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Brain Tumor Detection Using MRI Images

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Abstract- **Brain tumor is a disease difficult to cure it can lead to disability and in severe conditions can be fatal. Therefore, detecting tumor at an early stage can help to save someone's life. Tumors can be located anywhere in the brain, which makes it a difficult task to segment them for medical purposes. Tumor is an uncontrolled growth of cells or tissues. Magnetic Resonance Imaging (MRI) is used to diagnose brain tumor. For better and faster detection of the disease in its initial stage and to start the treatment at the earliest it is important to determine a methodology to detect the tumor accurately without the direct intervention of doctors. Here we have introduced a technique for brain tumor detection. CNN for detecting tumor images and SVM for classifying images into benign and malignant. Before this the noise from the images is removed using a median filter. The methodology proposed here aims to detect tumors faster and with better accuracy saving time of the patient otherwise needed.**

Keywords* — *Brain tumor detection, CNN, Median filter, SVM.

I. INTRODUCTION

Tumors are abnormal cell growth. With time the tissues and cells in our body die and are replaced by new cells. When this cycle is disrupted it leads to tissues getting accumulated causing tumors. There are various techniques used for imaging the brain tumor like Positron emission tomography (PET), Computed tomography (CT), Magnetic Resonance Imaging (MRI).CT's use ionizing radiations of x-rays which prove to be damaging. Since MRIs use powerful magnets to predict the water molecule movement in living tissues it is considered to be safest and best. There are primarily two types of brain tumor Benign (low grade) and Malignant (high grade).Benign tumors are small tissues grown in the brain which are non- cancerous. Once treated they may not regrow. Malignant tumors are cancerous tumors. They are dangerous and need immediate medical attention. They may regrow after treatment and need continuous monitoring even after years.

Brain tumors account for majority of all primary fatal tumors. Out of these, many deaths occur due to delayed detection or inaccurate detection of its severity. An appropriate system that could be used in detecting the tumor accurately without many visits to the clinics is the need. Developing a system that can be used in run time can help the doctors to divert the attention towards the right patients depending on the presence and severity of tumor.

II. RELATED WORK

In paper [1] Normalization of Histogram and K-means Segmentation are used for detection of tumor. First the input image is pre-processed in order to remove the noise from it. The histogram of the pre-processed image is normalized and classification of MRI is done. Then image is segmented using K-means algorithm. But it is difficult to predict the number of clusters and detection is not accurate as it could not find out accurate boundary of tumor region.

In paper [2] The proposed methodology is Histogram thresholding. This includes segmentation of an image based on thresholding of histogram features and grey level thresholding and perhaps the simplest technique. This is particularly suitable for an image with region or object of uniform brightness placed against a background of different grey level. Thresholding can be applied to segment the object and background. But this lacks sensitivity and specificity needed for accurate classification and it is sensitive to noise and difficult to set threshold.

In paper [3] Sigma filter is used for removing noise from MRI Images. The sigma filter finds the average of pixels in the box that has been predetermined size which not deviate too far from the pixel which the box is centered on. And Shape Features method is used to extract features for MRI Images and two Machine learning algorithm for classification were used to compare their performance which are decision tree algorithms and multi-layer perceptron (MLP). It can be combined with other decision techniques but they are unstable.

In paper [4] application of histogram is essential for machine learning algorithms like kNN because it gives the total number of specified value of pixels distributed in a particular image. In Re-Sampling given input image is resample for proper geometrical representation of every

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image which undergo through this algorithm. kNN is a non-parametric and regression algorithm. It learns based on training and works well with any number of classes, it is robust to noisy training data and its effective if the training data is large but it needs a determined number of nearest neighbors and distance based learning is not clear and even the computing cost is quite high.

In paper [5] CNN is used for automatic tumor region segmentation. A small 3x3 filter size is used to outline more profound design. Activation function used here is the leaky rectifier linear unit(LReLU) however using a small filter size fails to incorporate information with large receptive fields and processes only local information causing confusion in the location and image neighborhood.

