Alzheimer Disease Classification Based on Spatial Optimization of the ROI and Imaging Modalities with Deep CNN

[1] Manisha Garasiya, [2]Asst.Prof.Chinatan Makwana [1]Scholar, [2]Assistant Professor, [1],[2]Department of Information Technology, Shantilal Shah Engineering College, Bhavnagar, Gujarat, India.
[2]chmakwana@it.ssgec.ac.in@gmail.com, [1]manugarasiya98@gmail.com

Abstract - In Recent ERA of Medical Domain Research Field MRI Images is main source to study various problems including Tumor, Alzheimer, Heart Problem, Knee Problem etc. To Detect and Classification of Alzheimer is also an important research topic. There is a huge scope of research to use MRI for Alzheimer Classification. Combination of Machine Learning and Image Processing can provide a good result toward the same problem. Applying Machine Learning Deep Learning Methods like CNN can be used for classification of Alzheimer Disease. Cross Modal Transfer Method can be combined from structural MRI for diffusion. Applying various Optimization techniques can improve the result of current researches. As Trained dataset is an main issue with the Alzheimer Classification we propose a slide different method of a cross-modal transfer learning: from Structural MRI to Diffusion Tensor Imaging modality. In this method Models are pre-trained on a structural MRI dataset with domain-depended data augmentation are used as initialization of network parameters to train on Mean Diffusivity data. Our proposed method also deals with problem of over fitting. Our work will classify like Normal Control, Alzheimer Patients and Mild Cognitive Impairment subjects on a subset of ADNI dataset.

*Keywords —**Alzheimer 's disease (AD), Classification, ADNI, CNN, Machine Learning, Image Processing, Mild Cognitive Impairment (MCI), Normal Control (NC).***

I. INTRODUCTION

The most prevalent form of dementia is Alzheimer's disease. One in every three seconds is a new person somewhere Dementia-affected. It means the lack of functional cognitive thinking. The brain is the human body's most significant organ [1]. While Alois Alzheimer's was identified for the first time more than 100 years ago, its causes, signs, risk factors and treatment have only been intensively studied in the last 30 years[2]. There are so many Alzheimer's disease symptoms, such as memory loss, progressive loss of ability to perform everyday activities [3], loss of control of vision, ability to identify and use familiar objects, inappropriate usage of terms, day-to-night uncertainty, problems in problem solving preparation [4].

The disorder has the most effects on the brain, as it is so important to deal with. Alzheimer's disease (AD) is a neurological condition that often affects individuals over the age of 65 and whose rate of occurrence rises exponentially with age, almost doubling every 5 years[4][5][10]. Consequently, There are more than 46.8 million in the new figures, People who are now dealing with dementia, and that would be the amount In 2050[4],[10],[16], [19]it grew to 131.5 million[6][9][13].

Mild Cognitive Impairment (MCI) is the type of impairment Risk-related condition for converting to Alzheimer's the sickness [11]. The Structural Magnetic Resonance for A Long Time The most used technique for imaging (sMRI) has been Diagnosis of gradual degradation and examination. This enables to track brain structural changes and the unavoidable Atrophy caused by the ADD component of neurodegeneration [9]. Most studies use the modality of sMRI to Exploring the mechanism of degradation of some parts of the brain Such as the hippocampus, proven to be affected by AD [13].

Different traditional machine learning methods have been suggested for the CAD to identify the characterized extracted features of AD [8]. These characteristics are derived from the volume of interest (VoI) and from the regions of interest (ROI). Similarly, characteristics were excluded from the different gray matter (GM) voxels and hippocampal regions [3] [8].

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Deep learning models have been implemented successfully for Different analyses of medical images, such as structural MRI Functional MRI, (referred to in the rest of this paper as MRI),(fMRI), Positron Emission Tomography (PET), and Diffusion Tomography Imaging Tensor (DTI).[3]

Multiple For categorization, traditional classifiers are available, such as K-NN, SVM, PCA, ICA, LDA, ANN, Naïve Bayes, Decision Tree, fuzzy method, etc[11][17]. That gives the best results for basic results Extraction of characteristics used for the diagnosis of Dementia and Alzheimer's Illness.

