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Evaluation of K-Means and CNN Architectures for Segmentation of Brain Tumor

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Abstract
A Brain that is accumulated with anomalistic group of cells is tumor and this tumor can be present in any part of the brain. Tumors are consolidated and are of distinct shapes and sizes. Tumors can be fatal and non-fatal. Non-fatal tumors are basically known as primary brain tumors which is originated in your brain, technically known as Benign. Fatal tumors are known as secondary brain tumors which occurs due to deadly cells that diffuse/disperse into the brain which is scientifically called as metastatic brain tumors. There are different techniques for brain tumor segmentation, Deep Learning is one among them and it provides better results when compared to other techniques like Fuzzy Clustering, SVM Technique, Region Growing Method and so on. This article provides/presents K-Means, CNN (LeNet, UNet) architectures to segment brain tumor using MRI images. Kaggle datasets has been used for our work which comprises of multiple images. This proposed network shows the comparision of different architectures and disclose the best architecture that is accurate.

Keywords**:** *Kaggle dataset, Deep Learning, K-Means, CNN, UNet, LeNet*

1. Introduction

Brain Tumor are the outgrowth of abnormal and uncontrolled division of cells in the brain. If brain tumor are not identified at the initial stages it can lead to death. There are different types of brain tumors namely Meningioma, Glioma, Pituitary tumors and so on out of which gliomas are the most common type of tumors found in human brain.

These are categorized into two types based on their level of severity such as LGG (low-grade gliomas) which is benign tumor and HGG (high-grade gliomas) which is malignant tumor. There are different approaches for obtaining brain tumor images. For instance, CT Scan, MRI, Angiography, Skull X-Ray, Biopsy.

In our work, we have used MR Images. Magnetic Resonance Imaging (MRI) is a non-invasive imaging technology that uses magnetism, radio waves, and a computer to produce images. This technique is used as an accurate method for detection of diseases, diagonise and treatment monitoring. The dataset of MR Images is taken from Kaggle.

Brain Tumor Segmentation is one of the crucial and challenging tasks in medical field because it consists of enormous heaps of data. It is basically a process of separating the different tumor tissues from normal brain tissues. There are varities of variant type of tumors which may appear in different shapes and sizes with different image intensities.

Few of the brain tumor segmentation techniques are edge detection-based method, color based technique, thresholding method, region-based method, clustering method, watershed method. We have used Watershed Clustering and Color based technique for our work.In our work, brain tumor segmentation is done using the

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following techniques: K-Means, CNN (LeNet, UNet). Segmentation is used to identify areas surrounded by tumor. The motivation of our work is to compare the results of these techniques and disclose which technique is accurate.

2. Literature Survey

This field discuss about the works pertaining to the brain tumor detection and segmentation. Somkantha, [1] designed new edge technique for detecting the boundary in noisy images and enforced it to object segmentation problem. The proposed technique was used for object boundary detection in several types of noisy images. Gooya, [2] presented a method GLISTR for segmentation of gliomas in multimodal MR images by joint registering the images to a probabilistic atlas of healthy individuals. The main contribution of this paper was adding tumor growth model to adopt the normal design into the anatomy of the patient brain. Parisot,[3] proposed a different approach for detection, segmentation and characterization of brain tumors. This technique handles the foregoing knowledge in the form of a sparse graph defines the expected spatial positions of tumor classes. In this paper, implied a novel way to encode prior knowledge in tumor segmentation, making use of the fact that the tumors tend to appear in the brain in preferential locations. They combined an image-based detection scheme with identification of the tumor's corresponding preferential location, which was associated with a specific spatial behaviour. Manikis, [4] recommended a framework for assessing tumor changes based on histogram analysis of temporal Magnetic Resonance Image (MRI) data. This method detects the distribution of tumor and quantitative models. Ravi Babu Kancharla,[5] proposed an algorithm which is a composite of support vector machine and fuzzy -c-meansa combined technique for prediction of brain tumor that provides accurate and effective result for classification of brain MR Images. This approach is a combination of intensity, texture, shape-based features and classifies the abnormal area in the image as tumor or non-tumor area. Mukambika P S,[6] presented the comparision study of two techniques used for tumor detection of MR Images. One is based on the level set method and the other is K-Means segmentation algorithm. Astina Minz,[7] proposed a method which can be used for brain tumor detection easily. Using Adaboost machine learning algorithm accuracy issues can be improved and also minimise the error and it is less time consuming.

