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Brain Tumor Detection Using Convolutional Neural Network (CNN)

Miss. Sonali B. Rode [1], R.S. Dabir [2] Dr.Vaijnath V.Yerigeri [3]
[1](M. Tech Student, Department of Post-Graduation (Digital Communication)
2,3 Professor, Department of Post-Graduation (Digital Communication)
MBESs College of Engineering, Ambajogai, MS, India)

Abstract:
Background*: The most aggressive and dangerous disease of the Central nervous system is Brain tumor, if detected in highest grade it's like a life-threatening situation. Hence, early detection of Brain Tumor is very crucial part to avoid all the risky factors and to enhance the quality of life. In general, many computerized based techniques are used which starts with Magnetic resonance Imaging (MRI), Ultrasounds, CT scan etc. All this involves MRI images to detect the Brain tumors and classification was done as Tumorous or non-tumorous by inspecting those images. However, with enormous amount of data it becomes difficult as well as time consuming to detect and classify the Tumor along with consideration of Human errors. So, to minimize all these consequences, in this paper Brain Tumor detection is proposed with the help of convolutional Neural network (CNN) technique. CNN is a Deep Learning technique which does not require an expert from that particular field to work on it.*
Results: *To produce better classification of image using CNN it needs diverse and large amount of data. Here we are training some data set then test data set will be compared with the trained one and depending upon the result Brain Tumor will be detected and classified.*
Key Word*: Magnetic Resonance Imaging (MRI), Convolutional Neural Network (CNN), Brain Tumor.*

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I. INTRODUCTION

The brain is arguably the most important organ in the human body and is the command Centre for the nervous system which enables memory, thoughts, feelings, actions and reactions. While living in this modern era everyone is being ignorant with the health so, getting diagnosed when diseases has already reached the highest grade and at that stage, neither any medical science nor any technology or experts can help to survive the one's life especially in case of Brain tumor hence, maintaining healthy brain is the highest goal for pursuing healthy life.

A brain tumor is a collection or mass of abnormal cells formed in brain. Skull which encloses brain is very rigid so, any growth of abnormal cells inside such a restricted space causes a problem which destroys healthy brain. When there is growth of brain tissues itself inside the brain that is considered as primary brain tumor however metastasis brain tumor is when it starts in other parts of body and then spreads to the brain. Diagnosis of tumor in brain is very tough compared to tumor in other part of the body. Brain tumor is classified into two types- cancerous or malignant and non-cancerous or benign tumor. Benign tumor being non-cancerous, it does not spread into other parts of brain however malignant tumor spreads very rapidly in other parts of the body which may lead to death. hence, detection of brain tumor plays such an important role. Magnetic resonance imaging (MRI), CT scan are some ways to diagnose brain tumor however traditional MRI is very hard and time-consuming method which needs an expert doctor to diagnose the tumor often may lead to wrong diagnosis. To overcome this Automatic brain tumor detection from MRI Images is the need of today's modern medical imaging research. The major challenge in medical imaging process to detect and classify tumor is image detection and classification for which we will be implementing solution in this paper.

This paper proposes Deep learning technique which is Convolutional neural network (CNN). CNN is a sequence of multiple layers where each layer extracts features which is useful for identification and classification of tumor. The main contribution of this CNN based computer aided system is- It will be helpful for early detection on brain tumor which will start rapid treatment hence reducing death rate.

Rest of the paper is organized as follow: In this paper section II includes Related work, section III represents Proposed methodology, section IV describes CNN, section V includes proposed output and section VI explains conclusion.

II. RELATED WORK

A lot of research has already been done on Brain tumor detection using various techniques and many more are undergoing. Different approaches are being used to perform detection and classification of tumor such as Artificial Intelligence, Machine learning, Deep learning etc. Some of the relevant work is discussed here. In [1], Hybrid methodology of Support Vector Machine (SVM) and Fuzzy c-means clustering (FCM) was used for classification, and it has given precise results for identifying brain tumor. For future work SVM algorithm should be proposed for better accuracy and less error rate [2]. In one of the research, tumor is detected by using both handcrafted features and feature extracted by Deep Learner [3] resulting a complex system. Tumor detection with the help of Support Vector Machine (SVM) was done and it has achieved accuracy of 82% [4].

