Brain Tumor Classification using MRI images with Deep CNN

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Abstract: Brain Tumor is a group of cells growing in a certain region in brain. This tissue mass may increase abruptly due to cell multiplication. As brain being the most crucial organ controlling different organs its safety is of utmost importance. The cancer should be precisely identified because early and accurate detection can reduce risk to patients. The MRI images have been taken for applying the imaging processing techniques to classify benign and malignant tumors.MRI images have been chosen for its spatial resolution, contrast and also help in providing greater detail of information. Gaussian filter is used as a de-noising method for the MRI medical data. The medical data holds very important information hence by combining them with Machine Learning(ML) algorithms and feature extraction techniques may produce more accurate and automated results. This research provides the state of the art classification of tumors using advanced ML algorithm CNN(convolutional Neural Networks). The CNN kernels used are of size 3X3 that prevents over-fitting. The accuracy achieved by this deep CNN containing 3-layers is 96.08%. Compared to various ML techniques CNN achieved the best result over MLP, SVM, KNN,etc.,

Keywords-Convolutional Neural Network (CNN),Brain Tumor, Classification, Feature Extration

I.INTRODUCTION

Brain tumors account for 85-90% of tumors in central nervous systems according to research[10]. The probability of survival of an individual diagnosed with a malignant tumor is around 36%. Hence the detection must be done accurately and rapidly to increase the survival chance of the individual. The non-invasive medical imaging techniques help us in identifying the tumor without bloodshed. The most common imaging techniques include Magnetic resonance imaging(MRI) and Computed tomography(CT) scans. MRI images give us greater details of information related to the brain than a CT scan. The doctors also prefer the MRI images to decide the abnormality such as tumors than a CT scan because it provides detailed information about soft tissues, Spatial resolution, and contrast. There are different grades of the brain tumor where Grade-1 MRI looks similar to normal MRI, where the growth is very slow.In Grade-2 the tissue becomes malignant and is detectable from MRI Image with proper visualization.

Recently Deep learning has gained interest in recent times because of its the state of the art performance in segmentation, feature extraction. Deep learning has shown some promising results in speech recognition, hand character recognition, Image classification, etc. Out of the many deep learning techniques in use image classification could best be done with good accuracy with the help of convolution neural networks. Deep learning excels in recognizing details in the images since it has more layers where each layer extracts one or more features of the image. It also reduces the human efforts for feature selection and Region of interest identification[8] which prevailed before Deep Neural Networks(DNN).

Multi-Layer perceptron(MLP) is a fully connected neural network where each node is connected to every node in the next layer. This complex architecture results in overfitting hence less accurate in the application such as image classification. But Deep learning architecture such as CNN's is regularized because of shared-weight architecture that prevents over-fitting. It works by adding a regularized term to the loss function. Moreover, it does not require much preprocessing compared to other computer vision problems because of less complex architecture. The CNN architecture contains convolutional layers, a pooling layer, and fully connected layer

II. LITERATURE REVIEW

In the early era of Artificial intelligence, the Brain tumors classification from MRI is done using Artificial neural net- works(ANNs) such as MLP, SVM..etc., The system using a sliding window and Central Moments for feature extraction is done in[11]. A sliding window of size 16X16 pixels was used. Histogram was calculated on each zone(16X16 pixel area) on the MRI image of the brain. Each histogram was considered as a sequence for which the central moments of order 1,2 and 3 are calculated. The classification was done using a multi-layer perceptron(MLP) technique. This initial technique for brain tumor classification achieved a tumor recognition rate(R_R) of 88.33%. This method acquired an error_rate(E_R),Ambiguity rate(A_R), the Rejection rate(R_R) of 3.333%,5.00% and 3.333% respectively.

The classification of cancerous and non-cancerous MRI images using an SVM classifier and a lot of image pre- processing is done in this research[2]. Under pre-processing the following steps like RGB to Grayscale conversion, filtering the noise using median filter,skull removal which includes removal of skull, eye and other non-brain information from MRI image. Then the features which include grayscale,texture and symmetrical were extracted and are directly fed PCA(feature reduction technique) and then to the SVM classifier. SVM with different kernel functions such

[malignant tumor][width=2.5cm]yes

[benign tumor][width=3cm]no

Fig. 1. Dataset

as linear, polynomial, quadratic were studied in [2] which showed an accuracy of 74% 76% and 84% respectively. This prototype for object detection using SVM achieved an accuracy of 82%. A similar work using SVM was done in this paper[1] which achieved an accuracy of 83% which includes anisotropic filtering as a noise removal technique and SVM as a classifier. If the SVM results show it as a tumor MRI image then morphological operations using erosion and dilation are performed to identify the tumor region.

