BRAIN TUMOR DETECTION AND CLASSIFICATION USING NEURAL NETWORK

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ABSTRACT

Brain tumor is one of the most dangerous disease which requires early diagnosis and accurate detection method. Tumor is the mass growth of abnormal cells. The tumor may be cancerous or non-cancerous, the cancerous cells are life threatening hence early diagnosis is necessary. The tumor can be detected by medical imaging techniques like Magnetic Resonance Imaging (MRI), which is most preferred imaging technique. The accurate detection of tumor in the MRI scan is quite challenging, hence segmentation is performed to detect the tumor accurately. The segmentation is done by clustering technique and then classification is performed. With the advances of deep learning in medical field the automatic classification of brain tumor can be performed. The convolutional neural network is used to perform classification of the tumor as benign or malignant. The convolutional neural network outperforms other machine learning algorithms and provides better results.

Keywords: *Brain Tumor, MRI, Segmentation, Deep learning, Convolutional neural network (CNN).*

1.INTRODUCTION

Brain Tumor is a mass of tissue or abnormal growth of cells in the brain that affects the functioning of the brain. It is one of the most dangerous disease which requires early and accurate detection method. There are two main types of tumors they include benign and malignant. The benign are non-cancerous type of tumor whereas the malignant is cancerous type of tumor. Cancerous tumors are often divided into primary tumors and secondary tumors. The primary tumors start within the brain and the secondary tumors most commonly have spread from tumors located outside the brain, they are also known as brain metastasis.

There are several ways to diagnose brain tumors. Many imaging techniques are available among which MRI is the most preferred technique. Magnetic Resonance Imaging (MRI) are extensively employed in diagnosing brain tumors. Therefore, development of systems for the detection and prediction of the grade of tumors supported MRI data has become necessary. But initially sight of the imaging modality like in resonance Imaging (MRI), the right visualization of the tumor cells and its differentiation with its nearby soft tissues is somewhat difficult task which can flow from to the presence of low illumination in imaging modalities or its large presence of knowledge or several complexity and variance of tumors-like unstructured shape, viable size and unpredictable locations of the tumor.

Automated defect detection in medical imaging is an budding field in several medical diagnostic applications. Its application in the detection of brain tumor in MRI is very crucial as it provides information about abnormal tissues which is necessary for planning treatment. The automatic computerized detection and diagnosis of the disease, based on medical image analysis, could be a good alternative to save radiologist time and also obtain a good accuracy.

2. LITERATURE SURVEY

The literature on Brain Tumor detection and classification can be elucidated as follows.In [1] **Z. Tang et al.,** have proposed a Deep learning framework to image the phenotype and genotype to predict the overall survival time of glioblastoma patients. They have used multi-task convolutional neural network to obtain the overall survival time in glioblastoma patients. The genotype and phenotype features are obtained by MGMT and diffusion weighted imaging. In [2] **Saniya Ansari et al.,** have proposed brain tumor detection and classification using K-nearest neighbour and LLOYD Clustering. Here the pre-processing is performed by filtering the MRI images using a high and low pass filter and morphological operations is performed. The tumor is detected using otsu thresholding. The segmented images further processed by KNN Clustering and LLOYD. The LLOYD is a two step implementation of k-means algorithm that allows to cluster data points into groups which are represented by the centroid. In [3] **R.S Latha et al.,** have proposed brain tumor classification using Support vector machine and K-nearest neighbour model for SMOTE based MRI Images. Here segmentation is performed by thresholding and then Synthetic minority oversampling technique based sampling is performed. The feature extraction is performed by the Discrete wavelet transform and feature selection is performed by the Principal component analysis. The classification is performed using the KNN and SVM. In [4] R. **Thillaikkarasi et al.,** have proposed a algorithm for brain tumor segmentation and classification. The MRI images are smoothed and enhanced by Laplacian of Gaussian filtering method (LoG) with Contrast Limited Adaptive Histogram Equalization. From the obtained results the features are extracted based on the shape and surface of the tumor. The classification is performed using the Support Vector Machine and further segmentation is performed using the kernel based Convolutional neural network. In [5] **M. Gurbina et al.,** have proposed brain tumor detection and classification using Support Vector Machine. The MRI images are pre-processed by denoising with different kinds of wavelet and then segmentation is performed by otsu thresholding. The features are extracted using Discrete wavelet transform and Continuous wavelet transform then classification is performed using Support vector machines. In [6] **Pushpa et al.,** have proposed brain tumor detection and classification using machine learning algorithms. The MRI brain images are filtered using median and gaussian filters and then morphological operations are performed to obtain the tumor. The required features are extracted for classification purpose. In [7] **Ghazanfar Latif et al.,** have proposed MRI Image classification by hybrid statistical and wavelet features. The tumorous or non-tumorous classification of the brain MRI images is performed. The first and second order features are extracted by discrete wavelet transform and further the classification is performed using Multiple layer Perceptron. In [8] **Javeria et al.,** have proposed Support vector machines with different cross validations to classify the tumor. Initially the tumor region is segmented and feature extraction is performed. The classification is performed with different Support vector machine kernels. The process is time consuming and it may not produce very high accurate results.