In research project [5] segmentation of brain tumor was done with multiple convolutional networks. In this method, 3D image voxels are provided as input to 2D CNN model and the output was tumor part of whole MRI image however it does not predict the type of tumor whether it is benign or malignant. Vrushali et.al [6] proposed a method using Artificial Neural Network- in this work K-means, Otsu, Fuzzy c-means, thresholding used for segmentation and classification done using ANN. Paper [7] proposed hybrid method for Tumor detection using neutrosophy and CNN (NS-CNN). In this work, features of the segmented brain images were obtained by CNN and classification was done using SVM and KNN classifiers which resulted with an accuracy of 95.62%.

In one of the studies, 8 CNN models were developed and trained on brain MRI for CAD system, and it has revealed accuracy between 90% and 99% [8]. Then 3D CNN model proposed to extract features from MRIs [9] in this model feature extraction done with the CNN and a feed-forward ANN used for classification and accuracy achieved for three different datasets are 92.67%, 96.79%, 98.32%.

III. PROPOSED METHODOLOGY

The main purpose of this paper is to identify the tumor part of the brain and to classify it as cancerous or non-cancerous using Convolutional Neural Network (CNN).

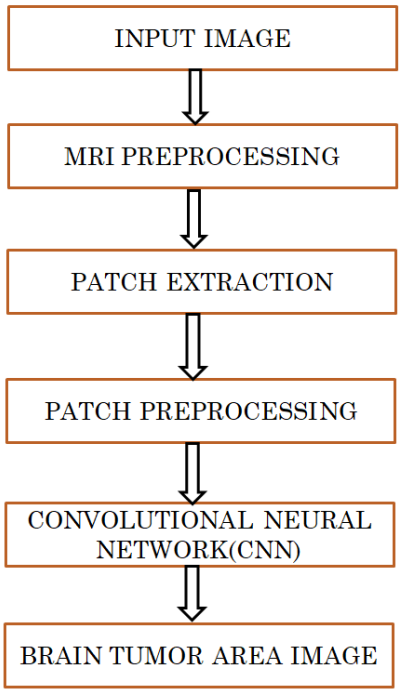

FIGURE 1. Proposed Methodology

This is achieved by providing brain tumor images (MRIs) to CNN. CNN extracts the features from those images and classify it using Labelled data. Here CNN uses preprocessed images for better performance. The important phases of work is gathering large amount and variety of latest brain tumor images, pre-processing those images and detection, classification using CNN and finally to check the performance/accuracy by providing new datasets.

This methodology involves Pre-Processing, Image Enhancement, Feature Extraction and CNN. Brain Tumour MRI image is provided as Input Image. Then pre-processing is done on that image.

The main objective of Pre-Processing is an improvement of the image data that suppresses unwanted distortions and enhances image features required for Convolutional Neural Network processing. Gaussian filter

will be used to remove the noise. Feature extraction is applied when we have large data set and need to reduce the resources without losing any relevant information.

Features such as Edge, shape, size etc. are extracted from input image. Segmentation and classification is performed on that extracted image using Convolutional Neural Network (CNN). CNN architecture uses training dataset to train a network and it predicts the class label using that trained network. With the help of help of trained data set CNN will provide Brain tumor area image as output.