3. Methodology

A. Kaggle Datasets

Kaggle is one of the most prominent websites and the datasets that are accessible in this website are absolutely free of cost. It is a platform that provides the users to search and publish datasets, analyze and build their models in a web-based environment. We have used Kaggle to obtain the dataset which contain enormous number of MR Images. The dataset consists of images that is both tumorous and non-tumorous.

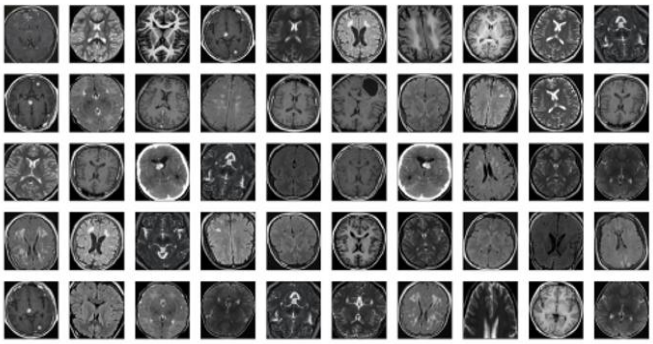

Figure 1: MR Images with No Tumors

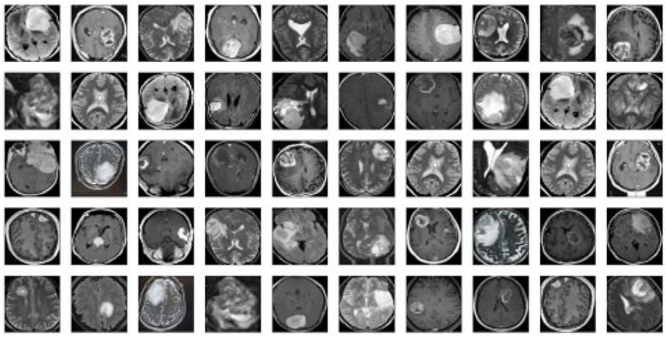

Figure 2: MR Images with Tumors

B. K-Means Segmentation

This technique falls into the category of unsupervised clustering algorithm. In this technique pre-processing is done using various filters after which segmentation is carried out using K-Means algorithm. K-Means Segmentation begins with pre-processing stage where the image is converted from RGB scale to Gray scale. This approach is also known as the color based segmentation technique. Different types of filtering are carried out on the image for removal of noise, the purpose of noise removal is to get an image that is accurate. Median Filtering is one of the frequently used filtering techniques in the pre-processing step to eliminate noise. Median noise is the noise generated in the image due to misrepresentation of image pixels. Watershed Segmentation is done for finding the location of the tumor in the MR Image.

To imbibe K-Means algorithm, define the number of clusters k after which the centres for k clusters are assigned randomly afterwards, the distance from pixel to each cluster centre is calculated. Every single pixel in the image is compared with centre of the k clusters using distance formula $\sqrt{(a^2 + b^2)}$. Each pixel is compared to the centroid and based on the shortest distance it is divided into different groups. This process continues until

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the centre converges. K-Means provides an accuracy of 85%. The flow chart of K-Means clustering is shown in Fig.3

