheimer's disease (AD), Convolutional Neural Network (CNN), Magnetic resonance imaging (MRI).

INTRODUCTION

Alzheimer's disease (AD) is a condition that affects the brain. Though the symptoms are mild at first it becomes more severe over time. Common symptoms of AD include memory loss, language problems, and impulsive or unpredictable behavior. As the symptoms get worse, it becomes hard for people to remember recent events and to recognize people they know. AD can range from a state of mild impairment, to moderate impairment, before eventually reaching severe cognitive decline.[26] People with Mild AD develop memory problems and cognitive difficulties that may take longer than usual to perform daily tasks, wandering and getting lost.[26] In Moderate AD, damages are done to the parts of the brain which are responsible for language, senses, reasoning, and consciousness.[26] In Severe AD, plaques and tangles are present throughout the brain, causing the brain tissue to shrink substantially. [26]

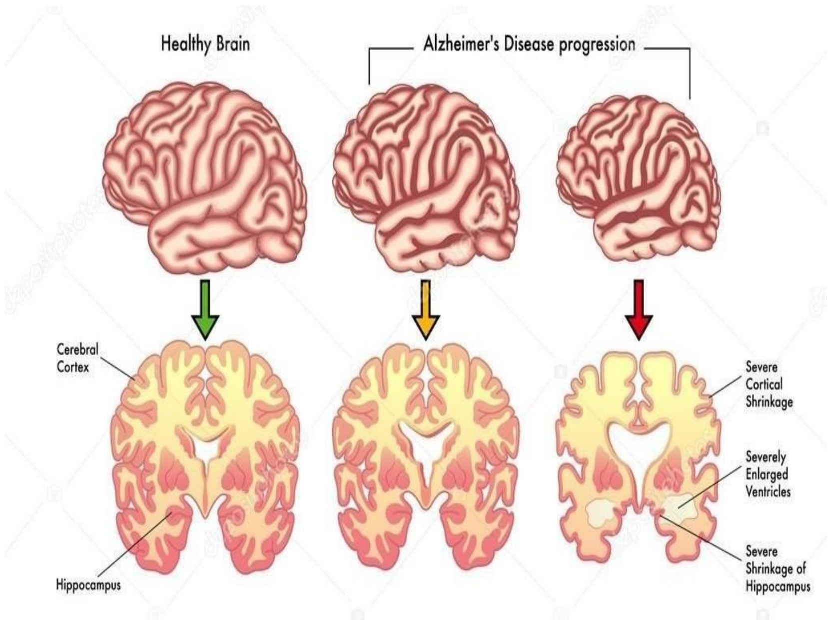

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Fig 1 : Stages of Alzheimer's disease[16]

Hippocampus is the responsible part of the brain for episodic and spatial memory. The reduction in the hippocampus causes cell loss and damage specifically to synapses and neuron ends thus neurons cannot communicate anymore via synapses. [1] As a result, brain regions related to remembering (short term memory), thinking, planning, and judgment are affected.[1] In elderly individuals over the age of 75, identifying differences between AD brain and a normal functioning brain is difficult as they share similar brain patterns and image intensities. [26] As per the reports, the below pie chart Figure 2 gives us a clear picture of the people who are mostly affected by AD considering age as an element:

