Detection and Classification of Alzheimer's disease stages using Deep learning approach.

LITERATURE SURVEY

ABSTRACT:

Alzheimer's disease (AD) is a progressive and irreversible brain degenerative disorder. Worldwide around 50 million people have dementia and there are nearly 10 million new cases every year. There is no treatment currently available to cure dementia, but it can be treated only if it is identified in the early stages. Analysis of tissue structures of MRI leads to more accurate classification of specific brain disorders. Here our aim is to provide insights of various methods used in AD classification using a deep learning approach. Here we discuss different CNN architectures which are used in classification of AD in various datasets. We support how image processing and augmentation, segmentation enhance classification performance and summarize their results.

INTRODUCTION:

Dementia is a condition in which there is loss of memory & thinking ability of a person that reduces the ability of a person to perform day to day activities. It mainly affects older people but it is not a normal part of aging. Usually, it starts to slowly worsen over time. The complexities of brain tissue structure analysis make the early diagnosis of the disease a challenging task. Thus, there is a need for a computer aided system for early diagnosis of AD.

Various methods have been proposed for detection and classification of AD. Many machine learning algorithms have shown good results for small datasets by identifying only few features. This is the main reason to choose deep neural networks instead of machine learning algorithms. A large amount of data is required for more accurate diagnosis. It includes various steps for precise classification such as preprocessing of MRI images, augmentation of data whenever required amount of data is not present, segmentation, training, testing and evaluating the trained model.

Preprocessing improves the efficiency of the algorithm. This can be done using various image enhancement technologies. Augmentation is the process of increasing the amount of data by adding slightly modified copies of existing data. Segmentation the technique used to segment the image to extract features. Recent studies say that brain segmentation can be a building block of AD diagnosis.

There are various methods for segmentation unsupervised hierarchical segmentation method, as hippocampus is one of the first affected part of brain in AD patients, the irregular shaped hippocampus can be segmented using multiple deep CNN model and 3Ddensenet for classification of AD, autoencoder patch indexing has also shown good results in medical image segmentation and so on. Training deep CNN models using various architecture showed better results. Moreover,

deep learning is also used to perform quantitative analysis of brain MRI through the self-learning features.

This paper aims to provide an overview of CNN architecture, segmentation of brain structure, how preprocessing and segmentation improve the accuracy. Finally we conclude by analyzing the results obtained by different methods.

DATASETS:

In order to classify patients with AD, we need large sets of data to evaluate and segment different types of brain tissue. There are datasets which are available to the public used for classification and diagnosis of AD. Some of the datasets are: Open access series of imaging studies (OASIS), Alzheimer's disease neuroimaging initiative (ADNI), Medical image computing and computer assisted intervention (MICCAI)

OASIS

The oasis dataset [10] is a publicly available imaging data which can be used for research and analysis. It contains 416 subjects between the ages of 18 to 90 years. 100 of the subjects have been diagnosed with mild to moderate AD. T1-weighted MRI scans from single imaging sessions are included.

ADNI

ADNI [5] used for AD classification contains fMRI scans from 138 subjects including 25 CN, 25 SMC, 25 EMCI, 25 LMCI, 13 MCI, and 25 AD. The subject's age considered here above 71 and have been diagnosed with at least one stage of AD based on tests conducted.

MICCAI

The 2017 MICCAI WHM segmentation challenge is available to public and the dataset contains 60 subjects from 3 different scanners. All images were bias-corrected and 30 FLAIR images were selected without the association of T1 sequence. Image registration is performed through Elastix.

PRE-PROCESSING:

Pre-processing technique mainly involves skull-stripping, enhancement based on image thresholding, filtering, brain extraction and noise reduction.

Liu,M[1] et al., the pre-processed images were taken from ADNI datasets. Here they used the MR images obtained with 1.5T scanners in consonance with the acquisition protocol of ADNI. The images that are obtained after correction of intensity non-homogeneous method were skull-stripped and cerebellum-removed.

U. Rajendra Acharya[2] et al., they make use of median filter algorithm for image noise reduction and was implemented to elevate the test picture which are under study.