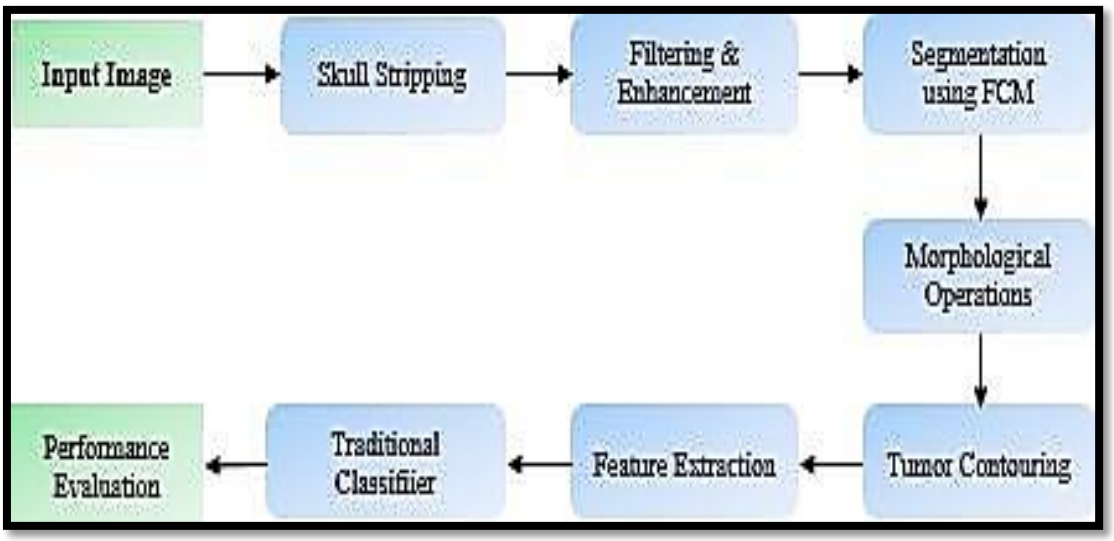

FIGURE 2. Proposed methodology for classification using Traditional Classifiers

1) Skull Stripping:
Skull stripping is a very important step in medical image processing because of the background of the MRI image not containing any useful information, and it only increases the processing time. In our work, we removed the skull portion from the MRI images in three steps. These three steps are:
a) Otsu Thresholding: For skull removal, at first we used Otsu's Thresholding method which automatically calculates the threshold value and segments the image into background and foreground. In this method, the threshold that is selected minimizes the intra-class variance, defined as a weighted sum of deviations of the two classes.
b) Connected Component Analysis: At the last stage of our skull stripping step, we used connected component analysis to extract only the brain region and as a consequence the skull part was removed.

2) Filtering and Enhancement:
For better segmentation, we need to maximize the MRI image quality with minimized noise as brain MRI images are more sensitive to noise than any other medical image. Gaussian blur filter was used in our work for Gaussian noise reduction existing in Brain MRI which prevailed the performance of the segmentation.

3) Segmentation using FCM:
Fuzzy C-Means clustering algorithm was used for segmentation, which allows one piece of data to belong to two or more clusters. We got the fuzzy clustered segmented image at this stage, which ensured a better segmentation.

4) Morphological Operation:
To segment the tumor, we only need the brain part rather than the skull part. For this, we applied morphological operations in our images. At first, erosion was done to separate weakly connected regions of the MRI image. After erosion, we will get multiple disconnected regions in our images. Dilation was applied afterwards.

5) Tumor Contouring:
Tumor cluster extraction was done by an intensity based approach which is thresholding. The output of this image is the highlighted tumor area with a dark background.

6) Feature Extaction:
Two types of features were extracted for classification. Texture-based features such as Dissimilarity, Homogeneity, Energy, Correlation, ASM and Statistical based features including- Mean, Entropy, Centroid, Standard Deviation, Skewness, Kurtosis were extracted from the segmented MRI Images.

7) Traditional Classifiers:
We used six traditional machine learning classifiers which are K-Nearest Neighbor, Logistic Regression, Multilayer Perceptron, Naïve Bayes, Random Forest, and Support Vector Machine to get the accuracy of tumor detection of our proposed model.

8) Evaluation Stage:
Implementing other region-based segmentation methods and comparing it to our proposed segmentation technique, our model segments the ROI and segregates the tumor portion most accurately. An illustration of the whole process is depicted in Fig. 5. After segmentation and feature extraction from the tumor, we applied six classification techniques. Among them, we got the best result from SVM and obtained an accuracy of 92.42%.

IV. CONVOLUTIONAL NEURAL NETWORK (CNN)

CNN is a class of Deep learning neural network, and it works by extracting features from the images. CNN consists of Convolution Layer, Rectified Linear Unit (ReLU) layer, pooling layer and fully connected layer.