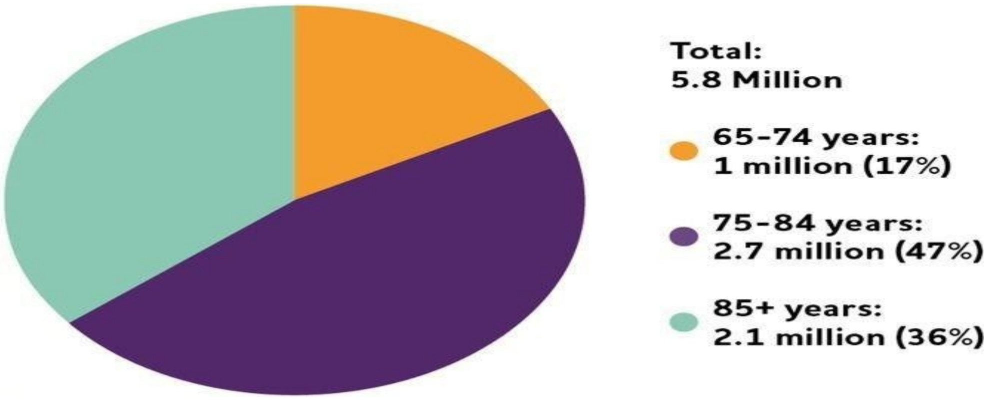

Fig 2 : Pie-chart of Patients affected by Alzheimer's Disease considering AGE as a Factor. [17]

TYPES OF NEURAL NETWORK

Artificial Neural Network techniques are used for prediction and classification which take been applied in various fields, including computer vision and natural language processing, both of which validate breakthroughs in performance. Although hybrid approaches have generated relatively good results, theydo not take full advantage of neural networks, which automatically extracts features from large amounts of neuroimaging data. [22]

I. Artificial Neural Network (ANN)

Artificial Neural Network (ANN), is a group of multiple neurons in every layer. ANN is also recognizedas a Feed-Forward Neural network as the data is being processed in the forward direction only. [22] ANN consists of 3 layers – Input, Hidden and Output layers shown in Figure 3. The input layer takes the inputs, hidden layer processes and analyses the inputs, and then further the output layer produces the result. Essentially, each layer tries to learn certain weights.[22]

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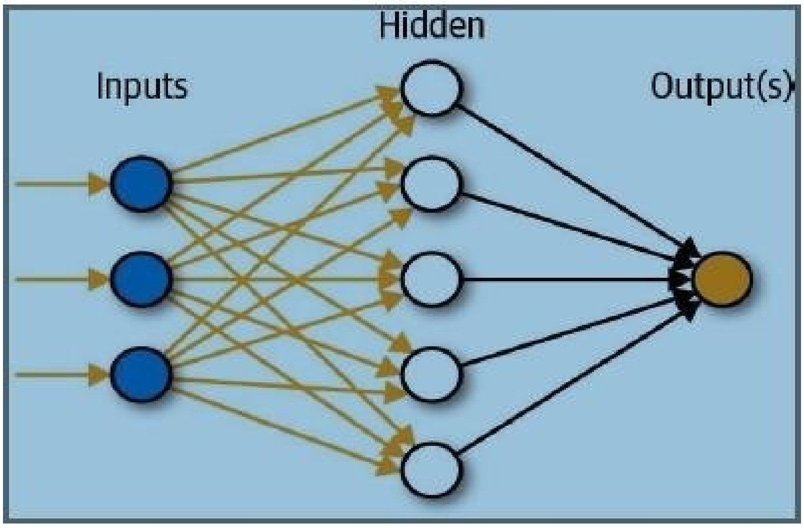

Fig 3: Artificial Neural Network [18]

Advantages of ANN :

- ANN is accomplished of learning any nonlinear function. Hence, these networks are widely known as Universal Function Approximators. ANNs have the capacity to learn weights that map any input to the output.

- One of the foremost reasons behind universal approximation is the activation function. Activation functions present nonlinear properties to the network. This helps the network learn any complex relationship between input and output.[22]

II. Recurrent Neural Networks (RNN)

Recurrent Neural Networks (RNN) is a special type of network shown in the Figure 4., which unlike feedforward networks has recurrent connections. RNN has a recurrent connection in the hidden state. This looping constraint makes sure that sequential information is captured in the input data. Therefore, a looping constraint on the hidden layer of ANN turns to RNN.[22]