A.Alzheimer's disease and it's Symptoms

For a category of brain disorders, dementia is a general term. It is deterioration in mental function, medically referred to as decline, about cognition. Progressive dementia is Alzheimer's disease. It is caused by gradual degeneration of brain cells. Alzheimer's disease results in memory, thinking and thinking disability [14]. Conduct. It is named after the German physician Alois Alzheimer, Who, in 1907, first identified it.[11]

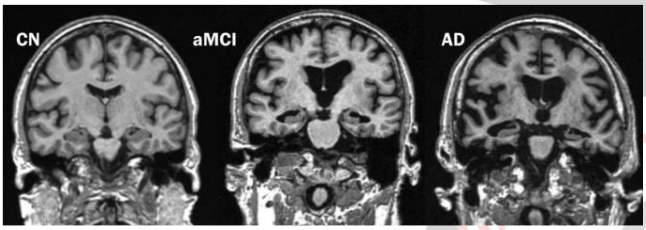

Figure 1: Alzheimer MRI Image [12]

This figure is the Alzheimer's disease Classification like Control Normal (CN), Mild Cognitive Impairment (MCI), and Alzheimer's disease.

Alzheimer's disease symptoms like hesitation to speck Mood Change, judgment, confusion for day from night, inappropriate for familiar object, change behaviour [12].

B.. Image Processing

Image processing is a method to perform certain operations on an image, in order to get an improved image or to obtain some useful information from it. It is include following three step Importing an image using software for image acquisition, Analysing the image and manipulating it, and Output in which an image or report based on image analysis may be altered. Image Processing is the fundamental tool for classifying and pre-processing Alzheimer's-related MRI images. Segmentation, Grouping of Pictures etc It is used for the classification of MRI diseases. Different steps, such as pre-processing of structural MR images.

C.Medical Image Processing

The processing of medical imaging refers to the handling of images using a computer. This processing requires many kinds of methods and practices, such as image collection, storage, presentation, and communication. Medical image having multiple modalities like MRI (magnetic resonance imaging), (CT) computed Tomography or (CAT) Computed axial Tomography, (PET) Positron emission Tomography, ultrasound, X-ray.

D.Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is a type of medical imaging used in radiology to produce images of the body's anatomy and physiological processes. In order to produce images of the organs in the body, MRI scanners use intense magnetic fields, magnetic field gradients, and radio waves.

E. Image Pre-processing

Image pre-processing is a fundamental component in order to satisfy the basic specifications of a CNN model [3]. It serves an essential function by carrying out substantial knowledge research in order to obtain ideal outcomes [3]. Acquisition of data was Performed with the following scanner using a 3 Tesla Siemens scanner Parameters: angle of flip=90o; size of matrix=64 x64; voxel=64; Thickness=3.4 mm; 197 volumes; 48 slices; TR=3000 ms and 48 slices ;TE=30 MS[11]. Each is subject to a four-step pre-processing procedure Brain Picture MRI. Non-parametric, non-uniform bias first, The algorithm of correction (N3) is used to correct strength Inhomogeneity here[16]. Note that the normalized resolution SMRI and MD volumes are relatively small (121x145x121, see The hippocampal ROI thus occupies a small amount (above) Voxels (28 x 28 x28)[13].

The processing of the image two important steps are involved: linear alignment and landmark exploration [18]. MRI data pre-processing was carried out using SPM8 tools.(http://www.fil.ion.ucl.ac.uk/spm) and the VBM8 (http://://) toolboxUh, dbm.neuro.uni-jena.de/vbm)[19]. It is consisting of five pre-processing phases. T1-weighted brain Magnetic Resonance (MR) the standard ADNI [30] pipeline initially pre-processed the images Skull-stripped using the method as defined in and Suggested in [21][22].

F. Machine Learning And Deep Learning

Machine Learning is also used for Classification of MRI Images. Various Machine Learning Algorithms like SVM etc are used for this purpose. Feature Extraction, Feature Selection, Pre-processing, Classification are the basic steps. Model is trained for this purpose and then testing is done based on this model. Machine-based approaches to learning are widely used in medical applications and have received considerable attention in recent decades [3].

