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Classification of Images using Multi-Layer Neural Network using Machine Learning

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***Abstract*—This paper is focused on development of system for analysis with advanced Imaging Technologies with Machine Learning and Deep Learning. It also focuses on research and development of technological solutions for detection and analysis of brain cancer disease from health care domain. This paper focuses on implementation and analysis of convolution neural network algorithm in combination with multi-layer neural network algorithm on brain cancer MRI image dataset. This system will be useful in detection, classification, segmentation, analysis and prediction of brain cancer disease by using machine learning and deep learning technology. Proposed system is to detect whether brain tumor is cancerous (malignant) or not (benign) as well prediction of tumor grade on segmented region of interest. This implemented research work will enable all the stake holders like doctors, radiologists, neurosurgeons to detect and predict brain cancer precisely, efficiently and accurately with speedy performance.**

***Index Terms*— Machine Learning, Deep Learning, Feature Extraction, Image Analysis, Image Pre-processing, Classification, Segmentation, Convolution Neural Network (CNN), Brain Tumor, Magnetic Resonance Image (MRI).**

I. INTRODUCTION

In the field of neuroscience brain MRI analysis is diagnosing the medical image by presenting useful details without affecting the image quality is mandatory. Classification, Detection and prediction of brain cancer is very challenging task. Medical image analysis is an important biomedical application, which is highly computational in nature and requires the aid of the automated systems.

This paper focuses on implementation of Multi-Layer Perception Neural Network (MLP) to work on brain tumor classification. The implementation is done using python libraries. The data that are used is provided by Jakesh Bohaju on Kaggle. This data set consist of brain tumor feature including five first-order features and texture features also called as Second Order Features .First Order Features like Mean, Variance, Standard Deviation, Skewness, Kurtosis. Second Order Features Contrast, Energy, ASM (Angular second moment), Entropy, Homogeneity, Dissimilarity, Correlation, Coarseness. Image column defines image name and Class column defines either the image has tumor or not. This paper focuses on representing brain cancer MRI images and then pre-process those images. A neural network model is built and accuracy is obtained by the MLP model on the

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Tumor dataset. The result obtained by using trained machine learning model is in terms of accuracy and speed.
This paper is organized as follows; Section 2 covers the survey on various neural network techniques. Section 3 Presents the implementation details about proposed methodology on brain cancer MRI using python. Section 4 represents the results of MLP Model. Finally, Section 5 focuses on conclusion.