The rest of the work is organized as follows: Section 1 briefs the introductory part, Section 2 elucidates the literature survey, Section 3 explains about the Methodology, Section 4 shows the Results and Discussion and Section 5 concludes the proposed work.

3. METHODOLOGY

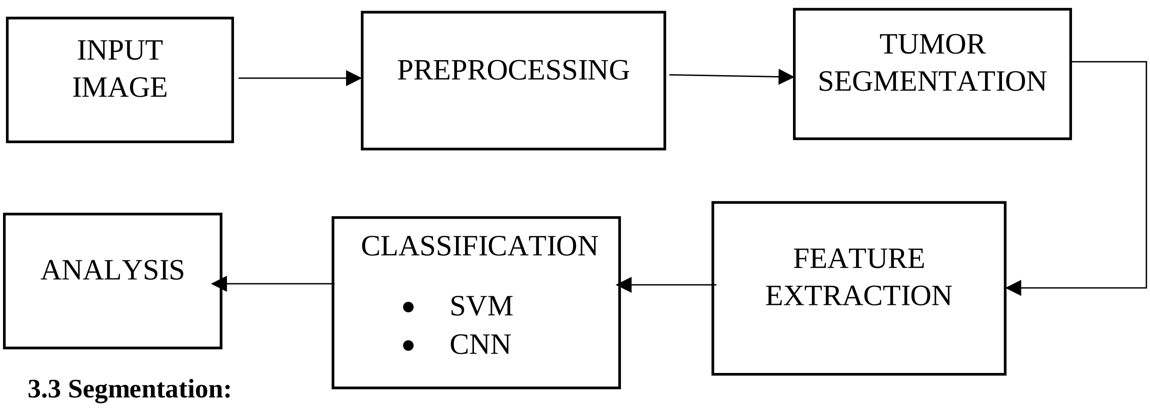
The methodology section explains the steps involved in Brain tumor detection and classification.

3.1 Input image:

The Dataset includes images obtained from Brain tumor MRI images. It consists of benign and malignant tumor images.

3.2 Pre- processing:

In the pre-processing step the grey scale conversion and resizing is performed. The noise is removed using median filter. The image are resized to 200X200.



3.3 Segmentation:

The segmentation is performed to identify the tumor region.The pre-processed images undergo segmentation. The segmentation is performed using Fuzzy C-Means Clustering and the tumor region is shown using a bounded box.

Fuzzy C-Means Clustering:

Fuzzy clustering is a form of clustering in which each data point can belong to more than one cluster. Clustering or cluster analysis involves assigning data points to clusters such that items in the same cluster are as similar as possible, while items belonging to different clusters are as dissimilar as possible. Clusters are identified via similarity measures. These similarity measures include distance, connectivity, and intensity. Different similarity measures may be chosen based on the data. FCM is also referred as soft clustering. It is the most widely used clustering algorithm. The objective function minimized in the original version measured distances between data points and prototypes in any inner product norm, and memberships were weighted with an exponent m>1.

