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Brain Tumor Segmentation using K-Means Clustering and Detection using Convolutional Neural Network

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Abstract*: This paper presents brain tumor detection and segmentation using image processing techniques. Convolutional neural networks can be applied for medical research in brain tumor analysis. The tumor in the MRI scans is segmented using the K-means clustering algorithm which is applied of every scan and the feed it to the convolutional neural network for training and testing. In our CNN we propose to use ReLU and Sigmoid activation functions to determine our end result. The training is done only using the CPU power and no GPU is used. The research is done in two phases, image processing and applying neural network.

Keywords: Convolutional Neural Network, Image processing, K-Means clustering, ReLU rectifier.

I. INTRODUCTION

This review paper, we discuss the various methods for brain tumor detection. Studies show that relying on pure naked-eye observations of researchers to detect and classify tumors can be time-consuming and highly expensive, especially in rural areas and developing states. We propose a low cost and accurate method of completing this task. The process is composed of four main phases; At Processing, an input image will be resized and region of interest selection performed if needed. We perform image processing using k-means and thresholding, then feed it to the neural network for training and classification. The convolutional layer will comprise of 32 to 128 fitters to obtain multiple color features from the images for testing and training. The system will be used to classify the test images automatically to decide brain characteristics. To reduce the processing time, we will be using a small set of data for training the model. The neural network will not use any amount of GPU power and work solely on CPU power. For obtaining high accuracy K-Means clustering and thresholding applied on every MRI scan to segment tumor from it.

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II. RELATED WORK

[1] Color based segmentation methods are mostly used in study of brain tumor but in this paper Threshold-based OTSU segmentation was used. The experimental results showed that this method of OTSU segmentation is better than the conventional way of using color segmentation and gray scaling. This paper provided a minimum of 87% accuracy on multiple datasets. The method performed better than existing approaches in segmenting the tumor region from the rest of the brain.

[2] Two prediction approaches are evaluated: from the entire brain, and an automatically defined tumor region. Interpretability methodologies are employed as a top-quality assurance stage to ascertain if the tactic is using image regions indicative of tumor grade for classification.

[3] The main focus is on optimizing and parallelizing the KNN algorithm by exploiting the GPU technology. The KNN algorithm takes more computational power compared to any other methods. Due to the variations in the filtering process and the GPU used a speedup of 66.18% was achieved. By optimizing the search window in KNN major improvements occurred. This technique paves way for low computation and high accuracy models.

[4] To improve CNNs' performance for brain tumor segmentation test-time augmentation is researched. The paper observes that the segmentation performed on the test sets can also improve the detection accuracy on MRI scans of the brain and detect tumor in them. They tested their model on BraTS dataset available online. The study uses flipping, rotation and scaling for image processing in the training as well as on the test set. The study found an improvement in detection accuracy if the test set is also exposed to image processing and segmentation.

[5] In this paper the authors propose to use different angles of the brain to obtain the segmented tumor from rest of the brain. The images are not preprocessed and are given directly to the neural network for detection of the type of tumor preset in the brain. The study was conducted on T1-weighted CE-MRI image-dataset and was able to achieve a maximum dice of 0.79 on Sagittal views of the images while a lowest of 0.71 on axial view. This study suggests to reduce the preprocessing part and instead focus on having multiple angles of the brain MRI to correctly identify tumor and it type.

[6] In this study we use 3D imaging techniques to identify tumor in the brain.

The paper won the BraTS 2018 competition. It proposes to use small batch sizes of images for image segmentation, they introduce VAE branch to help increase the accuracy of the results obtained after training. They were able to achieve 0.8 dice on the index.

[7] The paper proposes to reduce significant amount of computational power using mathematical models. The study uses Fuzzy C-means clustering, PCA and SVM with non-linear kernels, it was able to improve the accuracy of the existing method 10 folds. While the research lacked in the amount of dataset used and the reliability of the model for real time use. The model was trained and tested upon a small dataset containing on 19 images.