II. LITERATURE SURVEY

Medical imaging [1]is the technique and process of creating visual representations of the interior of a body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues. Medical imaging seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease. There are various modalities who are involved in this technology as Digitized X-ray, Computed Tomography (CT),Magnetic Resonance Imaging (MRI) ,Ultrasound (US),Positron Emission Tomography (PET) ,Nuclear Medicine (NM),Radiation Therapy.
It is important to have a good representation of the input data, i.e. a good set of features that produces a feature space in which an algorithm can use its bias in order to learn.
[2] Among the various problems to the brain, the most common and the life-threatening problem these days is that of
the brain tumor. The broad classification categorizes the brain tumor into two classes, i.e., primary brain tumor and secondary brain tumor. Primary brain tumor is the one that stems inside the brain. Secondary brain tumor, on the other hand, originates in some other body part such as lung and then drifts to the brain generally via stream of blood. Manual detection of brain tumor by radiologists may be inaccurate and results can vary from one radiologist to another and may not necessarily guarantee proper diagnosis. There are different segmentation techniques available to segment the different tissue types in the human brain. A literature review have been done on work done by the researchers is to partially or fully automate the task of brain tumor detection. Various image segmentation techniques has been reviewed like thresholding, region growing, edge based watershed and clustering techniques. In thresholding the images are partitioned by organizing the nearest pixel of similar kind (homogeneity, texture, intensity levels and sharpness). Edge
based techniques figure out the image pixels that corresponds to the edges of the object visible in the image. Clustering technique classify the data into groups on the basis of attributes, features and characteristics. Watershed algorithm groups image pixels based on their intensities. Pixels with resembling intensities are assembled together.
In paper [3] authors have proposed an algorithm which segments the brain tumor tissues from MR images with noise and Intensity Inhomogeneity artifact. Here, preprocessing, enhancing, filtering and skull stripping done to remove noise and the skull region. Morphological edge detection algorithm has been implemented by image acquisition and by applying morphological operations like filtering, subtraction and edge detection on brain cancer MRI.
The primary task of pre-processing is to improve the quality of the MR images and make it in a form suited for further processing by human or machine vision system. In addition, pre-processing helps to improve certain parameters of MR images such as improving the signal-to noise ratio, enhancing the visual appearance of MR image, removing the irrelevant noise and undesired parts in the background, smoothing the inner part of the region, and preserving its edges [4].
Pre-processing is the first step in any data-driven study is to pre-process the raw images. Pre-processing removes noise by ensuring there is a degree of parity among all the images that in turn make the following segmentation and feature extraction steps more effective. This involves performing operations to remove artifacts, modify image resolution, and address contrast differences that arise from different acquisition hardware and parameters [5].
In past, various machine learning based segmentation approaches were proposed based on the criteria of either similarity measurement or dissimilarity analysis as presented in table1. [6].
Machine Learning is used in different domains. The general idea behind most machine learning is that a computer learns to perform a task by studying a training set of examples. Two of the most widely adopted machine learning methods are supervised learning and unsupervised learning. Supervised learning algorithms are trained using
labeled examples, such as an input where the desired output is known. Unsupervised learning is used against data that has no historical labels. The system is not told the "right answer." The algorithm must figure out what is being shown. The goal is to explore the data and find some structure within. Research in this area attempts to make better representations and create models to learn these representations from large-scale unlabeled data.

TABLE I. VARIOUS SEGMENTATION TECHNIQUES USED FOR BRAIN TUMOR

Segmentation Technique	Task Performed	Accuracy
Adaptive K-means Clustering [6]	MRI Images Enhancement and Tumor Segmentation for Brain on one single MRI sequence	98%
FCM-Kmeans[6]	Unsupervised Learning Algorithm for MRI Brain Tumor Segmentation	76%
Wavelet Multi-resolution Expectation Maximization Algorithm[6]	Brain Tumor Segmentation using Wavelet Multi-resolution Expectation Maximization Algorithm.	95%
Concatenated and Connected Random Forest with Multiscale Patch-driven Active Contour Model [6]	Complete Tumor, Tumor Core, Enhancing Tumor	90%,80%,73% respectively

Various deep learning architectures such as deep neural networks, convolutional deep neural networks, deep belief networks and recurrent neural networks have been applied to fields like computer vision, automatic speech recognition, natural language processing, audio recognition and bioinformatics where they have been shown to produce state of-the-art results on various tasks.[7][8]

Digital image processing is a rising field for the investigation of complicated diseases such as brain tumor, breast cancer, kidney stones, lung cancer, ovarian cancer, and cervix cancer and so on. The recognition of the brain tumor is considered to be a very critical task. Machine Learning and Deep Learning algorithms are mainly used for analyzing the medical images which can identify, localize and classify the brain tumor into sub categories, according to which the diagnosis would be done by the professionals.[9].

III. SYSTEM METHODOLOGY AND IMPLEMENTATION

Classification of brain tumor images and the segmentation of the tumor region from the normal part of the brain. The MRI images of brain are first classified into classes as normal or abnormal. Deep learning technology, in particular, Convolution Neural Network is used for classification as it has been found to provide higher accuracy than other machine learning algorithms. As shown in figure 1 there are various stages of proposed system like Collection and preprocessing of image dataset, further applying machine learning and deep learning algorithms on dataset. A trained model is built and then segmentation and classification of brain cancer is based on trained machine learning model. Finally, analysis and prediction are performed based on grade of brain cancer.