Deep learning, a state-of-the-art machine learning approach, has shown outstanding performance over traditional machine learning in identifying intricate structures in complex high-dimensional data, especially in the domain of computer vision. The application of deep learning to early detection and automated classification of Alzheimer's

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disease (AD) has recently gained considerable attention, as rapid progress in neuroimaging techniques has generated large-scale multimodal neuroimaging data. Diagnosis for Alzheimer's Disease based on aProblem in classification. These analysis utilizes CNNs, such as LeNet [2], AlexNet [6]-[2], Inception or GoogleNet [2], VGG [2]-[6][8], ResNet ,DenseNet and Xception as well as some custom CNNNs[2] AD Diagnosis Architectures [2].

II. RELATED WORK

A Related work for Alzheimer's disease Classification with MRI images is become most important of medical images. The diagnosis involve to major step: (a) Alzheimer's Disease Classification, (b) Alzheimer's Disease Detection. Image classification is the process of classifying irregular images into various categories on the basis of some measure of similarity. The accuracy of this detection technique for Anomalies must be since the care preparation is based on this identification, it is considerably high [15].

Multiple academic papers with various methods in the literature, they are recorded for image classification [15]. TABLE I The systematic literature survey on classifier forms provides, Different stages of AD, sources of publicly accessible tools Databases, features extracted, classification results, etc., which It is used in brain images for abnormality detection.

In research work by lodewijek Brand et al[1].They have used Multi-Modal Longitudinal Regression Joint and Classification approach to other state-of-the-art algorithms used by their work. Classification Compared to a selection, output results of our system Five-fold cross validation of broadly used classification algorithms. We compare our approach against logistic regression (Logistic), random forest classifier (RandomForest), help using a sigmoid-kernel (SVM) vector machine[18], k-nearest Neighbors Classifier (KNN), elastic net logistic regression, Regularization (ElasticNet) , vector machine linear support (LinearSVM) and an intense machine for learning (ELM) and then they have got better reseat.

The author Jia Xian Fong, et al[2]. To summarize, without using any pre-processing MRI,We managed to obtain a test methodology for the dataset. 0.998 accuracy for YOLOv3, 0.982 for SSD, and 0.988 accuracy for YOLOv3Faster R-CNN when exceeding 0.75 IoUU in AD/NC territory A threshold in all three architectures of deep learning. The work by sitra afzal,et al[3]. They have used CNN's technique for the efficient and reliable classification of Alzheimer's. We suggested two models for AD classification, one with the use of a single main MRI view of the brain. Whereas, the second approach integrates 3D views. The author Amir Ebrahimi-Ghahnavieh,et al[4]. In this paper by combining 2D CNNs with LSTM, 2D slices of MRI.The ADNI1 (Alzheimer's disease) dataset used was derived from Research Neuroimaging Initiative). Following the initial step of Feature extraction using a pre-trained CNN model on We used ImageNet and re-trained on the ADNI dataset, an Architecture of LSTM to catch helpful ADD details Detection on a photo set. The work by pholpat Durodhan et al[5]. In the MATLAB 2017 environment, a novel dementia classification system based on EEG data was developed and implemented to distinguish Alzheimer's disease patients from healthy control participants using signal processing and ML algorithms. The author Emimal Jabason,et al[6]. In this paper the efficiency of the proposed algorithm is calculated. Data available in the open on longitudinal neuroimaging data Plan, Access Sequence of Imaging Studies-3(OASIS-3).They have used Test DenseNet architectures with various versions, DenseNet121 [8], Densenet169, and DenseNet201 [2], in particular, With ResNet50. in combination. In each variant, the numbers Correspond to the model's depth. We are now playing with 8, 16, and 32 for 100 epochs for different batch sizes. And then they have to get a result.