III. IMPLEMENTATION

Implementation is divided into four part as shown in Fig 1 and explained as following:

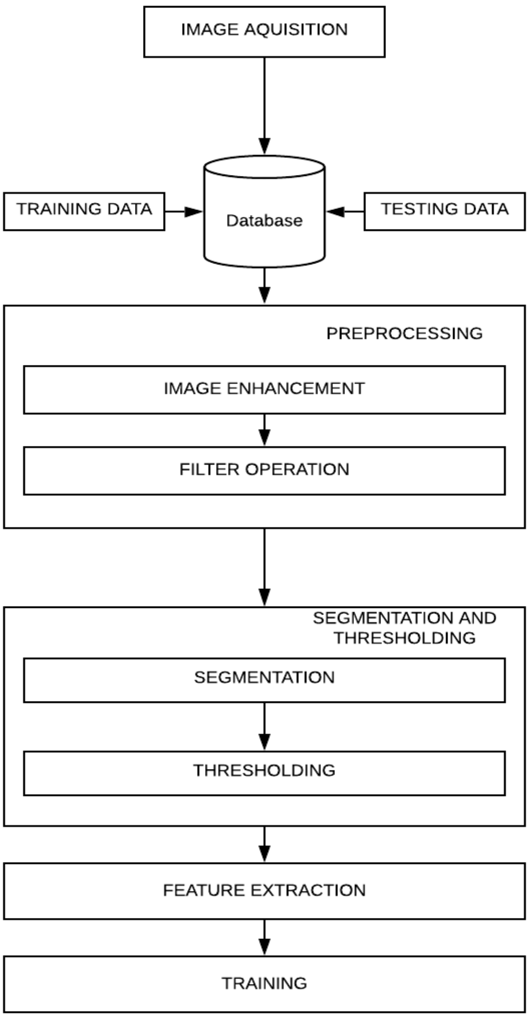

Fig 1. Architecture Diagram

A. Preprocessing

Preprocessing is a method for actions with images at the lowest level of abstraction. In this module, the image is improved in order to remove any kind of unwanted distortion and enhance signal features required for further processing. Any kind of unwanted noise is removed from the image to achieve a perfect image. For achieving this we apply Gaussian blur and Bilingual Filter to the image and then convert it into a greyscale image for further modules. Result for the same is compared in fig 2.

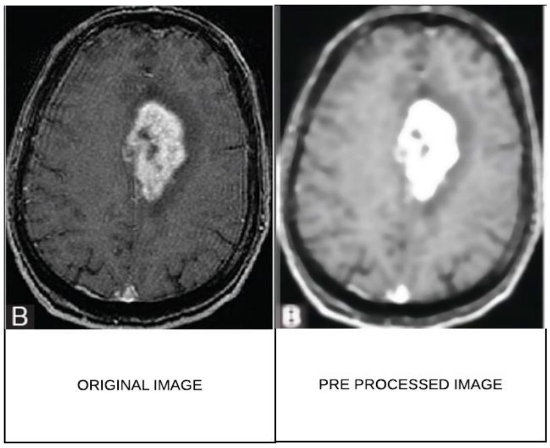

Fig 2. Comparison between original and preprocessed image

B. Segmentation and Thresholding

Segmentation process involves removing the tumor form the rest of the MRI image, we use K-means clustering for segmentation. We propose to use 3 clusters in the algorithm and extract the part with maximum number of pixel score, that is the white part in the image which is usually the tumor part. In this we also use OTSU thresholding to achieve accurate results. Clustering and thresholding are the two techniques used in this process. Result for the same is compared in fig3.