I. Behesthi[3] et al., the pre-processing steps were carried out using SPM8 software and the VBM8 toolbox. All the 3D raw-MRI scans are rectified for bias field in the VBM8 toolbox and the rectified images were normalized and they are fragmented into white matter, grey matter and CSF components.

Sitara Afzal [4] et al., the images are taken from OASIS dataset are of size 256x256, but the data preprocessing of the proposed model involves positioning the input MRI scan dimension to 227x227 and then image scaling is done over the input images of OASIS dataset.

Farheen Ramzan [5] et al., a standard pipeline comprising of various steps is used for preprocessing rs-FMRI. Here the dataset taken from DICOM and NIFTI format by using Chris Rordan conversion toolbox. The non-brain tissues like neck tissues and skull are being removed by brain extraction.

Jun Yu [9] et al., here they make use of two resizing methods. First one as DA(Database-version-A) that resizes the image size directly in no respect of the aspect ratio and the other method is DB(Database-version-B) that resizes the size of the data to 224x224x3 with respect to original aspect ratio and then they process the resized data into several image patches of size 8x8x3.

V Sathiyamoorthy [6] et al., here for preprocessing they make use of two techniques called image restoration and image enhancement. The image restoration technique is accomplished using 2D Adaptive Bilateral Filter(2D-ABF) to eliminate unwanted noises and the image enhancement technique is achieved using 2D Adaptive Histogram Adjustment(2D-AHA) algorithm to enhance visual contrast and brightness for consistency of the image.

Shaik Basheera [8] et al., the preprocessing is done using two techniques called Thresholding technique and Skull-Stripping algorithm. In thresholding technique, filtered image is divided into brain and non-brain tissues. Skull Stripping algorithm is done on multiplying the final binary mask with the original voxel.

AUGMENTATION:

The computer aided diagnosis approach using deep learning approach have been considered better than traditional machine learning approaches. But there are few drawbacks for applying deep neural network directly on the data acquired, as they often have an imbalance in the categories of data, and the most important aspect of deep learning technique is that it performs very well with the large amount of dataset. But as there are many limitations for collecting large amount of dataset, data augmentation helps to solve this problem. [4] Sitara Afzal and et, it their work discussed about the need for augmentation on the insufficient and uneven distribution of data for training as they lead to overfitting issues.

SEGMENTATION:

Image segmentation plays a vital role in the computer-aided diagnosis of the Alzheimer's disease. There are various traditional segmentation approaches like edge detection filters and other mathematical methods which helped extract the features to enhance the ability of classification using computer-aided approach. Then machine learning approach for segmentation and extracting the features came into picture. But segmentation and feature extraction using machine learning algorithm was a tedious job. Hence the deep learning approaches has now been the better option for medical image segmentation. They have showed greater improvement in training the model and it has helped in increasing the performance as well. [1] Manua Liu and et. in their paper discusses mainly on the segmentation of hippocampus using the ADNI dataset, which is the primary affected area in the brain, they propose a multi-task CNN model for jointly learning hippocampal segmentation and classification of the disease. [3] Iman Behieshti and et, discussed segmentation of grey matter using VBM analysis, which was further used for histogram based feature extraction. [6] V Sathiyamoorthi and et, proposed Modified expectation maximization technique for segmentation. [8] S Basheera and M S Sai Ram showed the unsupervised segmentation approach of MRI segmentation of brain tissues by using hybrid enhanced ICA.

TRAINING AND CLASSIFICATION:

In traditional machine learning approach, the features must be extracted manually and complex features are hard to extract using machine learning techniques. Whereas deep learning models helps to extract complex and high-level features and train the data, which provides greater classification results.