The objective function is given by

$$J(U,V) = \sum_{i=1}^{n} \sum_{j=1}^{c} (\cup ij)^{m} \parallel x_i - v_j \parallel^2$$

The FCM objective function is minimized when high membership values are assigned to pixels which are close to the centroid of its particular class, and low membership values are assigned when pixels are away from the centroid [11]. The membership function should satisfy the following condition

$$\mu_{ik} \in [0,1],\ 1 \leq i \leq c,\ 1 \leq k \leq N$$

$$0 \leq \sum_{k}^{N} \mu_{ik} \leq N,\ 1 \leq i \leq c,\ \sum_{k}^{N} \mu_{ik} = 1,\ 1 \leq k \leq N$$

3.4 Feature extraction:

Feature extraction is the mathematical statistical procedure that extracts the quantitative parameter of resolution changes or abnormalities that are not visible to the naked eye. Feature extraction is a critical task which involves huge amount of data as input and transforming it in to optimal feature set [12]. Texture is an important characteristics that is used for the analysis of different images. The statistical texture features are extracted, the statistical features determine the non-deterministic properties and the relation between the grey level pixels in an image. The GLCM is formulated to obtain statistical texture features. The features obtained are Entropy, RMS, Smoothness, Skewness, Symmetry, Kurtosis, Mean, Texture, Variance, Centroid, Correlation, Energy, Homogeneity, Dissimilarity, Contrast, Shade, Eccentricity, IDM, Perimeter, Area and many more.

3.5 Classification:

Support Vector Machine

Support Vector Machine is a supervised machine learning which is widely used in classification and regression problems. The classification is usually carried out in n-dimensional space. The hyperplane differentiates between two classes and the further classification is performed, the mapping is done based on the features. The predictions are performed based on which gap they fall. In case of non-linear classification the kernel trick is used for mapping in the feature map space.

The kernel function or window is defined as

$$K(\bar{x}) = \begin{cases} 1 & \text{if } x<1 \\ 0 & \text{otherwise} \end{cases}$$

Convolutional Neural Network

Convolutional neural network is a deep learning algorithm which widely used for classification. A 2D convolutional network is used which has kernel size 3x3 and same pooling. The neural network has three layers, the first layer has a filter size of 32 and the following layers filter size is 64. Maxpooling of 2x2 is used. The activation function used for classification is the softmax. The loss function used is categorical crossentropy. Three optimizers such as SGD, Adam and Rmsprop is used. The dataset is divided into train and testing and the resultant loss, validation loss, accuracy and validation accuracy is calculated.

4. RESULTS AND DISCUSSIONS:

4.1 Input Image and Pre-Processing:

The Dataset consists of Brain tumor MRI images. It includes 164 benign and 170 malignant tumor images. The first step is pre-processing which includes gray scale conversion, noise removal and the images are resized to 200x200.

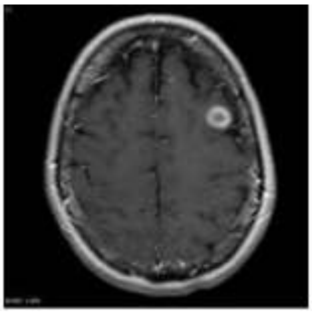


Fig 1(a) Benign Tumor

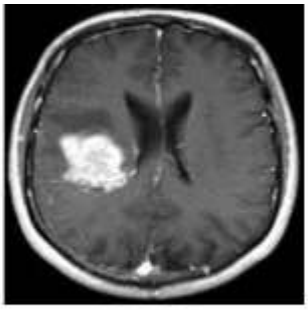
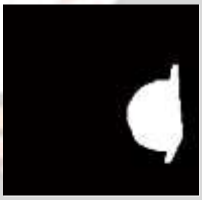
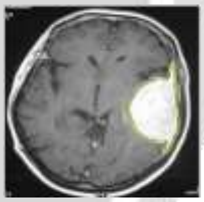
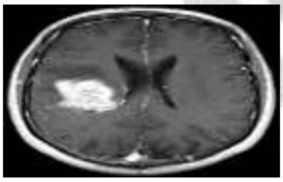
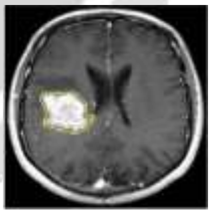
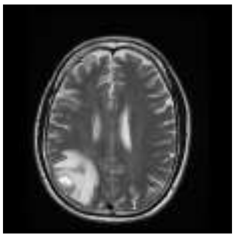
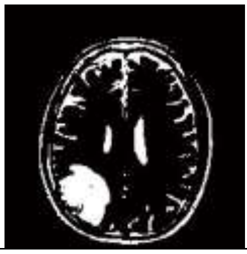
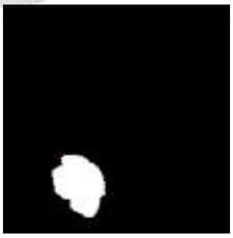
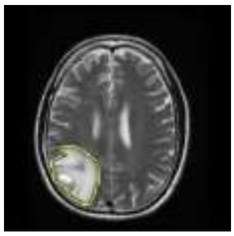