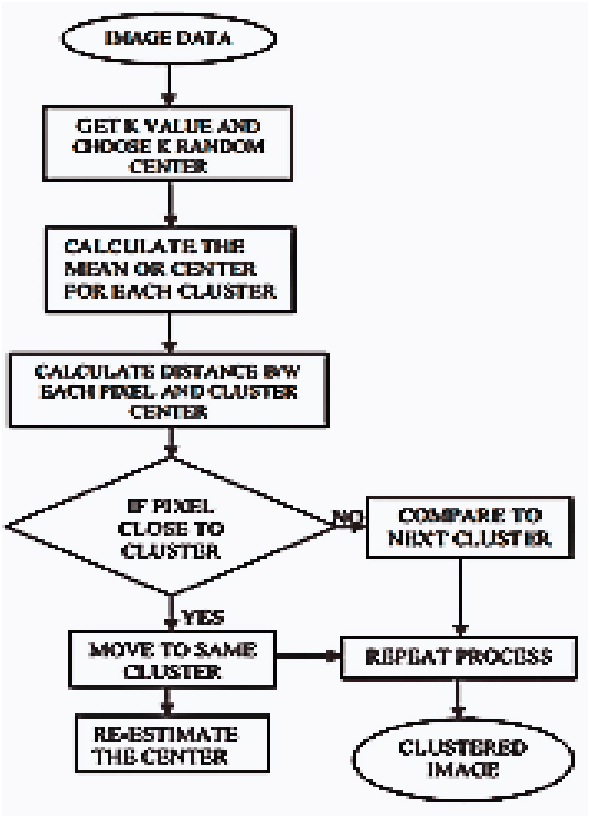

Figure 3: K-Means Clustering Flow Chart

C. Convolution Neural Network (CNN)

A Convolutional Neural Network falls into the category of Artificial Neural Network generally used for image recognition and processing which is specifically designed to process pixel data. The Convolutional Neural Network comprise of input layer, convolutional layer (3×3), rectified linear unit layer (ReLU), pooling layer and fully connected layer. CNN takes an image as an input, process it and classifies it under certain categories. The images are viewed as an array of pixels which depends on the resolution of the image. In Convolutional Neural Network, the images are scalable. Now, in the convolutional layer the given input images will be segregated into different regions. The activation function is performed in ReLU layer on the picture elements. ReLU is used to introduce the non-linearity in our convolutional neural network. Convolutional is the first layer for feature extraction from an input image. It retains the relationship between pixels using small squares of input data.

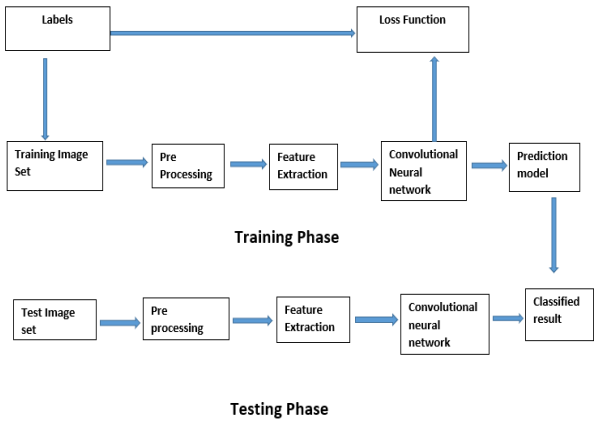

Figure 4: Block Diagram of Brain Tumor Classification Using CNN

The block diagram shown in Fig 2 indicates the brain tumor classification using Convolutional Neural Network. The brain tumor classification in CNN is divided into two phases namely training and testing phases. The image obtained from the dataset categorized into two types by using labels such as tumor and non-tumor brain image. In training phase,pre-processing, feature extraction and classification with loss function is performed in order to prepare a prediction model. Pre-trained model is used for training the dataset since it consumes less amount of time. Once the model is been trained it is tested further to achieve the result.

CNN works as follows:

1. Add the input image into the convolutional layer.
2. Select the required parameters and apply the filters accordingly. Perform convolution on the image and apply the ReLU activation function.
3. Perform pooling in order to reduce the size of dimensionality.
4. You can include as many convolutional layers based on your requirement.
5. The output is fed into a fully connected layer which generates the class score value based on the probability.
6. The output of the class is obtained by using an activation function which classifies the images as tumorous or non-tumorous.