PERFORMANCE EVALUATION:

Sl. No.	Author	Dataset	Segmentation	Training and Classification	Accuracy
1	Manhua Liu[1]	ADNI	V-net	Combination of multi task deep CNN and DenseNet	88.9 %
2	U Rajendra Acharya [2]	University of Malaya Medical Centre	-	ST + KNN	98.48 %
3	Iman Behishti [3]	ADNI	VBM	SVM	97.01 %
4	V Sathiyamoorthi [6]	ADNI	Modified Expectation Maximization	CNN	98 %

5	Junhao Wen [7]	Oasis	-	CNN and ImageNet	88 %
6	Shaik Basheera [8]	ADNI	Enhanced ICA	CNN	98 %
7	Sitara Afzal [4]	ADNI	-	AlexNet	98.41 %
8	C H Suh	Oasis		XGBoost	84.40 %

EVALUATION:

Authors	Method	Accuracy	Specificity	Sensitivity
Liu, M., Li, F., Yan, H., Wang, K., Ma, Y., Shen, L., Xu, M.[1]	Deep CNN for automatic hippocampus segmentation and classification	88.9	90.8	86.6
U. Rajendra Acharya & Steven Lawrence Fernandes & Joel En Weyco & Edward J. Ciaccio & Mohd Kamil [2]	CABD system to classify normal versus AD cases.	98.48	96.67	96.97
I. Beheshti, N. Maikusa, H. Matsuda, H. Demirel, G. Anbarjafari[3]	Automatic CAD technique using the mean of Histogram of Individual similarity matrices.	84.07	81.81	86.27
Sitara Afzal, Muzzam Maqsood, Faria Nazir, Umair Khan, Farhan Adhil, Khalid M, Irfan Mehmood and OH Awan -Young song[4]	A Data Augmentation Based Framework to handle class imbalance	86.35	-	-
Farheen Ramzan & Muhammad Usman Ghani Khan & Asim Rehmat & Sajid Iqbal & Tanzila Saba & Amjad Rehman& Zahid Mehmood[5]	A Deep Learning Approach for Automated Diagnosis and Multiclass Classification of AD Stages.	94.97	-	-
Sathyamoorthi V, Ilavarasi A K, Murugeswari K, Syed Thouheed Ahmed, Aruna Devi B, Murali Kalipindi[6]	A Deep CNN based CAD Sysytem for Prediction of AD.	96	100	93
Zahid Ullaha , Muhammad Umar Farooq, Su-Hyun Leea, Donghyeok Ana.[12]	A hybrid image enhancement-based brain MRI images classification technique	95.8	-	-

CONCLUSION:

The research of AD in classification and diagnosis of the disease is improving every year with new and improved methods and state of the art technologies. Here, we discussed how pre-processing helps in the detection and identification of different stages of the disease. Even though technology is improving it is still not perfect and there is no robust solution. Different studies were conducted to explore the effectiveness and techniques in deep learning, computer aided diagnosis (CAD) system, automatic brain segmentation and classification algorithm. Brain MRI segmentation is a challenging task as images contain different types of noise, low contrast and blurry images. These challenges are overcome by using different methods and techniques. These methods have resulted in faster and more accurate results in recent years. Deep learning has gained popularity due to its ability to provide effectual results over large scale data over its machine learning counterpart. The diagnosis of AD in early stages could help in research of drug development which could help prevent and cure it in the future.

REFERENCES:

[1] Liu, M., Li, F., Yan, H., Wang, K., Ma, Y., Shen, L., Xu, M., for the Alzheimer's Disease Neuroimaging Initiative, A multi-model deep convolutional neural network for automatic hippocampus segmentation and classification in Alzheimer's disease, NeuroImage, 2020.

[2] U. Rajendra Acharya & Steven Lawrence Fernandes & Joel En WeiKoh & Edward J. Ciaccio & Mohd Kamil Mohd Fabell & U. John Tanik & V. Rajinikanth & Chai Hong Yeong, “Automated Detection of Alzheimer’s Disease Using Brain MRI Images– A Study with Various Feature Extraction Techniques”, Springer Science+Business Media, LLC, part of Springer Nature 2019

[3] I. Beheshti, N. Maikusa, H. Matsuda, H. Demirel, G. Anbarjafari,Histogram-based feature extraction from individual gray matter similarity-matrix for Alzheimer’s disease classification, J. Alzheimer’s Dis. Journal of Alzheimer's Disease, vol. 55, no. 4, pp. 1571-1582, 2017.