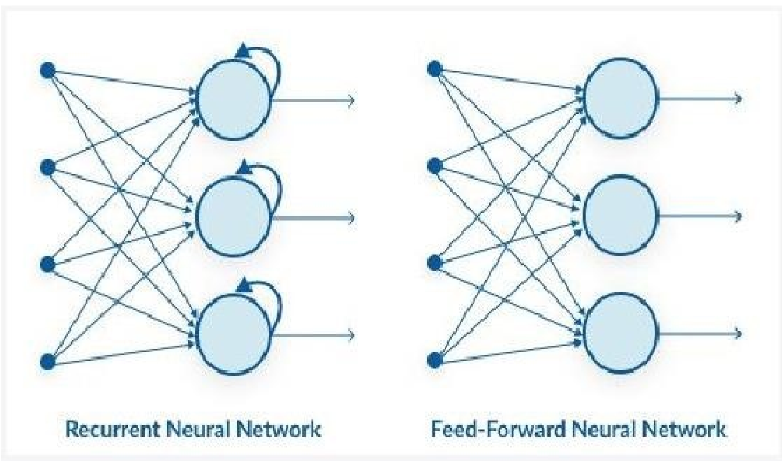

Fig 4: Recurrent Neural Network [19]

Advantages of RNN:

● RNN captures the sequential information present in the input data i.e. dependency between the words in the text while making predictions.[22] As you can see here in the Figure 5 , the output (o1, o2, o3, o4) at each time step depends not only on the current word but also on the previous words. RNNs share the parameters across different time steps. This is popularly known as Parameter Sharing. This results in fewer parameters to train and decreases the computational cost. [22]

***Fig 5 : Many2Many Seq2Seq model* [20]**

III. Convolutional Neural Network (CNN)

Convolutional neural network (CNN) is a deep Feed-forward Neural Network (FNN) composed of multi-layer artificial neurons, which has excellent performance in large-scale segmentation, image processing, classification and also for other auto correlated data. The building blocks of CNNs are filters i.e,. *kernels*. Kernels extract the relevant features from the input using the convolution operation. The importance of filters using images as input data is as shown in the Figure 6 below. Even though CNN were introduced to solve problems related to image data, they perform impressively on sequential inputs as well. [22]

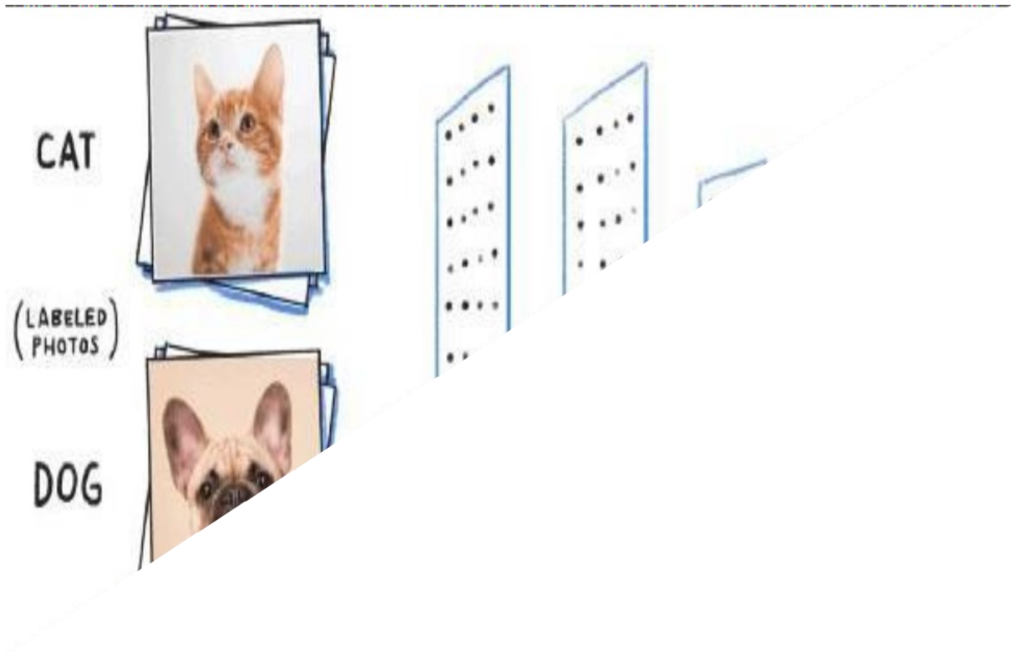

Fig 6 : Convolutional Neural Network – Image Classification [21]

Advantages of CNN :

● CNN learns the filters automatically without mentioning it explicitly. These filters help in extracting the right and relevant features from the input data.