1) LeNet-5 Architecture: LeNet-5 architecture was introduced by LeCun in 1998. It is a straight forward and small, accomplishing it in an absolute way in order to teach the basics of CNNS. It can run on CPU in case you do not have a suitable GPU. LeNet-5 architecture was the first architecture for Convolutional Neural Network. LeNet-5 is small and easy to understand but large enough to provide interesting results. It is an open source implementation of LeNet-5 Convolutional Neural Network. This architecture is trained to detect tumorous and non-tumorous cells in the brain using Kaggle dataset. It is written in python and uses Tensor Flow packages.

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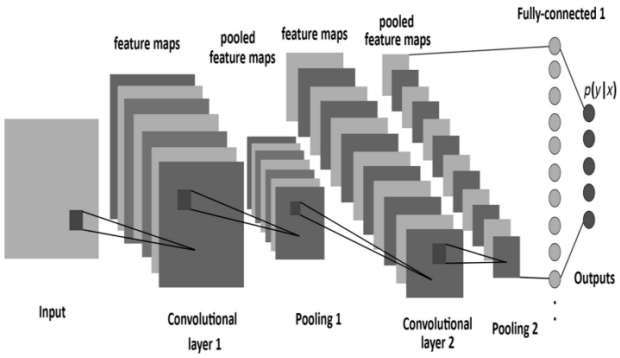

Figure 5: LeNet-5 Architecture

LeNet-5 architecture consist of 2 batches of convolutional and pooling layers, followed by flattened convolutional layer, then 2 fully connected layers and finally a soft max classifier.

1. First Layer

The input for this architecture is a gray scale image that passes through the first convolutional layer with 6 feature maps.

2. Second Layer

LeNet-5 architecture applies the average pooling layer with necessary filters.

3. Third Layer

In this layer, the second convolutional layer with 16 feature maps have been applied.

4. Fourth Layer

The architecture applies average pooling layer with filters again in this layer. It is similar to second layer.

5. Fifth Layer

This layer is a fully connected convolutional layer with 120 feature maps.

In our project, LeNet-5 architecture for brain tumor detection has been implemented in the following way:

Firstly, the necessary modules for our project have been imported then the dataset containing images is obtained and pre-processing procedure is carried out on the data after which we have loaded the data and further it's been splitin order to build a model. Furthermore, the model has been trained and its tested to get accuracy. The accuracy obtained for brain tumor detection using this architecture is 88.7%.

2) UNet Architecture: UNet is originated from "Fully Convolutional Network". UNet was first designed by Long and Shelhamer. UNet architecture has two paths namely contraction path also known as encoder, it helps to conquer the frame of reference in the image and also contains the symmetric expanding path termed as decoder that permits for decisive localization using transposed convolutions. This architecture accepts any size of image since it does not contain any dense layer.

The moto behind this architecture is to know more about feature mapping of an image. In this architecture the image is converted into a vector format for further classification. Further conversion of the image into vector format can be done by using the same mapping technique which is one of the advantages of using UNet. This architecture retains the structural integrity of the image which would reduce distortion. The architecture of UNet is shown in Fig.6

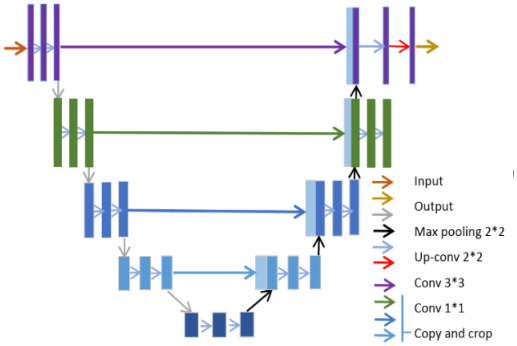

Figure 6: Block Diagram for UNet Architecture

As the name indicates the architecture looks like a 'U' shape generally, it has three sections: the contraction, the bottleneck and the expansion section. The contraction section has been made from many contraction blocks wherein each block takes the input and implements the two convolutional layers followed by max pooling. The number of feature maps for each block doubles so that UNet architecture can understand the complex structures in an efficient manner. The bottleneck section acts as an intermediate between the contraction layer and the expansion layer.