In paper [6], SVM is been used to solve one of the classical problems in image processing that is image classification. The major goal of image classification is to predict the input image categories by using the features. SVM is used to classify the images into two classes. It provides accurate results with less number of data samples. But it is not sensitive towards noise that leads to inexact detection and modal complexity cannot be increased further.

III. PROPOSED METHODOLOGY

The proposed brain tumor detection and classification system consist of 3stages:Pre-processing stage, detection stage and the classification.

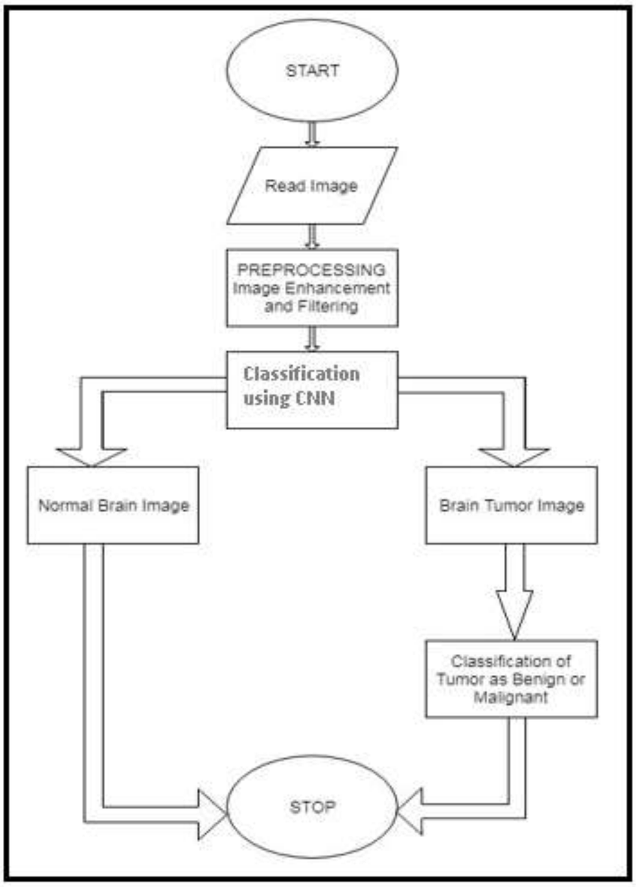

Fig 1:System Architecture

Pre-processing

Median Filter would be used for pre-processing of MRI images. Median Filter is a digital filtering technique. And it is used so as to improve the results of the later processing of the MRI images during the CNN and SVM processing. 'Salt and Pepper' type of noise is effectively removed by median filter. Median filter moves through the image pixel by pixel replacing the value with the median value of the neighboring pixels and this is the main idea behind the median filter.

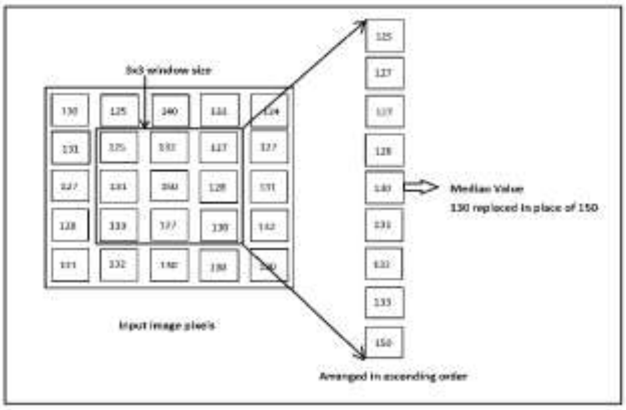

Fig 2. Median filter

Algorithm for the median filter:

Step 1: In the corrupted image, a two dimensional window of size 3x3 is selected and centered around the processed pixel $p(x, y)$.