The work by Shumao Pang, et al[7]. In this paper a process based on local linear iterative mapping with representative and local structure-preserved (ILLM) the embedding of features is proposed to segment the hippocampus Photo from MR. The proposed system consists of three versions, Semi-supervised deep auto encoder components (SSDA), Local linear (LLM) mapping, and ILLM. The research work by FUJIA REN,et al[8]. They have used Three 2D CNNs-based classifiers were created, In order to increase diagnostic precision and to assess For AD, specific position effects. Simultaneous with our models Record slice positions and perform well Tasks in AD classification. The purpose work by Peiyao Wang,et al[9]. They have main approach is also linked to Alzheimer's disease.Knowledge from the Neuroimaging Initiative (ADNI) to make predictions on Longitudinal clinical ratings dependent on multiple modalities of clinical assessment Features of a baseline brain picture. The work by Tao Zhou,et al[10]. Second, they research the impacts of multiple factors.The most unequal ROIs and parameters and current SNPs that have been defined by their proposed system. Then, they compare with many state-of-the-art processes, our technique and provide the variations between our system and other methods correlated with it. Finally, they discuss some of our model's constraints.

The work by Yang Li, et al[11]. In this paper, they suggested a new ultra-constrained category For efficient connectivity, a sparse linear regression model Inference, and the classifier was used as a novel EMLPC For Identification with MCI. The have used a Constrained structure detection ultra-group The algorithm enhances the efficient discriminative power of the connectivity network, the UOFR connectivity algorithm Estimation of strength

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further increases the discriminative power, The regularization of l1-norm and l2-norm raises the MLPC generalizability, hierarchical characteristics are They learned from the EMLPC weights. In a research work by Karim Aderghal,et al[13]. they have propose a method of a cross modal transfer learning: from Structural MRI to Diffusion Tensor Imaging modality. Models pre-trained on a structural MRI dataset with domain-depended data augmentation are used as initialization of network parameters to train on Mean Diffusivity data. The method shows a reduction of the over-fitting phenomena, improves learning performance, and thus increases the accuracy of prediction. Classifiers are then fused by a majority vote resulting in augmented scores of classification between Normal Control, Alzheimer Patients and Mild Cognitive Impairment subjects on a subset of ADNI dataset. The Following figure 3 shows their methodology. The another research work by H. M. Tarek Ullah et al[14]. has work an alternative approach has been discussed, that is fast, costs less and more reliable. Deep Learning represents the true bleeding edge of Machine Intelligence. Convolutional Neural Networks are biologically inspired Multilayer perceptron especially capable of image processing. In this paper we present a state of the art Deep Convolutional Neural Network to detect Alzheimer's disease and Dementia from 3D MRI image. This paper introduced a deep learning based method to detect Alzheimer's disease and dementia. However similar approach can be applied to detect other diseases from 3D MRI data. This paper can also serve as an inspiration to other kind of 3D image analysis using deep learning.

III. PROPOSE METHODOLOGY

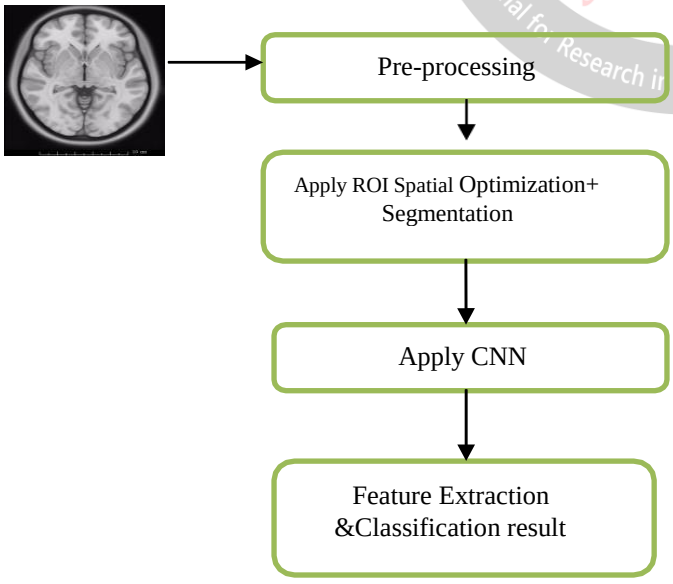

Diagram 1: Propose Methodology

The purpose flow Consist following Stages: First input MRI images then Pre-process the image after pre-processing apply ROI Spatial Optimization with Segmentation then Apply Convolutional neural network Alex net Model for Feature extracting and classification. This Section explains the detail approach for classifying the Alzheimer's disease MRI images into Different Alzheimer's, AD vs NC, NC vs MCI and MCI vs AD using ROI and Segmentation with Deep CNN. The goal of this study is to use Deep Learning toolbox in matlab to improve the accuracy of classification of Alzheimer's disease. The procedure includes the following steps: preprocessing, read MRI images, ROI with Segmentation, then apply Convolutional neural network. CNN apply for Feature Extraction and Classification. In this research usig u-net model for Segmentation-net model is Convolutional neural Network Architecture Used for fast and precise Segmentation of image. Spatial optimization of Region of interests it means optimizing image preforming Mathematical Operation Spatial Domain. In given below all the explanation method used for purpose work:

