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Brain Tumor Detection and Classification Using Convolutional Neural Networks

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Abstract— ***We have developed a web application using Artificial intelligence and Deep neural networks that studies the human brain tumor MRI images and classifies the tumor into Malignant and Benign category also highlighting the tumor portion and providing necessary information in an easier way such that it is understandable by everyone. The system will be accessible to all doctors only and not patients as knowing about the tumor will definitely be panicking for the patient and the situation will turn more problematic. Doctor will get the result and guide the patient. Tumor segmentation is an important task in the model for which we are using Fuzzy C-Means clustering and then for further classification, we are using a 4 layer Convolutional Neural Network. As compared to other traditional classifiers from the previous studies that we did, our model using CNN gave the best results. Brain tumor detection is a difficult task for doctors and specialists as well. Hence a trained and reliable model can be very useful to them to ease their job and reduce the pressure on human judgement. We aim to build a model that can prove very useful to the medical and healthcare sector and revolutionize the disease detection process in the sector.***

Index Terms— ***Gaussian filters, Segmentation, Fuzzy C-Means clustering, Convolutional Neural Networks, Benign and Malignant tumors***

I. INTRODUCTION

According to WHO, Cancer is the second leading cause of death in the world. So many people die because they could not identify and diagnose the problem in early stages and when they did, it was already too late. One such cancer is caused due to Brain tumors. Brain tumors are of 2 types benign and malignant tumors. Benign tumors are non-cancer causing tumors as they do not spread to other tissues and are also curable and once cured they do not come back while malignant tumors are exactly opposite of this. It is very important to identify malignant tumors at early stages. Currently Brain tumor detection and classification is done by performing Biopsy which is a very time consuming process. You cannot directly go and get a biopsy performed as there is a whole lot of preparation that needs to be done before you actually perform it. So we developed a deep learning based CNN architecture [1] that would classify the tumors in MRI images into Benign and Malignant tumors and act as a strong base for the doctors to decide the curing procedure. The development of the model will be divided into training and testing phases and would be tested using large datasets from various sources and different methods. With good accuracy, reliability and execution speed, the developed CNN architecture would act as a strong decision supportive tool in medical diagnostics for radiologists.

II. LITERATURE SURVEY

Existing Methodologies

Brain Biopsy Method:

Brain tumor detection and classification is a very difficult process to be done manually even for experienced and trained doctors due to similarity in structures of the tumors. By looking at the brain MRI or CT scan, It is possible for the experts to identify whether a tumor is present or not and the region of the tumor. But it is difficult to identify the small dissimilarities in the structure of a tumor and classify it into types. Hence this manual process gets stuck here for verification of the type of tumor.

Type of tumor and its exact position and other details are found out by doctors by performing a medical process called Biopsy. Brain Biopsy is a process in which a portion of the abnormal tissue of your brain is extracted by first giving you anesthesia and then using a medical needle methodology to extract the part from your brain. This is a very delicate process and not all doctors can do it. Only expert Neurosurgeons can perform Biopsy.

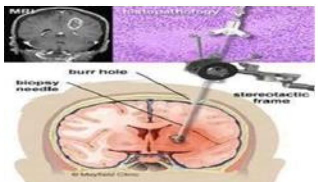

Fig.1 Brain Biopsy Method

After the sample is extracted, It is examined under a microscope and various tests are performed on it to obtain the type of cell. Only then the doctor can suggest you further enttreatm plans. Results can be obtained in 5-7 days .Brain Biopsy is difficult to Biopsy other body parts as it is a very delicate region [2]. Hence Brain Biopsy cost can vary from Rs.7000 to Rs.12000 in India. Also it is a time consuming process and usually an entire procedure may take about 15 days. Performing Biopsy is definitely important if the tumor is identified to be Malignant. But using this model, if a tumor is found to be Benign type then Biopsy can be avoided. Instead simple tests like Angiogram can be done to verify and then suggest further treatment plans for the patient.

Machine learning based Method

Brain tumors can also be detected and classified using Artificial intelligence, Machine learning and Deep learning approaches. Algorithms such as Support Vector Machine and Logistic regression have been proved useful in this field although these models are just proposed but not actually in use due to accuracy and reliability issues [3]. Hence a more accurate and reliable method using CNN can be useful for detection and classification of brain tumors.

III. PROPOSED METHODOLOGIES

We propose a model trained using Deep learning algorithm Convolutional Neural Network that would identify the presence of tumor in brain and also the type of tumor in brain with high accuracy and would have the capability to replace the existing system in future.

Many such models have been proposed before but they were just able to identify the presence of tumor and not its type and also their accuracy was less due to less dataset and different methods used. Also they did not have any facility of medical assistance or consultation from doctors which we have tried including in our project to serve users with maximum facilities. Hence no such model is currently being used [4].