Step 2: Pixels in the selected window are to be sorted

in ascending order.

Step3:Median pixel value denoted by$P_{med}$is calculated.

Step 4: The $p(x, y)$ is replaced by the median value thus calculated.

$$p(x, y) = P_{med} = median_{i,j\in\omega}\{y(i, j)\}$$

$$where\ \omega = neighbourhood$$

Detection using CNN

In this project, CNN is used to detect tumor in an MRI brain image. It classifies the image as tumor or non tumor. Features are extracted from an image using this algorithm which helps to detect tumor.

CNN consist of various layers:

Input Layer- This is the initial layer of the CNN network. Here a 64x64x3 image is taken and stored in raw form. The range of each pixel is from 0 to 255.

Convolution Layer- A kernel of 3x3 is used for convolution. First, convolution of the image pixels takes place with the 3x3 filter matrix which generates a feature

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map. Here, the number of convolution layers used is 3 with 32, 64 and 128 kernels respectively.

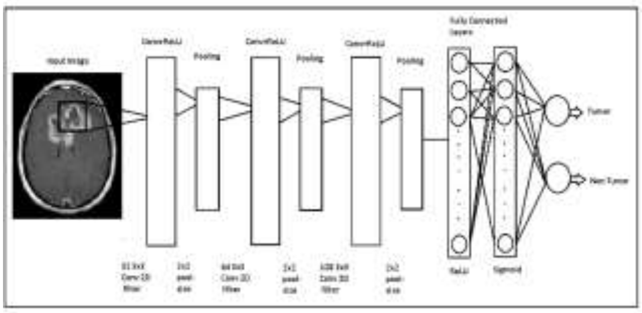

Fig 3: CNN model

Comparison between the various filters is shown in the table below. Convolution 2D filter is used here.

FILTER	ADVANTAGES	DISADVANTAGES
DILATED	COMPUTATIONAL OVERHEAD IS LOWER. CONTEXTUAL INFORMATION IS PRESERVED	POSSIBLE SPATIAL LOSS
CONVOLUTION 2D	ENABLES DETECTION OF FEATURES FROM LOW TO HIGH LEVEL IN EACH INCREASING LAYER	THEY ARE COMPUTATIONALLY EXPENSIVE
SOBEL	EDGE DETECTION IS GOOD	FEATURES LIKE CONTRAST AND CORRELATION GO UNDETECTED

Table1: Comparison of various filters in CNN.

Rectified linear unit activation function

An element wise activation function is applied. It introduces non-linearity in our model. The tanh, sigmoid or other non linear functions can also be used instead of ReLU. Since performance of ReLU is better than other two, it is used in our model. ReLU is represented mathematically as

$$f(x) = \max(x, 0)$$

Max-Pooling Layer- A down-sampling operation is used after every convolution layer along the spatial dimensions (width, height). A max pooling layer is used in the pooling layer, which selects the largest element from the rectified feature map. A 2x2 pool size is used in our model.To convert into vector data, flattening is performed on feature map.

Fully-connected layer- Features are combined together in this layer. Two fully connected layers are used where the first layer has 128 units with ReLU activation and second layer has sigmoid activation. Mathematically sigmoid activation function is represented as

$$f(x) = 1/(1 + e^{-x})$$

Output Layer- This layer gives the output of the model. It provides the result as tumor detected or normal brain.

Optimizer

To compute the learning rates, Adaptive Moment Estimation (Adam) algorithm is used for individual parameter, which is a combination of RMSprop and gradient descent with momentum.