Dataset Details

In this work using Alzheimer's Diseases neuroimaging initiative (ADNI) Dataset on official Web site. In this Dataset 188 is Normal Control (NC) images, 399 Mild Cognitive Imperilment (MCI) images, and 228 Alzheimer's patient brain images. In this image using feature is Age, Gender, Subject and image modalities. Dataset having a Dicom format convert dataset in png format.

Pre processing

Preprocessing is technique that is used improve quality of image. The images in dataset are different dimension so the images are resizing to 256*256 in preprocessed step and increase overall lightness of image then the read MRI images.

Spatial Optimization ROI

Spatial Optimization Region of interest it means Optimizing image by performing Mathematical Operation Spatial Domain. It is going form image classification to object detection is fixed size of input requirement. In this work used free hand method for selection region.

Segmentation

Image segmentation is one of the most important tasks in medical image analysis and is often the first and the most critical step in many clinical applications. In brain MRI analysis, image segmentation is commonly used for measuring and visualizing the brain's anatomical structures, for analysing brain changes, for delineating pathological regions, and for surgical planning and image-guided interventions. In the last few decades, various segmentation techniques of different accuracy and degree of complexity have been developed and reported in the literature. In this

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paper we review the most popular methods commonly used for brain MRI segmentation. We highlight differences between them and discuss their capabilities, advantages, and limitations. To address the complexity and challenges of the brain MRI segmentation problem, we first introduce the basic concepts of image segmentation.

In this Work research using U-net model For Segmentation-net model is convolutional Network Architecture for fast and precise Segmentation of images-Net Architecture Consists of Encoder sub-network and Decoder sub-Network that are connected by Bridge Section. Encoder Sub-Network having two sets: Convolutional+ Rectifier Linear Unit Layer Followed by 2 by 22 Max pooling Layer and Decoder having a transposed Convolution Layer Up sampling this all process by using Deep Learning toolbox in a Matlab.

Convolutional Neural Network

Neural networks are well known for their good performance in classification and function approximation, and have been used with success in medical image processing over the past years, particularly in the case of pre-processing segmentation, registration and recognition. The structure of the neural network consists of 6 layers in total[14]. Table 1 gives an overview of the main types of neural network used in these fields; detailed description of most important applications is included in the remainder of this section. CNN used for selection of Feature and Classify Alzheimer's disease.

Classification

Classification is defined as a way of Classification is defined as a way of identifying and distinguishing things or patterns based on their features. Classification technique is to classify the MRI images it Different stages AD vs NC, NC vs MCI, MCI vs AD. This research work used Alex net model.

IV. EXPERIMENTS AND RESULTS

In this section we are going to discuss the result of the Proposed Methodology. In order for classifying brain MRI images of Alzheimer's disease into AD vs NC. The feature extracted and Classify from CNN based Alexnet model are used. The model Developed by Matlab R2019b.first of CNN Analyzing in Matlab Deep learning toolbox .Training images is 712 and testing images.

In below given figure 2 is saw the input and read MRI image using pre-processing step Image resizing Convert the image into 256*256.