[4] S. Afzal et al., "A Data Augmentation-Based Framework to Handle Class Imbalance Problem for Alzheimer’s Stage Detection," in IEEE Access, vol. 7, pp. 115528-115539, 2019

[5] Farheen Ramzan & Muhammad Usman Ghani Khan & Asim Rehmat & Sajid Iqbal & Tanzila Saba & Amjad Rehman & Zahid Mehmood, A Deep Learning Approach for Automated Diagnosis and Multi-Class Classification of Alzheimer’s Disease Stages Using Resting-State fMRI and Residual Neural Networks, Journal of Medical Systems (2020).

[6] : V. Sathiyamoorthi, A.K. Ilavarasi, K. Murugeswari, S. Thouheed Ahmed, B. Aruna Devi, M. Kalipindi, A Deep Convolutional Neural Network based Computer Aided Diagnosis System for the Prediction of Alzheimer's Disease in MRI Images, Measurement (2020)

[7]Wen J, Thibeau-Sutre E, Diaz-Melo M, Samper-González J, Routier A, Bottani S, Dormont D, Durrleman S, Burgos N, Colliot O; Alzheimer's Disease Neuroimaging Initiative; Australian Imaging Biomarkers and Lifestyle flagship study of ageing. Convolutional neural networks for

classification of Alzheimer's disease: Overview and reproducible evaluation. Med Image Anal. 2020 Jul;

[8] Shaik Basheera, M Satya Sai Ram, Convolution neural network–based Alzheimer's disease classification using hybrid enhanced independent component analysis based segmented gray matter of T2 weighted magnetic resonance imaging with clinical valuation, Alzheimer's & Dementia: Translational Research & Clinical Interventions 5 (2019)

[9] Jun Yu , Di Huang , Zhongliang Wei , Unsupervised Image Segmentation via Stacked Denoising Auto-encoder and Hierarchical Patch Indexing, Signal Processing (2017)

[10] OASIS-3: Longitudinal Neuroimaging, Clinical, and Cognitive Dataset for Normal Aging and Alzheimer's Disease. (Alzheimer's & dementia: the journal of the Alzheimer's Association) Posted December 15, 2019.

[11] Zicong Zhang, Kimerly Powell, Changchang Yin, Shilei Cao, Dani Gonzalez, Yousef Hannawi, Ping Zhang, Brain Atlas Guided Attention U-Net for White Matter Hyperintensity Segmentation. (Computer Vision and Pattern Recognition): *[Submitted on 19 Oct 2020 (v1), last revised 22 Dec 2020 (this version, v2)]*

[12] Zahid Ullah, Muhammad Umar Farooq, Su-Hyun Lee, Donghyeok An, A hybrid image enhancement based brain MRI images classification technique,Medical Hypotheses,Volume143,2020,

[13] Yamanakkanavar N, Choi JY, Lee B. MRI Segmentation and Classification of Human Brain Using Deep Learning for Diagnosis of Alzheimer's Disease: A Survey. Sensors (Basel). 2020 Jun 7

[14] Junhao Wen, Elina Thibeau-Sutre, Mauricio Diaz-Melo, Jorge Samper-Gonzalez, Alexandre Routier, Simona Bottani, Didier Dormont, Stanley Durrleman, Ninon Burgos, Olivier Colliot, Convolutional neural networks for classification of Alzheimer's disease: Overview and reproducible evaluation, Medical Image Analysis, Volume 63, July 2020.

[15] Development and Validation of a Deep Learning–Based Automatic Brain Segmentation and Classification Algorithm for Alzheimer Disease Using 3D T1-Weighted Volumetric Images C.H. Suh, W.H. Shim, S.J. Kim, J.H. Roh, J.-H. Lee, M.-J. Kim, S. Park, W. Jung, J. Sung, G.-H. Jahng, and for the Alzheimer's Disease Neuroimaging InitiativeAmerican Journal of Neuroradiology November 2020