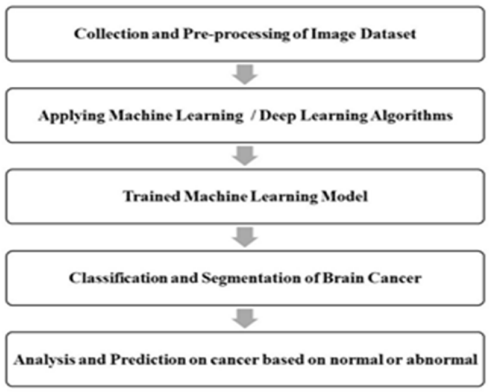

Figure 1 Proposed Methodology

A. Collection of Data Sets

The image data set consist of 3000 images of brain cancer MRI. The data that is used is taken from publicly available dataset for researchers. This is a brain tumor feature dataset including five first-order features and eight texture features with the target level (in the column Class).

B. Setup for implementation

The entire system has been implemented using Python programming language. Various machine learning and deep learning algorithms and techniques are implemented. The machine learning models are being trained and build on CPU.

C. Segmentation Process

For extracting region of interest image segmentation is required. There are different types of image segmentation techniques like Thresholding, Clustering, Edge based Segmentation, Region base segmentation, Artificial Neural network-based segmentation etc. following are the results of some of the image segmentation techniques implemented using python libraries.

D. Experimental Results for Classification using Neural Network

To start the process of neural network model for classification, first data is loaded. Input data is normalized using various image processing techniques. For working on machine learning and deep learning model has to be trained on some features. These features vary application to application. For this research brain cancer MRI images are considered as input. Machine learning model training process consist of following steps that are being implemented. In the first step is parameters are initialized. After that second step is iterating till the max iteration by various steps like Forward propagation, Loss calculation, and Back propagation, updating parameters and calculated a convergence estimation.

E. Correlation Heatmap of all the Important Features

Correlation heatmaps is to find relationships between variables and to understand the strength of these relationships. A heat map is a two-dimensional representation of data that are represented by different colors. Correlation Heat map is a two-dimensional plot of the amount of correlation (measure of dependence) between variables represented by colors. The varying intensity of color represents the measure of correlation.

F. Evaluation of Train/Validation losses for Trained Models

There are nine iteration that are executed while training the model and learning Rate of Model by representing Train and Validation data.

G. Confusion Matrix and Model Performance

Finally machine learning model test accuracy is calculated. Finally Confusion matrix is used to represent the classification model performance on the test data during the prediction is generated.

IV. MLP Model Result

Figure 2 represent sample images from brain cancer MRI dataset.

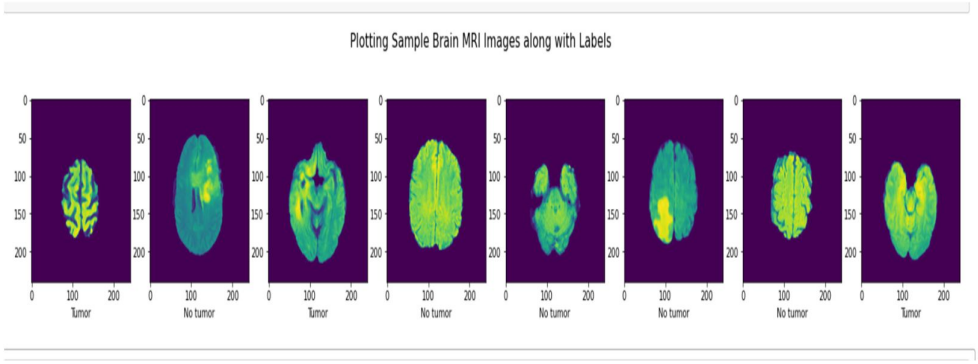

Figure 2 Sample brain Cancer MRI Images

Correlation heat maps is to find relationships between variables and to understand the strength of these relationships. Each square shows the correlation between the variables on each axis. Figure 3 represents heat map of features from dataset.