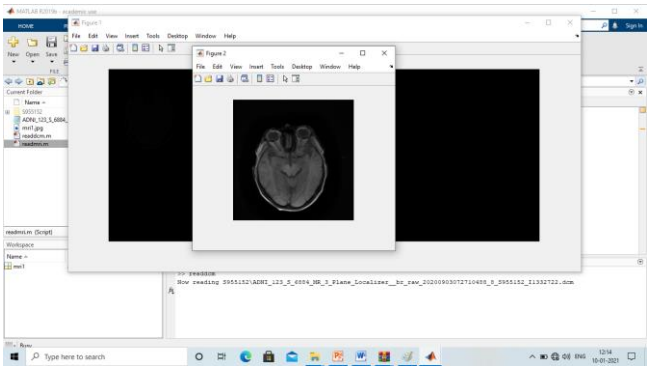

Figure 2: Read MRI images

Below fig.3 Shows Select Region of interest using free hand Method Frist step is selecting region in figure shows the select Region of interest (ROI).After selecting ROI used Segmentation.

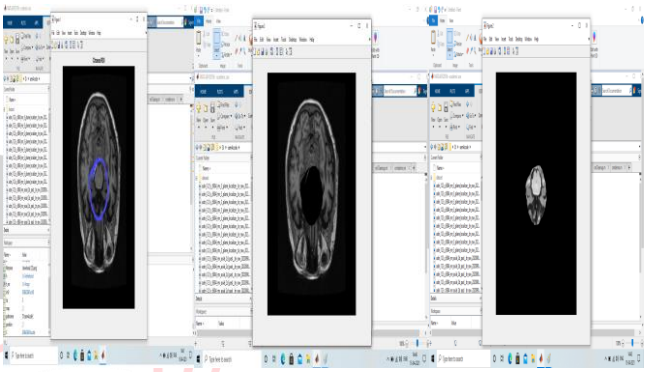

Figure 3: Selection of ROI

Below Fig 3 Shows Segmentation MRI images Using U-Net Model. It is used for fast and prices Segment images. It followed by 2 by 22 Max pooling Layers.

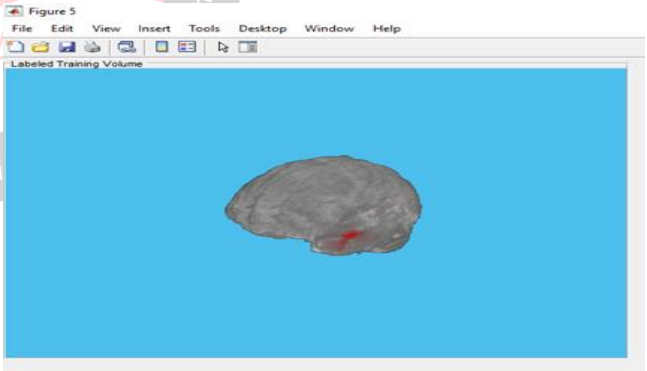

Figure 4: Segmentation

To automatically resize the training photos, use an enhanced image data store. This Code is Calculated Accuracy:

```
TP=
sum(and((predictions==2)',testLabel==2))
TN=
sum(and((predictions==1)',testLabel==1))
FP=
sum(and((predictions==2)',testLabel==1))
FN=
sum(and((predictions==1)',testLabel==2))
precision(fold)= TP/(TP+FP)
recall(fold)=TP/(TP+FN)
f1(fold)=2*(precision*recall)/(precision
+recall)
```