Adam algorithm

- G_{dw} ,G_{db}, SG_{dw}, SG_{db} set to zero.
- Compute derivatives dw & db using present batch.
- Update G_{dw} & G_{db} as follows

$$G_{dw} = (1 - \beta_1) \times dw + \beta_1 \times G_{dw}$$

$$G_{db} = (1 - \beta_1) \times db + \beta_1 \times G_{db}$$

- Update SG_{dw} & SG_{db} as follows

$$SG_{dw} = (1 - \beta_2) \times dw^2 + \beta_2 \times SG_{dw}$$

$$SG_{db} = (1 - \beta_2) \times db^2 + \beta_2 \times SG_{db}$$

- Here bias correction is implemented as below

$$G_{dw}{}^{cor} = G_{dw} / (1 - \beta_1{}^i)$$
$$G_{db}{}^{cor} = G_{db} / (1 - \beta_1{}^i)$$
$$SG_{dw}{}^{cor} = SG_{dw} / (1 - \beta_2{}^i)$$
$$SG_{db}{}^{cor} = SG_{db} / (1 - \beta_2{}^i)$$

- Update parameters w & b.

$$w = w - \left(G_{dw}{}^{cor} / \sqrt{(SG_{dw}{}^{cor} + \varepsilon)}\right) \times \alpha$$

$$b = b - \left(G_{db}{}^{cor} / \sqrt{(SG_{db}{}^{cor} + \varepsilon)}\right) \times \alpha$$

where:

ε = small number to avoid dividing by zero (10^{-8})

α = learning rate

β_1, β_2= control exponential weighted averages. ($\beta_1 = 0.9$ & $\beta_2 = 0.999$).

Classification using SVM

Support Vector Machine (SVM) is a classification algorithm which constructs a hyperplane to separate different class labels. SVM is used to classify the images as Benign or Malignant.

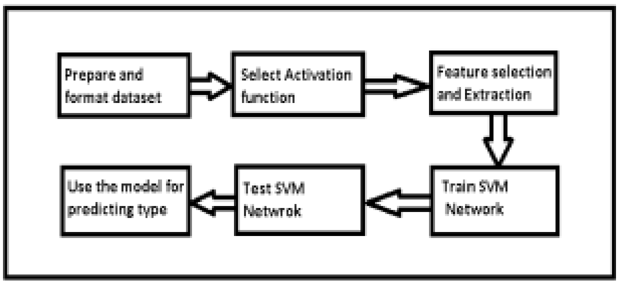

Fig 4. SVM Steps

Texture, contrast and edge features are extracted from the images along with a sigmoid activation function is used in the SVM model.

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SVM Algorithm

- Aim is to find the find the optimal hyperplane in the pool of infinite hyperplanes in case of linearly separable data. The optimal hyperplane separates the two classes so that the distance between the extreme data points is maximum. Mathematically, it should separate so well that the function defined by:
- $G(x) = wx + b$is positive if and only if $x \epsilon A$
- $G(x) = wx + b$is negative if and only if $x \epsilon B$
- The equation for hyperplane is $wx + b = 0$.
- Mathematically solving the equations we get the margin as $\frac{2}{|w|}$.
- Therefore, $|w|$ is minimized to maximize the margin.

IV. RESULTS AND ANALYSIS

The dataset is made by taking cases available on the website openi.nlm.nih.gov. We used CNN which successfully classifies the dataset into tumor and non tumor categories. And SVM is used to further classify the images as benign and malignant.

In Pre-processing stage median filter is used to remove the noise from the images. Following is the image showing the MRI brain before and after median filter implementation.