● CNN captures the spatial features from an image. Spatial features refer to the arrangement of pixels andthe relationship between them in an image. They help us in identifying the object accurately, the location of an object, as well as its relation with other objects in an image. [22]

IV. Deep Learning

Deep learning (also known as deep structured learning) is part of a broader family of machine learning methods based on artificial neural networks that enables computers to learn from experience and understandthe world in terms of a hierarchy of concepts. Because the computer gathers knowledge from experience, there is no need for a human computer operator formally to specify all of the knowledge needed by the computer. The Figure 7 hierarchy of concepts allows the computer to learn complicated concepts by building them out of simpler ones.[24][25]

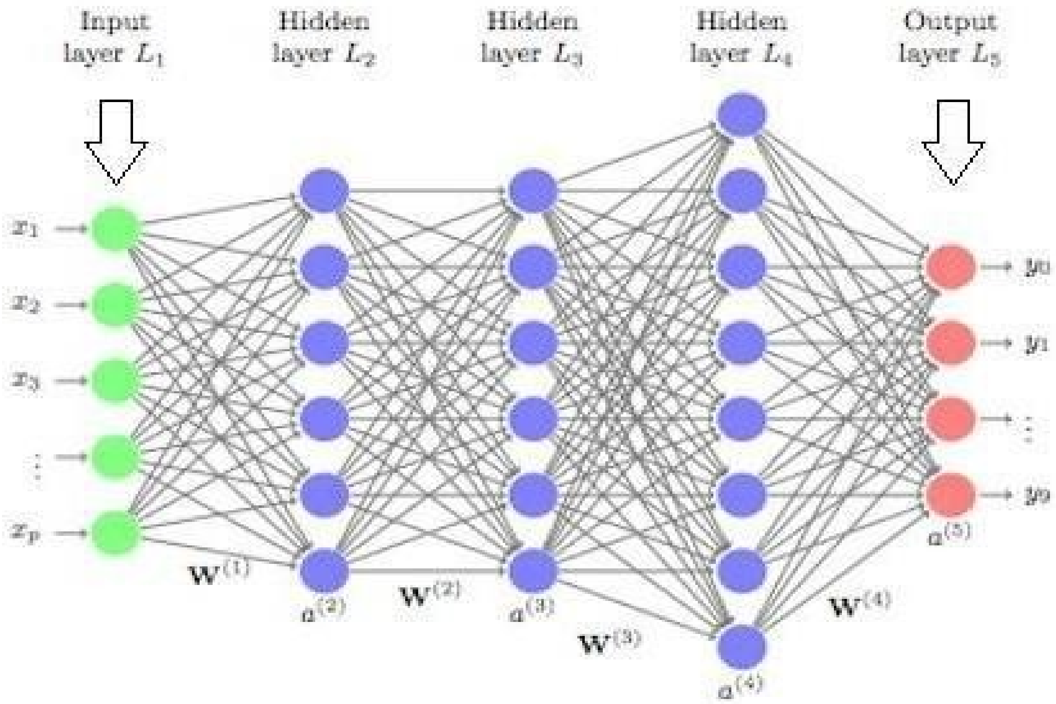

Fig 7: Simple Artificial Neural Network with three hidden layers.[23]

Deep-learning architectures such as deep neural networks, deep belief networks, recurrent neural networks and convolutional neural networks have been applied to fields including computer vision, machine vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation, bioinformatics, drug design, medical image analysis, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance. [24]