The entire project will be mainly divided into three modules i,e..the Image Pre-Processing module the Detection module and the Classification module. The output of the detection module will be fed as input to the classification module. The entire preprocessing of image, Skull stripping, Gaussian filtering and segmentation using Fuzzy C-Means clustering will be done in the detection module .If the tumor is detected, then tumor image will be fed as input to the classification module which will have a multilayered CNN [5].

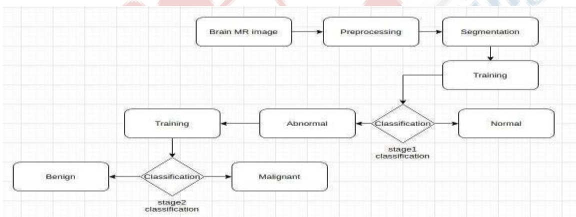

Fig.2 Work Flow diagram for the proposed methodology

We have tried to increase the accuracy by using a large dataset for training as well as testing. The dataset used is from Kaggle,BraTS'2020 data and image net. Also our proposed multi layered CNN model will filter the image and extract necessary information and the final output will be a combined classified result of all the layers.

This proposed system is specially designed for doctors so that can verify their result with the result generated from this system and suggest further plan to the person. If the result comes out to Benign than the patient can be just kept under observation and regular tests from time to time. This system can also be helpful to patients who have symptoms of brain tumor and MRI facility in their town but no availability of expert doctors. In such a scenario, a patient can check the result from this system and if needed can consult a doctor.

IV. SYSTEM ANALYSIS AND DESIGN

Architecture:

The system will take brain MRI images as input and then it will be passed to the first module which is the image pre-processing module. In the image pre-processing module we will perform skull stripping and noise removal and image enhancement. After image enhancement we will save the MRI image with patient data in our dataset for patient details and betterment of the system, then we will pass the pre-processed image through the segmentation module for segmentation of tumor and display it to the patient for better understanding of tumor location. Afterwards the image passes through a classification module to classify tumor type into benign and malignant tumor.

Algorithms and Methodologies:

Skull Stripping:

Skull stripping is image processing algorithm that will remove skull from brain MRI image. We are going to perform skull stripping using following methods:

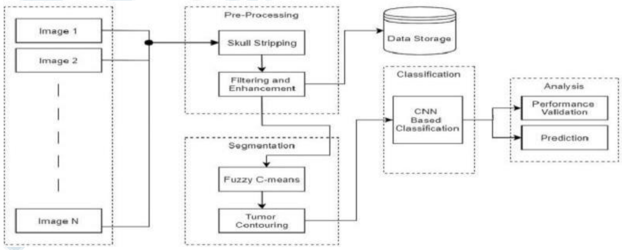

Fig.3 Skull Scripting

OTSU thresholding:

OTSU thresholding is a image processing method which is used for automatic thresholding of image. The steps of OTSU thresholding is as follows:

1)Process input image.

2)Obtain image histogram.

3)Compute the threshold value.

4)Replace image pixels in those white regions, where saturation is greater than T and into the black in opposite cases.

OTSU thresholding processes image histogram, segmenting the objects by minimization of the variance on each of the classes. Usually, this system produces the appropriate results for bimodal images. The histogram of such image contains 2 clearly expressed peaks, that represent completely different ranges of intensity values.

For Otsu thresholding we are going to use OpenCV library in which using function cv.threshold(), where after passing cv.THRESH_OTSU as an extra tag we can perform OTSU thresholding.

Connected Component Analysis:

Connected component analysis is a image processing technique which can be used for extraction of different components of images. The first step in connected component analysis is accepting the image then converting pixels to either 0 or 1 values, then we will apply connected component labeling using OpenCV library function cv.connectedComponents().

Gaussian Filtering:

Gaussian filter is another image processing algorithm which is useful for removing noise from images. A Gaussian filter is used to blur the image and remove noise from the image. We are going to use the OpenCV library in which using the function cv.gaussianBlur() we will perform a blur of images. In a gaussian filter we will generate a 2D gaussian filter, The gaussian filter uses the following gaussian distribution.

Where, y is the distance along the vertical axis from the origin, x is the distance along horizontal axis from the origin and σ is the standard deviation.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Fuzzy C-means Clustering algorithm:

Fuzzy C-means clustering is a kind of clustering in which each data point can point to more than one cluster. Clustering algorithm is useful for segmentation of tumors from Brain MRI images.

Tumor Contouring:

Tumor contouring is a process of highlighting tumor portion of brain tumor in MRI images. we are going to use OpenCV library function cv2.findContours() to locate tumor in MRI image.