Convolution layer is the core and primary layer in CNN which focuses to extract features from the input. Convolution performs linear transformation of input data preserving spatial information of data and then this layer divides input image into smaller regions (can be called as feature maps) it convolves the input and provides output to the next layer.

ReLU layer applies activation function to increase the non-linearity without affecting fields of convolution layers. CNN uses Pooling layer as down-sampling method. It reduces the dimensions of feature maps received from the previous layer. In short, pooling layer summarizes the feature present in the feature map generated by convolution layer. Fully connected layer means each neuron in the preceding layer is connected to each neuron in the adjacent layer. The high-level features of the input image is obtained from convolution, ReLU and pooling layer. The main purpose of Fully connected layer is to use these extracted features for image segmentation based on the provided training dataset.

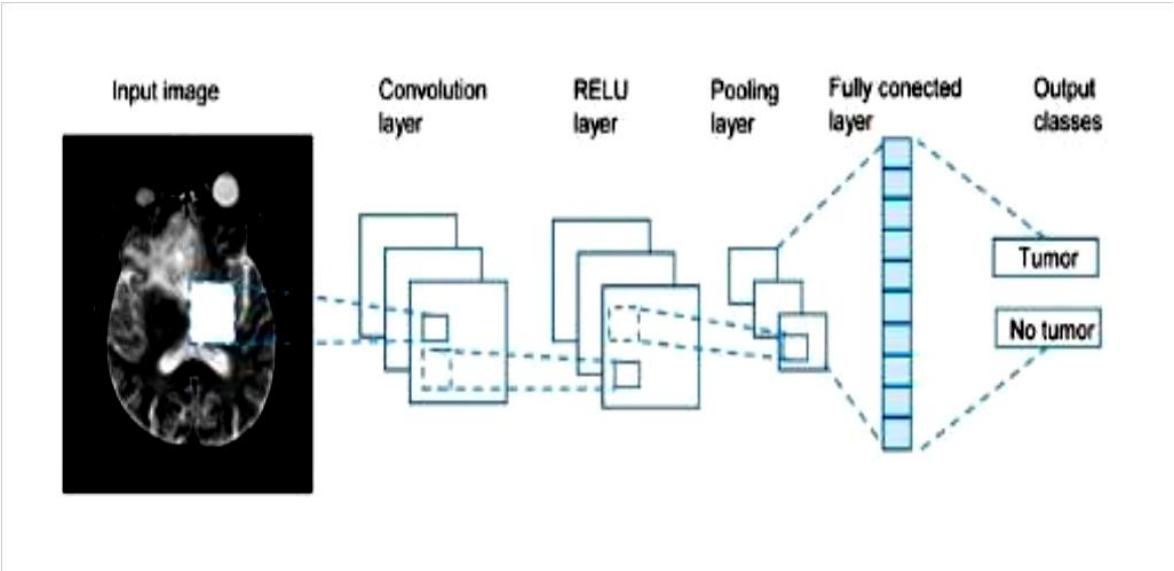

FIGURE 3. Convolutional Neural Network

V. PROPOSED OUTPUT

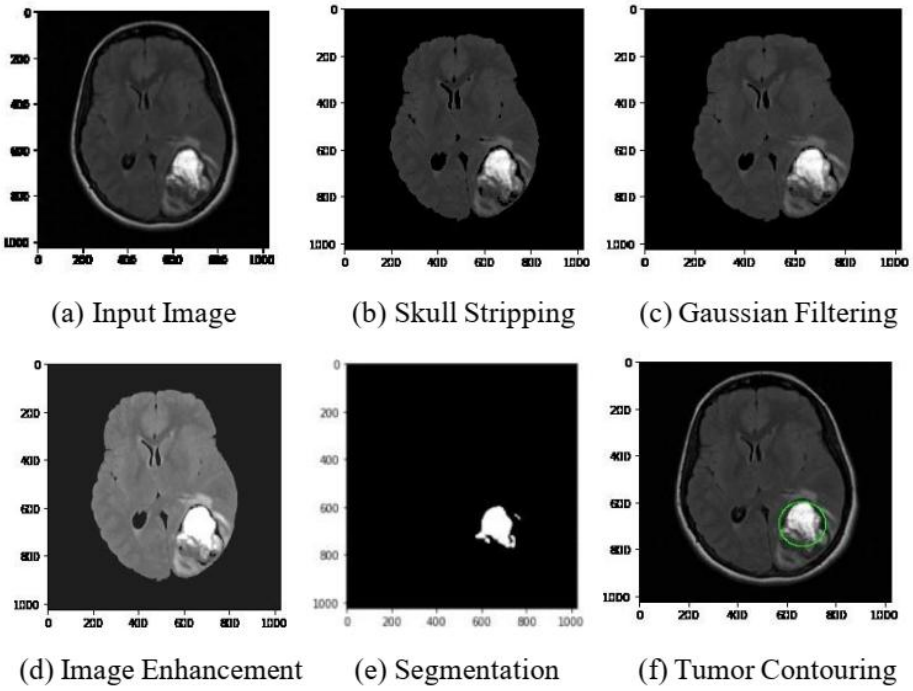

FIGURE 4. Proposed Output

Based on our proposed methodology, we segmented the tumor without loss of any subtle information. We removed the skull because for tumor segmentation the role of skull is approximately null and ambiguous in this process

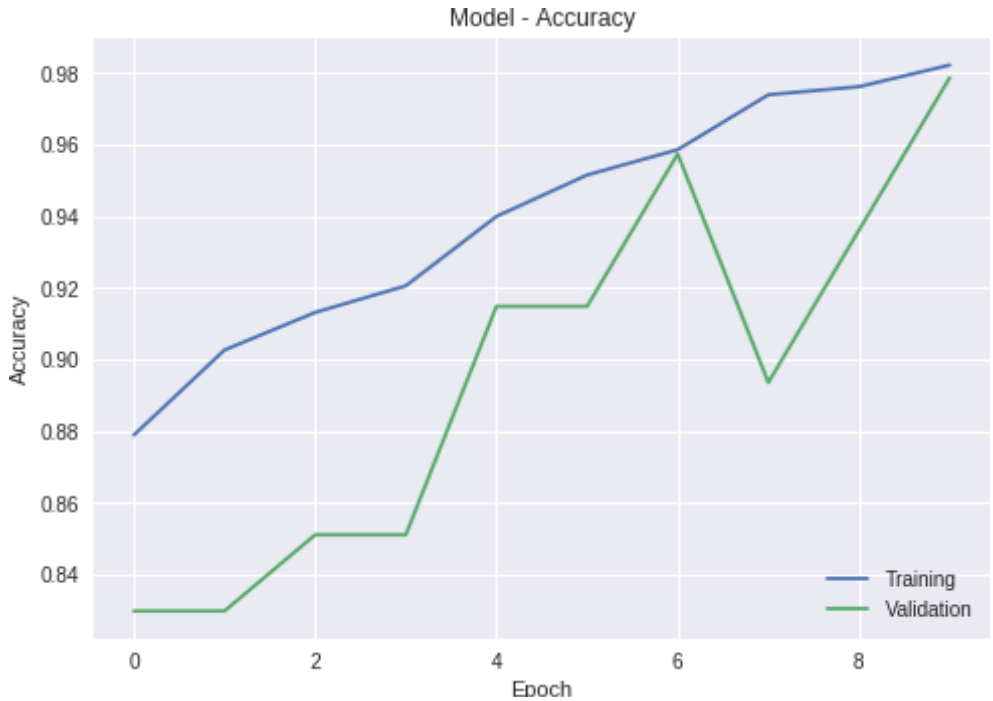

FIGURE 5. Accuracy of the proposed CNN model.

VI. CONCLUSION

In this paper, CNN based computer-aided diagnosis system is proposed for brain Tumor detection and classification. CNN having low complexity and quality of classification is dependent on Convolution Layers so, by increasing convolution layers better performance/accuracy can be achieved. From all above discussions CNN classifiers are better in brain tumor diagnosis with respect to accuracy and computational time.

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