The heart of the architecture is the expansion section. In this section, each block passes the input to two CNN layers followed by up sampling layer. After each block the feature maps used by the CNN layers get half to maintain the symmetry that is, the number of expansion blocks is same as the number of contraction blocks. The accuracy obtained by using UNet is 89% for brain tumor detection.

4. Experimental Results

A. Dataset and Tools

1) Kaggle Dataset: Kaggle.com is one the most popular website widely used by Data Scientists and Machine Learning Engineers, it is an educational platform for analytics and predictive modelling. Kaggle contains huge amount of codes and data required for works related to data science and machine learning, it contains almost 19,000 datasets which helps us to achieve certain interpretations within no time. It allows us to share and publish the dataset in public or private mode. The space limit for a single private dataset is about 20GB if it exceeds the limit the datasets are made public. It

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helps the user to find and publish the dataset, build models in a web-based environment. It is one of the best websites for beginners.

2) PyCharm: PyCharm is an integrated development environment (IDE) are used in computer programming especially for python language. It is free and open source environment and can be used anytime and anywhere according to our convenience. In addition, we can bifurcate and modify it. It is one of the best tools for backend development. It is cross-platform such as it can be used in Windows, Linux and Mac OS versions. It provides graphical debuggers, integrated unit tester, the code analysis as well as supports web development and data science with anaconda.

3) *Anaconda*: Anaconda is free and open source environment that supports Windows, Linux and Mac OS versions for data science and machine learning applications. Anaconda Navigator is a desktop GUI which allows the users to launch applications without using command line commands. The navigator has default applications such as Jupiter notebook, spyder, visual studio code and so on.

B. Loss Graph

Loss Graph is used to enhance the machine learning algorithm. Loss is calculated based on training and validation and its interpretation which depends on how well the model is performing in these two sets.

Figure 7: Loss Graph

Accuracy graph is used to measure the performance of an algorithm.

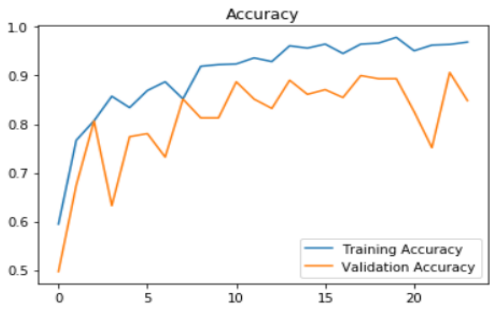

Figure 8: Accuracy Graph

C. Comparision

TABLE I specifies the comparision of different brain tumor techniques with its advantages and disadvantages. This comparision is done in-order to identify the precise techniques that is suitable for brain tumor detection.

Table I: Comparision of Brain Tumor Techniques

Technique	Advantage	Disadvantage
K-Means	it is easy to implement and generalizes clusters of different shapes and sizes	difficult to predict kvalue
LeNet	it is small and easy to understand and it was the first CNN layer	over fitting
UNet	it is used for fast and precise segmentation of images	it requires large amount of dataset to learn

C. Performance Matrix

TABLE II provides the accuracy and F1 score of different techniques.

Table II: Results of Different Techniques

Technique	Accuracy	F1 Score
K-Means	84%	0.89
LeNet	91%	0.91
UNet	91%	0.91

5. Conclusion

In this paper, we have conferred Brain Tumor Detection and Segmentation method using K-Means, LeNet, UNet based convolutional neural networks. The dataset used for our project is been taken from Kaggle which contains Brain images that are both tumorous and non-tumorous. A comparative study is done on the above 3 techniques that's been used. In this paper we have analyzed the best approach for brain tumor detection based on accuracy and F1 score.

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