Figure 4 (a), Figure 4(b) and Figure 4(c) , represents Learning Rate of Model by representing Train and Validation data in first three iteration of machine learning model.

Evaluation of training and loss of trained model is plotted by Learning Curve. Learning curve is a graph of model learning performance over the experience or over the time. Learning curve learns from the input dataset in an incremental way. Learning Curve consist of x-axis and y-axis. X-axis represent iteration and Y-axis represents Loss. Generally Learning curve represents two major components first is Training Learning Curve and second is Validation Learning Curve.

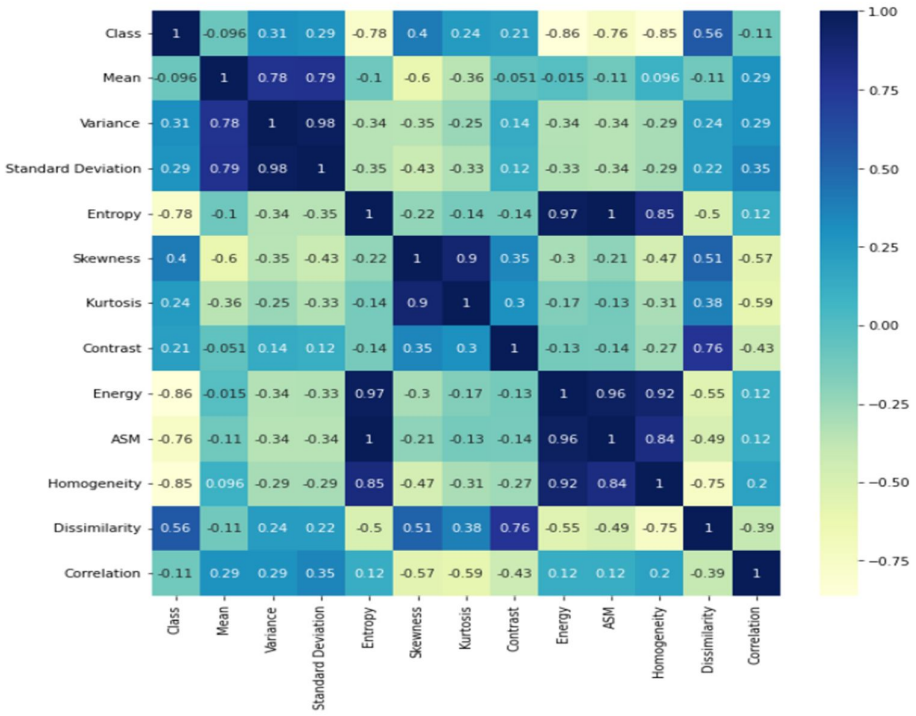

Figure 3 Heat map of features from dataset

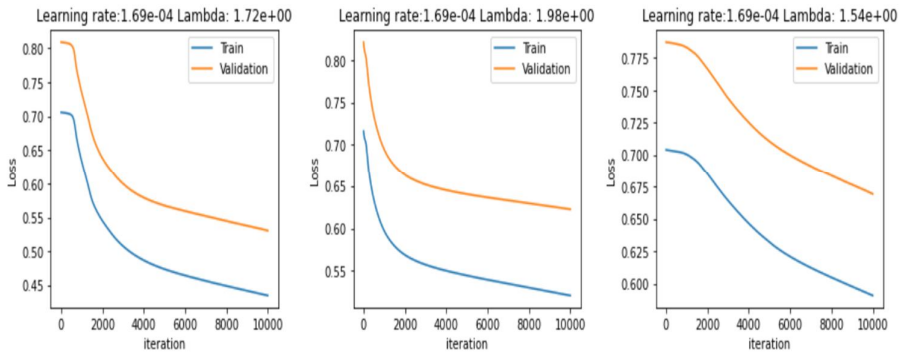

Figure 4a Learning Rate of Model

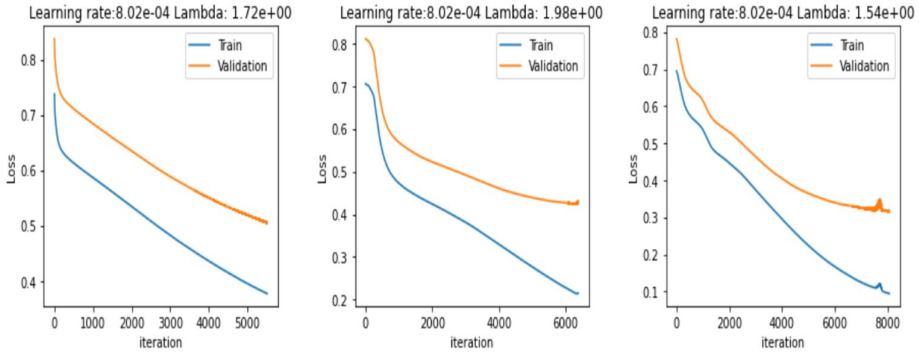

Figure 4b Learning Rate of Model

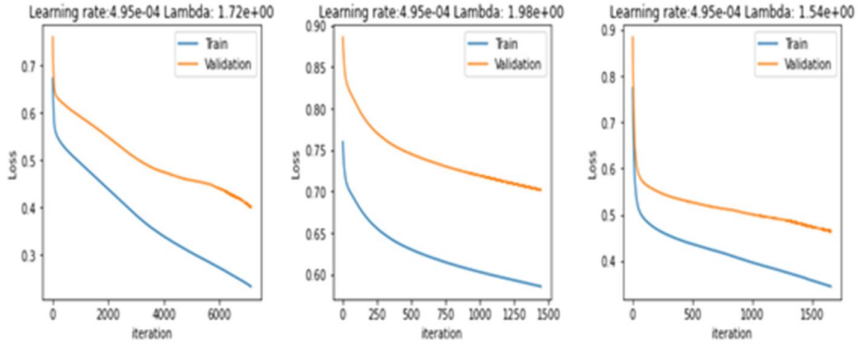

Figure 4c Learning Rate of Model

Confusion matrix is plotted for the implemented system and it is represented in figure 5.