Fig1(b) Malignant Tumor

4.2 Segmentation:

Segmentation is performed to obtain the tumor region. Here segmentation is performed by Fuzzy C-Means Clustering. The tumor alone is obtained by performing morphological operations and the region is highlighted using a bounded box.

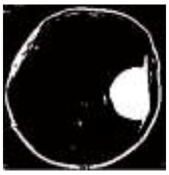
Table 1 Segmentation Results

INPUT IMAGE	SEGMENTED IMAGE	TUMOR ALONE	DETECTED TUMOR
			
			
			

4.3 Feature Extraction:

The texture based statistical features extracted are shown in the below table

Table 2 Feature Extraction

IMAGE	FEATURES
	Contrast = 0.224972 Correlation = 0.117869 Energy = 0.742300 Homogeneity = 0.928077 Mean = 0.005611 SD = 0.085635 Entropy = [illegible] RMS = 0.089803 Variance = [illegible] Smoothness = 0.904234 Kurtosis = 6.570366 Skewness = 0.496411
	Contrast = 0.239711 Correlation = 0.117030 Energy = 0.751879 Homogeneity = 0.930293 Mean = 0.004353 SD = 0.089709 Entropy = 3.633603 RMS = 0.089803 Variance = 0.008039 Smoothness = 0.941838 Kurtosis = 6.344813 Skewness = 0.527916

4.4 Classification:

The classification is performed using Support Vector Machine and Convolutional Neural Network. The classification results are shown below

Fig 2 CNN Classification Result

Performance Analysis:

Table 3 Performance of SVM

CLASSIFIER	ACCURACY
LINEAR KERNEL	80 %
RBF KERNEL	70 %
POLYNOMIAL KERNEL	70 %

Table 4 Performance Table of CNN

Epochs=15	ADAM	SGD	RMSPROP
Accuracy	97.4	96.10	96.2
Val_accuracy	92.2	87	89.2
Loss	0.07	0.11	0.17
Val_loss	0.28	0.29	0.62

The performance Table of both SVM and CNN is shown above. The above values show that accuracy obtained by Convolutional Neural Network is more compared to that of SVM. The results also show that Adam optimizer provides more accuracy compared to other optimizers.

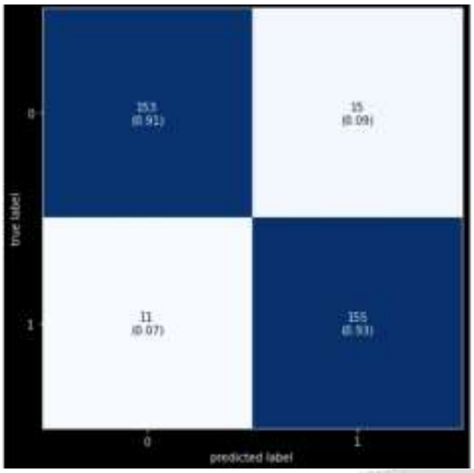
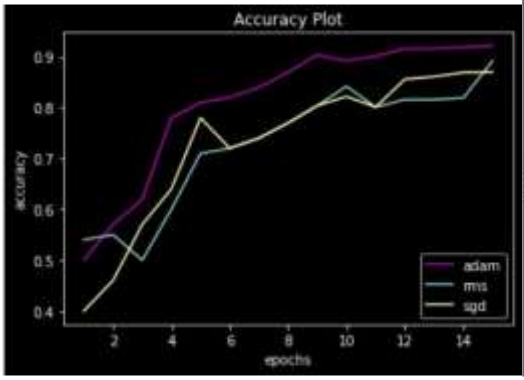