The pseudo code of finding contours in brain MRI image is:

Begin

Upload the image;

Change image to grayscale using cv2.cvtColor(); Find canny edges using cv2.Canny();

Find Contours using cv2.findContours(); Draw contour on tumor part ;

End

Convolutional Neural Network:

Traditional feature learning methods rely on semantic labels of images as supervision. They usually assume that the tags are evenly exclusive and thus do not point out the complication of labels. The learned features endow explicit semantic relations with words. We also develop a novel cross-modal feature that can both represent visual and textual contents. CNN is a method of categorizing the images as a part of deep learning. In which we apply a single neural network to the full image. The steps in CNN are as follows: convolution, subsampling, activation and full connectedness.

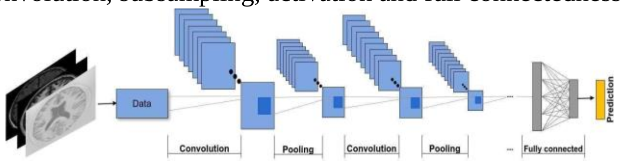

Fig 4. Convolutional Neural Network for brain tumor classification

Step 1: Convolution is the primary layer that accepts an input signal and is called convolution filters. Convolution is a procedure where the network tries to tag the input signal by referring to what it has learned in the past.

Step 2: Subsampling Inputs from the convolution layer can be smoothened to decrease the sensitivity of the filters to noise and variations. This smoothing procedure is labelled as sub- sampling and can be attained by taking averages or considering the maximum over a sample of the signal.

Step 3: Activation the activation layer manages the signal flows from one layer to the subsequent Output signals which are strongly connected with past references would activate more neurons, enabling signals to be propagated more efficiently for identify-

Step 4: Fully connected the final layers in the network are fully connected, such that the neurons of preceding layers are connected to every neuron in subsequent layers. This imitates high-Level reasoning where all feasible pathways from the input to output are measured [6].

V. IMPLEMENTATION

Stages of Implementations:

Data Preparation:

We will utilize BraTS 2020 dataset The picture information comprises 369 multi-contrast MR checks from glioma patients, out of which are low-grade (lgg) and some are high-grade(hgg) glioma patients. The pictures in datasets are formed by the following kind of MRI strategies:T1, T2, FLAIR. The dataset we are going to use is from BraTS 2020, kaggle.

Data Augmentation:

Data Augmentation can be used to increase the available data for training models, by modifying existing training dataset. Data imbalance issues can be solved using data Augmentation [7].

Data Preprocessing:

We are going to use the following pre-processing steps for every image in the dataset**:** Convert the image from 3D MRI image of .nii file format to .jpg format using med2Image python library. Then we are going to resize the image because for the creation and making of a convolutional neural network we need an image of the same size. Also we are going to crop the image so that only the brain remains in the image for better creation of CNN.

Data Split:

We will split data in the following way: For Training:80%, For Testing:20%.

We are going to use a separate dataset for validation(Development) consisting of 125 images.

Processing:

Image Pre-Processing:

Initially ,We will collect the patient's details such as age, gender etc. and MRI scan of Brain. Then we will perform pre-processing on the MRI image to remove the noise and non useful parts from the MRI image such as the skull.

The Pre-Processing Steps are:

Skull Stripping:

Skull stripping is a process of removing the skull from a brain

MRI image. We will implement skull stripping using OTSU thresholding and connected component analysis.

Gaussian filtering:
We will use gaussian filtering to remove noise from the image.

Image Enhancement:
Image enhancement will be used to improve image quality. For image enhancement we will use the add-weighted method.

Tumor Segmentation:
We will perform following operation to find out location of brain tumor in MRI image:

Segmentation:
Segmentation process will be used to separate tumors from brain MRI images. We will use a fuzzy c-means algorithm for segmentation of tumors.

Tumor Contouring:
Contours can be explained simply as a curve, having the same color or intensity. We are going to use edge detection and findContours() algorithms to contour tumors in the brain.

CNN based Classification model:
We will use a trained CNN model that will predict the tumor type(E.g. Benign and Malignant).

Implementation Issues:
As CNN requires a large amount of dataset for better prediction but the BraTS dataset contains limited amounts of images so we are going to use a data augmentation method to increase dataset images.

VI. RESULTS AND EVALUATION

EXPERIMENTS
This is the accuracy for the CNN architecture when test for learning rates(0.001,0.005,0.0001) with batch size(32,10) and dataset split into 80:20 for training and testing.