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```
specificity(fold)=FP/(FP+TN)
accuracy(fold)=(TP+TN)/(TP+TN+FP+FN)
accuracy = sum(predictions' == testLabel)/numel(testLabel)
```

Where, TP=True Positive, FP=False Positive, TN=True Negative, FN=False Negative.

Then goat a result by using a Graphical user interface in Matlab. In this work first of all selection of dataset then processed on a dataset. In this case disease detection accuracy like Patient having AD.

In propose Detection result comparison to existing work 91.00% and 93.20%.Given Comparison graph shown in figure 4

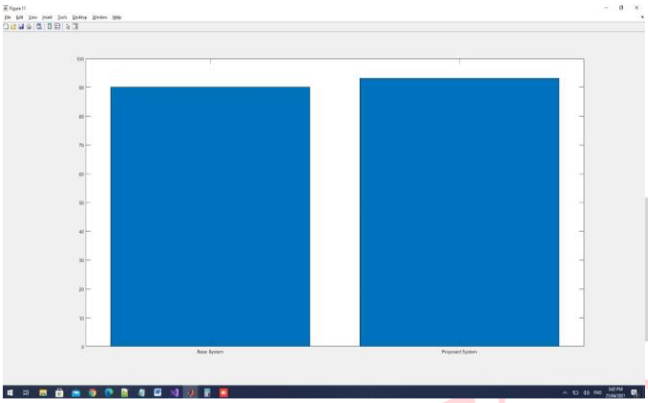

Figure 4: Detection accuracy

As shown in Fig.4 Comparison Result of Applying CNN and CNN with ROI Spatial Optimization for Classification of Alzheimer's Disease from MRI images in three classes first one is AD as NC, NC vs MCI, NCvs AD. Result shows accuracy respectively 91.00%, 82.90% and 72.24%.

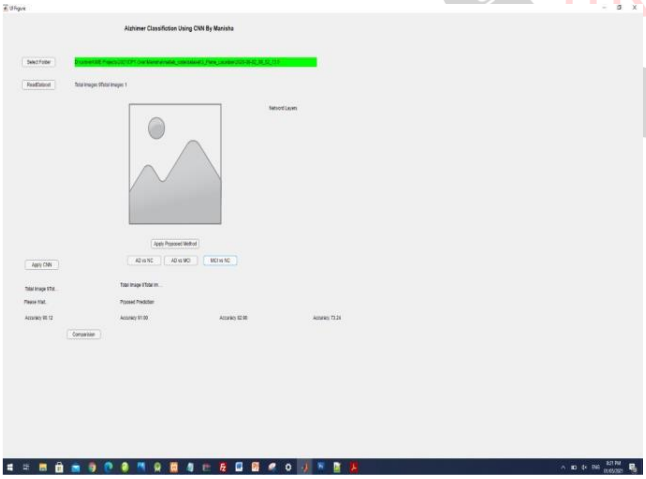

Figure 5: Classification Accuracy

Figure 5 Shown Comparison of result of CNN and CNN+ROI Spatial Optimization. CNN Network used Alex net Model For the feature extraction and classifies the disease. In this Alex net model having a eight layers. The picture input layer, the first layer, requires input images that are 227-by-227-by-3, with 3 being the number of color channels. The network requires 227-by-227-by-3 input photos, but the images in the image data stores are different sizes.

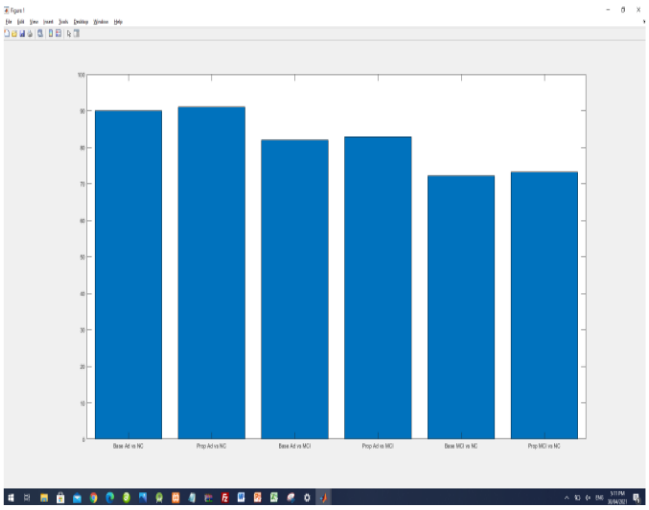

Figure 6: Comparison Graph

The fig 6 Graph show Different Stages of Alzheimer's Disease. Comparison of result of CNN is AD vs NC accuracy 90.00% ,AD vs MCI Accuracy is 81.87%and then MCI vs NC Accuracy is 70.00 % and CNN+ROI Spatial Optimization result is AD vs NC accuracy 91.00% ,AD vs MCI Accuracy is 82.90%and then MCI vs NC Accuracy is 72.24 % .

V. Conclusion And Future Plan

As a part of our research work in Image Processing with Medical Images; we have reviewed some of the work done earlier. We have founded that there is some scope to improve the work of Classification in Alzheimer. Some methods like Segmentation and Better Pre Processing and Increasing Samples by Augmentation cab ne done.

In this work uses higher memory and higher time for processing the Model. In future some lightweight model can be applied and multiple feature selection and feature ranking may improve the result.

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