Fig 2 Confusion Matrix



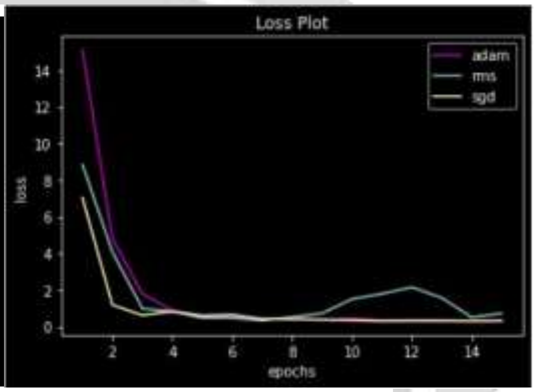


Fig 3 Accuracy Plot **Fig 4** Loss Plot

Figure 3 and 4 shows the Accuracy Plot and Loss Plot of different Optimizers

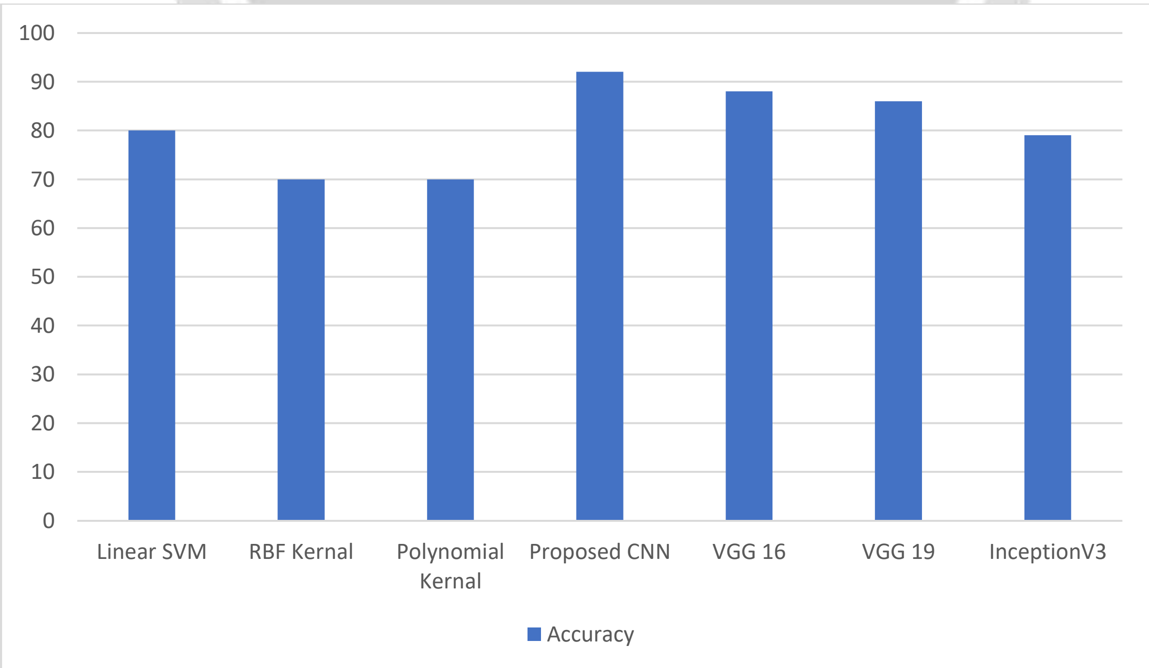


Chart 1 Accuracy chart

The above chart shows that the proposed Convolutional Neural Network gives more accuracy when compared to that of SVM and other Convolutional Neural Network Models such as VGG16, VGG19 and InceptionV3.

5. CONCLUSION

Brain Tumor is a life threatening disease that occur in people of all age groups. If the required treatment at the earliest is not given then it may lead to death. To speed up the diagnosis process and identify the type of tumor at first Segmentation is performed to get the region of interest that is the tumor region. Here Segmentation is performed by Fuzzy C-Means Clustering, the results show that FCM provides better accuracy . The second order statistical features are extracted and further classification is performed. The classification is performed using SVM and Convolutional Neural Network. The results show that the robust convolutional neural network provides more accuracy compared to SVM. The classification is performed with different Optimizers. The results show that Adam Optimizer provides better accuracy compared to other Optimizers.

6. REFERENCES

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