EXISTING METHODOLOGIES

Various methods of Neural Network (NN) have been used in the state-of-the-art literature. NN can adapt to changing input, so the network generates the best possible result without needing to redesign the output criteria. Here, Islam, et al.[1], has used an ensemble of three DenseNet styled models - DenseNet-121, DenseNet-161, and DenseNet-169. For each MRI data, the patches are created from three physical planes of imaging: Axial or horizontal plane, Coronal or frontal plane, and Sagittal or median plane. These patchesare fed to the proposed network as input. They've applied transfer learning and the three models have beenpre-trained with ImageNet dataset. The individual models are optimized with the *Stochastic Gradient Descent (SGD) algorithm* to achieve 83.18% overall accuracy. The *back-propagation algorithm* is used byJo Taeho et al.[2] to calculate the error between the network output and the expected output in Gradient Computation. After the initial error value is calculated from the given random weight by the least squares method, the weights are updated until the differential value becomes 0. To improve the performance, multimodal neuroimaging data such as MRI for brain structural atrophy, amyloid PET for brain amyloid-βaccumulation, and FDG-PET for brain glucose metabolism have been used. Deep learning approaches have yielded

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accuracies of up to 86.0% for AD classification and 84.2% for MCI conversion prediction.

The architecture is built using Keras with TensorFlow backend by Yagis, Ekin, et al[3]. In ***Data pre-processing*** all the data are transformed into a standardized structure by performing co-registration with a standard template and skull stripping. *A* 3D CNN model is created inspired by VGG-16 architecture shownin the Figure 8. The model has been trained with categorical cross-entropy loss and the Adam optimizer. 3D models are used here to avoid information loss. The average accuracy of the model achieves 73.4% onADNI dataset and 69.9% classification accuracy on the OASIS dataset.

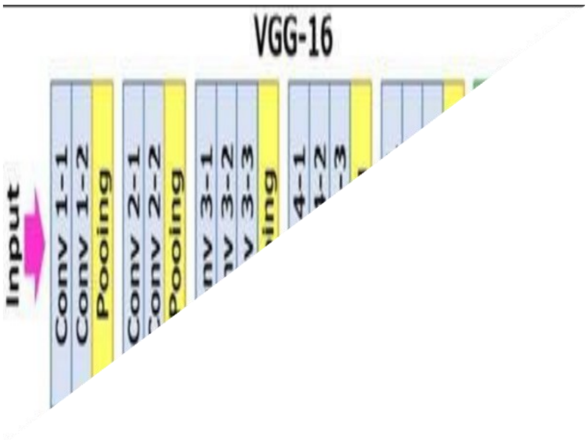

Fig 8: 3D VGG-16 Architecture**.[2]**

First the “Data Type Analysis” is done by Huang, et al.[4], where the proper types of data and ROIs are determined. To verify the effect of segmentation, they’ve segmented the AD and cognitively unimpaired subjects of T1-MRI with the MALP-EM algorithm and obtained the Segmented datasets.

Then the Figure 9, a set of VGG-like Multi-Modality AD classifiers is constructed, which considers both T1-MRI and FDG-PET data as inputs and provides predictions. Then they’ve trained and tested the networks with the pMCI and sMCI data. (MCI is partitioned into progressive MCI (pMCI) and stable MCI(sMCI). The term pMCI, refers to MCI patients who develop dementia in a 36-month follow-up, while sMCI is assigned to MCI patients when they do not convert. Distinguishing between pMCI and sMCI playsan important role in the early diagnosis of dementia) This network is then programmed based on TensorFlow. Training procedures of the networks are conducted on a personal computer with a Nvidia GTX 1080 Ti GPU. The first step by Mehmood, Atif, et al.[5] was data pre-processing and augmentation, the second stage was feature extraction from input images, and the third step was the classification of dementia 5 classes. They have developed a CNN - based approach inspired by VGG-16 for the classificationof dementia stages. Sarraf, Saman, et al.[6], have used a very deep CNN structure adopted for binary