The tumor region identification was done using morphological operation and pixel subtraction. Morphological operation includes erosion following the dilation. Pixel subtraction is done using the original and morphological operated image to remove the skull, eye and other non-brain regions from MRI images. Then the segmentation is done using maximum entropy thresholding on the skull removed MRI image. The features are extracted from these images and trained using naive Bayes classifier which achieved an accuracy of 94% as seen in the research work in [13]

KNN classifier with 30 MRI images was used for the classification of malignant and benign tumor and the detection was done using Matlab software. KNN classifier took less time for classification, it gave less accuracy. Hence the usage of GLCM(Gray Level Co-occurrence Matrix) gave more accuracy and the results were compared with the ones obtained without using GLCM based on the research in[12]. GLCM features included contrast, dissimilarity, energy, ho- mogeneity in the form of a matrix which was fed to the KNN classifier. A similar hybrid approach of classification using DWT, GLCM and Probabilistic Neural network(PNN) is done in

TABLE I

RELATED TABLE COMPARISION OF KNN WITH AND WITHOUT GLCM

PARAMETERS	KNN WITHOUT GLCM	KNN WITH GLCM
Error Rate	0.4	0.15
Accuracy	0.6	0.8
Sensitivity	0.5	0.8
Specificity	0.7	0.9
Precision	0.625	0.888
False Positive Rate	0.3	0.1

III.PROPOSED SYSTEM

A.Data set

The standardized MRI images data set was taken from kaggle[14] an open repository for data sets. This data set contains 98 images of Benign tumor MRI and 158 malignant MRI images. All the images are in JPEG or JPG format hence we can work with great ease.

B.Preprocessing

Gray Scale Conversion: The images collected from the data set are converted to grayscale.This is because the components of Cb, Cr in RGB images contain color information which is of no use hence these are nullified and only Y component is used for analysis. This conversion of RGB to grayscale returns us the more important component Y which is related to intensity or luminance levels related to the image. Moreover, the human eye is more sensitive to contrast variation than color variation. Hence the contrast information is used by doctors for judging the abnormality than using a colored image. The similar conversion has been done in [6] Gaussian filtering: The noise in an MRI image is of two types that is Internal noise due to faulty switching and wear and tear of instruments, external noise due to environmental conditions which affect the working of sensors and instruments. Good denoising is one that retains all the important features and edges. Hence among all gaussian filter suits the best in case of biomedical image processing for noise removal. This filter is applied to MRI image dataset as a preprocessing technique.

[width=6cm]architechtre

Fig. 2. Architecture

C.Feature Extraction

All the early Machine learning techniques used the manual feature selection and extraction such as contrast, GLCM, entropy, energy...etc, The drawback of manual feature selection is that we may lose some features that are important for having the best accuracy or some features which we might think as important may overfit the model. Recent days usage of the CNN model in image classification increased because of its automated and relevant feature selection. Hence the overfitting due to manual feature selection can be avoided. This is why Deep learning techniques are at a fast pace because of its capability of self-learning the features from the data given. proposed network model

- To use the dataset properly all the preprocessed images are resized to 256X256 pixels. Hence the images can be handled with ease.
- Next, a Convolutional layer of kernel size 3X3 is applied with Rectified Linear Unit(ReLU) as an activation function.
- Next, a pooling layer of size 2X2 is applied to the convolved image. Among various pooling techniques such as average, minimum, maximum pooling we used max-pooling. This is because max-pooling helps us in extracting the most extreme and important features such as edges whereas average pooling helps in extracting smooth features of the image.
- The above two steps contribute to a one ordered CNN layer architecture and are repeated in order to achieve a 3 layered CNN deep neural network model.
- The features extracted are flattened such that the obtained feature vector can be used as an input to the classifier. The obtained feature vector is fed to a Fully connected neural network layer(FCN). A dense or Fully connected neural layer has nodes connected to all nodes of previous layers.
- Sigmoid is used as an activation function for classification. An outermost dense layer has only one neuron that implements the binary classification. Two neurons can also be used but one neuron performs well.

IV.RESULTS

The proposed system architecture provides better accuracy than the existing methods because of its deep learning model. The model achieved an accuracy of 96.08% accuracy for 50 epochs.80% of the dataset taken is used for training the model and the remaining 20% is used for validation. Google Colab, an open-source research provider was used as a platform for implementing the trained model on a GPU. The supporting graphs of loss and accuracy were plotted against epochs. The blue line represents the training and the Orange line represents the validation. The graph in Fig 3. is plotted against Accuracy and epochs. The graph in Fig 4. is plotted against loss and epochs. From the plotted graphs it was found that the model had good accuracy and least error.

[width=8cm]CNN$_{a}rc$

Fig. 3. CNN Model

[width=8cm]train4

Fig. 4. Accuracy Vs Epochs

V.CONCLUSIONS

The performance of the CNN classification algorithm over other deep learning techniques was found to be more accurate. Out of various pre-processing techniques used, the Gaussian filter would be best suitable for denoising the signal in biomedical image processing. The accuracy of the proposed system was found to be more than machine learning algorithms. Hence this technique can be used for the rapid detection of brain tumors for large chunks of data processing.

[width=8cm]loss4

Fig. 5. Loss Vs Epochs

VI.FUTURE SCOPE

Further research can be done on the improvisation of the pre-processing techniques. The stages of cancer could be detected with the help of a detailed analysis of the features extracted. A generalized model can be built after the analysis of different types of cancer. A hybrid approach of different neural networks and classifiers can be applied as in[4], [5] for understanding the best model.

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