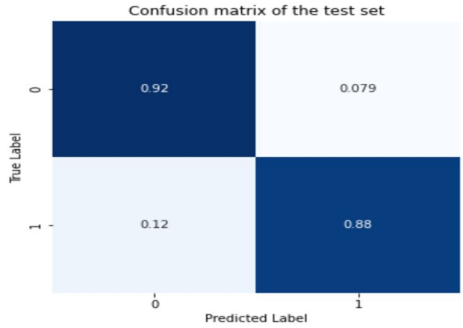

Figure 5 Confusion Matrix

V. Conclusion

Following table 1 represents the Model accuracy and F1 Score of trained neural network model.

TABLE I. MODEL ACCURACY AND F1 SCORE TABLE

Train accuracy	0.983013
Test accuracy	0.900398
F1 Score	0.886878
Training Duration	37.4089

This system is built by training the machine learning model with approximately 3000+ image dataset for accurate prediction on classifying the tumor and non-tumor part from the image. Initially various features are extracted and represented from the images that are most commonly used features to detect the tumor. Further, there are various techniques that are implemented for image segmentation to detect ROI. Segmentation is extracting tumor part as a region of interest from the MRI image.

This system is implemented to perform classification as well as segmentation on tumor and non-tumor dataset. Proposed Neural network algorithm have given us 88% of accuracy.

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