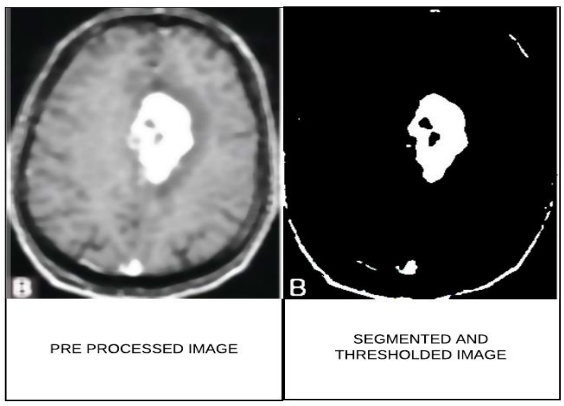

Fig 3. Comparison between preprocessed and segmented image

C. Feature Extraction

After achieving segmented image, we identify the tumor region from it and extract it. To extract the tumor from the image we compare the original image and segmented image, after collapsing both the images the tumor image is extracted. The extracted region contains the tumor as after applying K-means clustering we were able to segment the tumor from the rest of the brain.

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The skull region is eliminated and tumor image is achieved. The final result can be seen in fig 4.

Fig 4. Resultant image

D. Training

A sequential neural network is used for training the model in four steps. The neural network learns these features and then analysis them to decide their output using training which it had done previously by learning features of different other normal or abnormal images of brain MRI scans. Convolutional neural network is used for the same and explained below:

1) **Convolutional Layer:**

In this layer we take input image from the dataset and convert it into 64x64 RGB image. Then 32 feature detectors of size 3x3 is applied to the images to extract a feature map which consists of the regions of interest. ReLU rectifier is used as the activation function for this layer. In this layer we provide the preprocessed and segmented images as input and it perform automatic filtering to obtain feature maps from it.

2) **Pooling Layer:**

In this layer we apply Max pooling function to map the important region or the region of interest and obtain pooled feature maps containing the tumor region only. A pool size of 2x2 is used to map the pooled feature map.

3) **Flattening Layer:**

In this layer we flatten all the images from the pooling layers and convert them into a sequence of inputs of array type. The layer acts as an input converter for the final layer which is the dense layer of the CNN.

4) **Fully-Connected Layer:**

In this layer we use sigmoid and ReLU activation function to our keras model. A total of 128 nodes are present in the layers. Binary cross entropy is used as we only need to determine is the tumor is present or not in the MRI scan.

5) **Compilation:**

The dataset of 264 images is used to train and validate the CNN model. The dataset contains proper MRI scan images classified into two categories or normal or abnormal.

IV. RESULT AND DISCUSSION

The tumor was extracted properly from the images and trained upon them. After training the model, an accuracy of 93% was achieved. For manual testing a python file was created which tells if an MRI scan is tumor. Abnormal means this image contains a tumor while normal means it does not contain a tumor. Fig 5 shows the result obtained upon manual input of an abnormal image. The manual image is preprocessed and k-means and thresholding is applied to it before providing it to the neural network for identifying if the MRI scan is normal or abnormal, that is if it contains the tumor or not.

```
In [4]: runfile('D:/Projects/Brain Tumor Detection/Testing.py', wdir='D:/Projects/Brain Tumor Detection')
ABNORMAL
```

Fig 5. **Result after testing upon manual image**.

V. CONCLUSION AND FUTURE WORK

This research provides findings on various brain tumor classification techniques that can be used for brain tumor detection and a later mentioned algorithm for image segmentation technique used for automated detection and classification of brain tumor. The optimum results were obtained with very less computational effort, which also demonstrates the efficiency of the proposed K-means algorithm in identifying and classifying brain tumor. The benefit of using this approach is that it is possible to identify a tumor from a MRI scanned image using low cost hardware with small computation time. Scanned MRI images may differ from image to image considering the quality of the dataset. If a more precise dataset is used for training, then the computation power required can be reduced and achieve even more accuracy. I would like to suggest using other clustering methods for image segmentation to generate a better segmented image from the dataset.

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