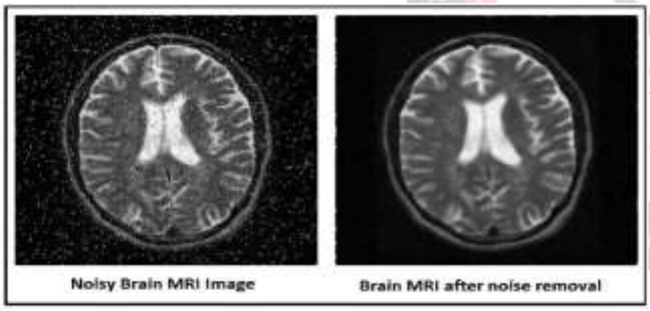

Fig 5 : Median Filter Results

In the detection phase CNN is used. The dataset is divided in a ratio of 80:20 for training and testing respectively. For Training the network a dataset of real case images and some synthetically generated images used. Numbers of epochs are kept 10. Below graph shows the training accuracy and the testing accuracy for the proposed model. Accuracy is plotted on y-axis and epoch number on x-axis. Highest accuracy i.e. 94% is achieved in the 10^{th} epoch. Whereas the training accuracy showing an optimal curve. As it may lead to over fitting, the number of epochs is kept limited to 10.

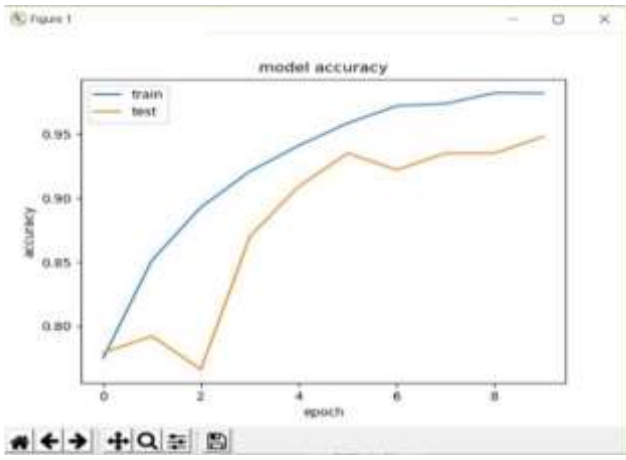

Fig 6: Accuracy graph of training and testing

In the classification phase SVM classifier is used to classify the MRI images as benign or malignant. For this purpose the classifier is trained using benign and malignant tumor images of brain MRIs. The mean accuracy is 65% as show in the plot below. A maximum accuracy of 78% and a minimum of 55% is observed.

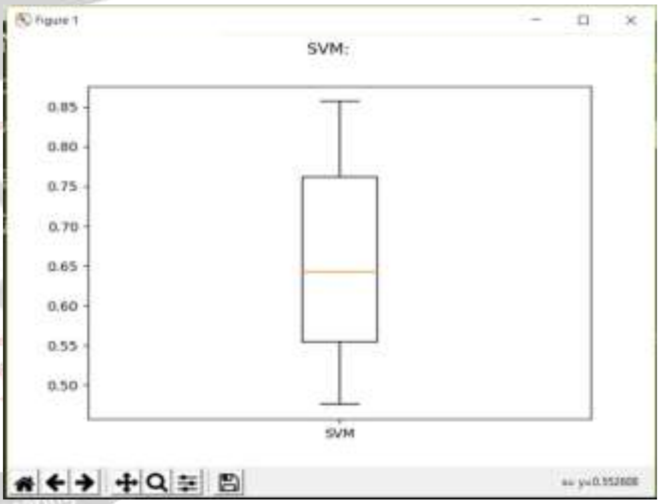

Fig 7: Accuracy plot of SVM.

V. CONCLUSION

The proposed system can successfully help in detecting whether the input image is a tumor brain image or a normal brain image. For Real time detection of tumor this technique can be used. So that tumor can be treated at early stage. We have used median filter for noise removal. Hence the system is made free from noise incurred inaccuracies and is in right format for further processing. In CNN process 3 layers are used which will effectively extract sufficient features such as contrast, circularity, etc. for the detection purpose. We can also modify the system by providing specific classification in the types of tumor. Future work can be done by applying the technique to detect tumors in other parts of body like the lungs, liver, kidney. We can expand the technology of X-rays, CT-scans. The system can be collaborated with other prediction systems to predict the life expectancy after treatment. We can also expand the system

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by specifying particular treatments for specific type of disease.

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