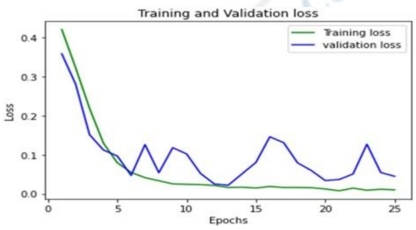

Fig.4 Training Time and Accuracy of the proposed CNN model

Model Accuracy Curve
The curve represents training and validation accuracy of the model
Prediction value in the last of the model is high, so the accuracy is high

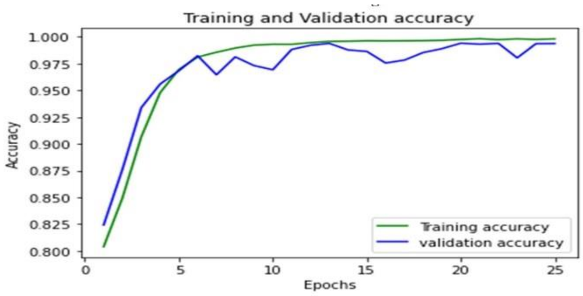

Fig. 5 Accuracy Curve of the proposed CNN model (splitting ratio - 80:20)

Model Loss Curve

- The actual loss per epoch represents the graph
- Estimate the loss of the model
- Initially no prediction so the loss function is high and up to 25 epochs it is gradually decreased.

Fig. 6 Loss Curve of the proposed CNN model (splitting ratio - 80:20)

Model Loss Curve
We found better accuracy in learning rate 0.0001 as compared to 0.001 and 0.005.

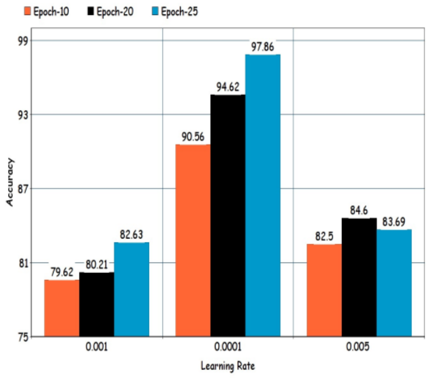

Fig. 6 Learning rate vs Accuracy curve

Detail Discussion of Expression Carried Out
We are Considering following testing in Malnutrition Detection system-

Result of Experiments

Skull Detection and Stripping:

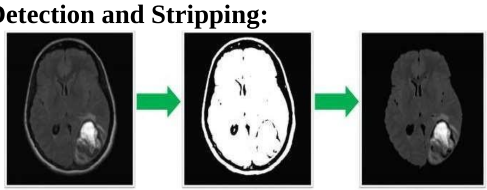

Fig. 17 Skull StrippingTumor Segmentation

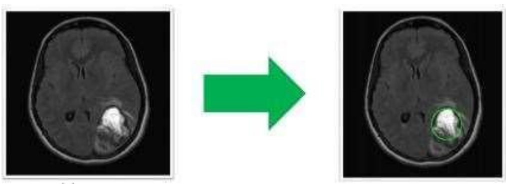

Fig 18 Tumor Segmentation

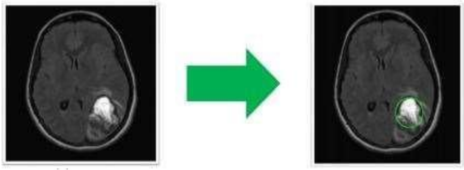

Fig 19 Tumor Contouring

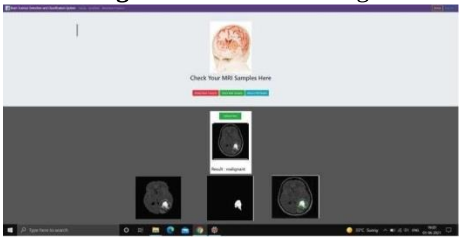

Fig. 20 Final Result

VII. CONCLUSION:

Thus we have successfully proposed a model that first studies the Brain MR images and predicts the tumor in the brain, also highlighting the tumor region and providing necessary information such that it is easily understandable by everyone. The proposed model first does preprocessing on the dataset and extract useful information to predict the presence of tumor. If the tumor is present, then the CNN architecture performs operations and classifies the tumor into Benign or Malignant types.

Our proposed system will act as a strong decision support tool for radiologists in clinical diagnosis. By achieving high accuracy and reliability, we hope to replace the existing system in future.

VIII. LIMITATIONS:

Brain tumors can be detected using CT scan images also but our system is designed to be used for MR images only due to its many advantages over CT images.MR images are less exposed to radiation as compared to CT images and also displays better information of softer tissues like the brain.

This system can be used by normal users to make decisions regarding consulting and diagnosis of tumors. If a tumor is detected, the user must consult a doctor immediately for better understanding of the issue and its diagnosis.

FUTURE SCOPE

In future ,we aim to work with 3D images

To build a model to detect the grade and stage of the tumour or predict survival chances.

Identifying or labelling the tumor sub-regions i.e specifying which subregion is edema, non-enhancing solid core, necrotic/cystic core and enhancing core.

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