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classification method. The shift and scale invariant features are extracted from different layers of CNN architecture resulting in the highly accurate trained model. Furthermore, extensive and unique pre-processing strategies utilized in this work improved the quality of the data fed into LeNet and GoogleNet which ultimately positively impacted the classifier performance. Al-azdi, Faransi, et al.[7], marked the random datasets for binary classification and the 75% of data for data training and 25% for data testing purposes. The dataset was pre-processed before through training and testing. The architecture of neural networks is using Alexnet architecture with ve layer of convolution. Compared to other journal results, thestudy method mostly uses ADNI database and LeNet or GoogleNet architecture. MRI scans are provided in the form of 3D Nifti volumes. At first, skull stripping and grey matter (GM) segmentation is carried outon an axial scans through spatial normalization bias correction and modulation using SPM-g* tool by Farooq, Ammarah, et al.[8]. GM volumes are then converted to JPEG slices using the Python Nibabel package. Slices from start and end which contain no information and discarded from the data set.

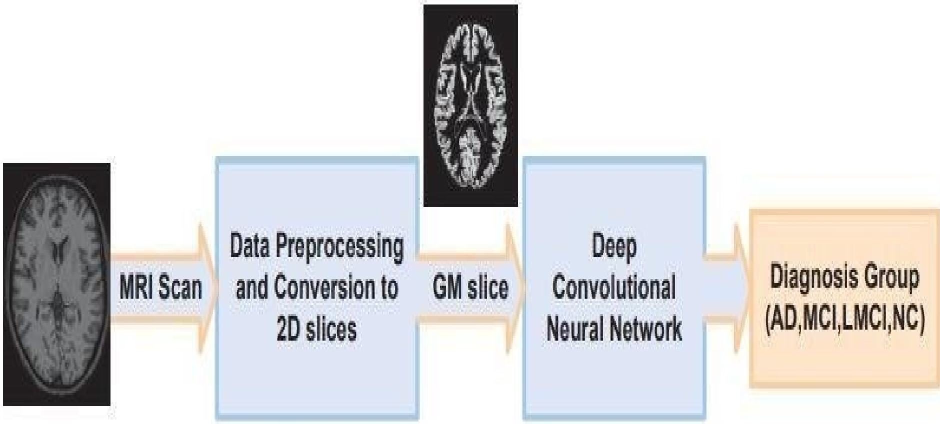

Fig 9: The proposed deep learning pipeline for 4-way classification of Alzheimer's into AD, MCI, LMCI and NC.[8]

RESULT COMPARISON

Table 1: Comparison of the results of the papers

Paper	*Method*	*Datasets*	*Accuracy(%)*
[1]	Dense Net	T1-MRI	83.18
[2]	3D CNN	T1-MRI, FDG-PET	91.09
[3]	VGG-16	T1-MRI	ADNI-73.4 OASIS-69.9
[4]	VGG based on ALEXNET	MRI, PET	CN/AD-77.2 CN/pMCI-70 sMCI/pMCI-65.28
[5]	VGG-16	MRI	89.05%
[6]	LeNet Google Net	MRI	87.4% 88.84%
[7]	Google Net ResNet-18 ResNet-152	T3-MRI	88.88% 88.01% 88.41%
[8]	Google Net	rs-fMRI	88.84%

This Table 1 gives the comparison of the result of the various papers

CONCLUSION

From this investigation, we can draw a conclusion that there are various technologies and methodologies used for detection of Alzheimer's disease at an earlier stage where each individual methodology has a variable precision and accuracy. The two main datasets, namely ADNI and OASIS are being used commonly. CNN based Classification model is used to predict Alzheimer's Disease affected-brain v/s a normal aging brain and is able to do so with higher accuracy. Therefore,we can conclude that CNN method can be used as it has the highest accuracy than the other methodswhich were used.

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