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Brain tumor detection from MRI images using deep learning techniques

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Abstract. Brain tumor is the growth of abnormal cells in brain some of which may leads to cancer. The usual method to detect brain tumor is Magnetic Resonance Imaging(MRI) scans. From the MRI images information about the abnormal tissue growth in the brain is identified. In various research papers, the detection of brain tumor is done by applying Machine Learning and Deep Learning algorithms. When these algorithms are applied on the MRI images the prediction of brain tumor is done very fast and a higher accuracy helps in providing the treatment to the patients . These prediction also helps the radiologist in making quick decisions. In the proposed work, a self defined Artificial Neural Network (ANN) and Convolution Neural Network (CNN) is applied in detecting the presence of brain tumor and their performance is analyzed.

Keywords: Convolution Neural Network, Machine Learning, Brain tumor, Algorithms

1. Introduction

The brain is a most important organ in the human body which controls the entire functionality of other organs and helps in decision making[10]. It is primarily the control center of the central nervous system and is responsible for performing the daily voluntary and involuntary activities in the human body.[1] The tumor is a fibrous mesh of unwanted tissue growth inside our brain that proliferates in an unconstrained way. On this year at age of 15 about 3,540 children get diagnosed [9]with a brain tumor. The right way of understanding of brain tumor and its stages is an important task to prevent and to carry out the steps in curing the illness. To do so, magnetic resonance imaging (MRI) is widely used by radiologists to analyze brain tumors.[1] The result of the analysis carried out in this paper reveals whether the brain is normal one or diseased one by applying the deep learning techniques .

In this paper ANN and CNN is used in the classification of normal and tumor brain. [10]**ANN**(Artifical Neural Network) works like a human brain nervous system, on this basis a digital computer is connected with large amount of interconnections and networking which makes neural network to train with the use of simple processing units applied on the training set and stores the experiential knowledge. It has different layers of neurons which is connected together. The neural network can acquire the knowledge by [3] using data set applied on learning process. There will be one input and output layer whereas there may be any number of hidden layers. In the learning process, the weight and bias is added to neurons of each layer depending upon the input features and on the previous layers(for hidden layers and output layers). A model is trained based on the activation function applied on the input features and on the hidden layers where more learning happens to achieve the expected output.

As ANN works with the fully connected layers, where it involves more processing and as in this paper the image is used as the input it focuses on applying CNN also. [10] In **CNN (**convolutional neural network)

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convolutional is name of mathematical linear operation. The dimension of the image is reduced at each layers of CNN without the loss of information needed for training. Different processing like convolve, [1] maxpooling, droupout, flatten and dense are applied for creating the model. This paper focuses on creating an self defined architecture of ANN and CNN model and finally the performance of ANN and CNN is compared when applied on brain tumor MRI dataset.

2. Literature review

In this paper a Brain Cancer Detection and Classification System have been developed with the use of ANN.[3] The image processing techniques such as histogram equalization, image segmentation, image enhancement, and feature extraction have been used. The proposed approach using ANN as a classifier for classification of brain images provides a good classification efficiency as compared to other classifiers. The sensitivity, specificity and accuracy is also improved. The proposed approach is computationally effective and yields good result.

[5]In this research work , the Convolutional Neural Network (CNN) was implemented, which drives an overall accuracy of 91.3% and a recall of 88%, 81% and 99% in the detection of meningioma, glioma and pituitary tumor respectively. Deep learning architecture by leveraging 2D convolutional neural networks for the classification of the different types of brain tumor from MRI image slices. In this paper techniques like data acquisition, data pre-processing, pre –model, model optimization and hyper parameter tuning are applied. Moreover the 10-fold cross validation was performed on the complete dataset to check for the generalizability of the model.

NOT YET FOUND IN THE PROJECT, STILL TO EXPLORE

[4]The method applied in this paper is based on Hough voting, a strategy that allows for fully automatic localization and segmentation of the anatomies of interest . It also used learning techniques-based segmentation method which is robust, multi-region, flexible and can be easily adapted to different modalities. Different amount of training data and different data dimensionality (2D, 2.5D and 3D) are applied in predicting the final results. Convolutional neural networks,[5] Hough voting with CNN, Voxel-wise classification and Efficient patch-wise evaluation through CNN are used in analyzing the image.

[1] The brain is an essential organ in the human body which control and coordinates the tasks carried out by the other parts of the body. It is primarily the control center of the central nervous system and is responsible for performing the daily voluntary and involuntary activities in the human body. The tumor is a fibrous mesh of unwanted tissue growth inside our brain that proliferates in an unconstrained way. To prevent and to cure the tumor, magnetic resonance imaging (MRI) is widely used by radiologists to analyze stages of brain tumors. The result of this analysis reveals the presence of the brain tumor.

3. Data set

The dataset is taken from Github website. This dataset contains MRI images of brain tumor. There are two folders one represents the normal brain image and the other represents the tumor images. Totally there are 2065 images in both these folders. Figure 1 shows the sample normal and brain tumor image. Totally 1085 tumorous and 980 non-tumorous images are taken. The images are of different shapes (eg.630X630,225X225) and these image are resized to 256x256.1672 images for training, 186 images for validation and 207 images for testing is taken. Out of 1672 training image, 877 images are tumor image and 795 images are non tumor image. 92 tumor and 94 non tumor images taken from 186 validation images. Among 207 testing images, 116 tumor images and 91 non tumor images.

NO   YES
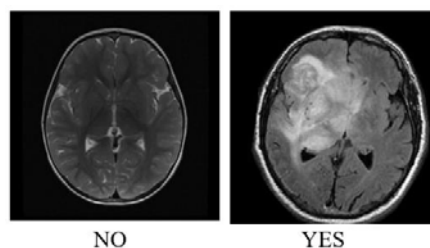
Figure 1. Normal Brain and Brain with Tumor

4. Materials and methods

The two techniques ANN and CNN are applied on the brain tumor dataset and their performance on classifying the image is analyzed. Steps followed in applying ANN on the brain tumor dataset are

ANN

1. Import the needed packages
2. Import the data folder
3. Read the images, provide the labels for the image (Set Image having Brain Tumor as 1 and image not having brain tumor as 0) and store them in the Data Frame.
4. Change the size of images as 256x256 by reading the images one by one.
5. Normalize the image
6. Split the data set into train, validation and test sets
7. Create the model
8. Compile the model
9. Apply the model on the train set.
10. Evaluate the model by applying it on the test set.

The ANN model used here has seven layers. First layer is the flatten layer which converts the 256x256x3 images into single dimensional array. The next five layers are the dense layers having the activation function as relu and number of neurons in each layers are 128,256,512,256 and 128 respectively. These five layers act as the hidden layers and the last dense layer having the activation function is sigmoid is the output layer with 1 neuron representing the two classes.

The model is compiled with the adam optimization technique and binary crossentropy loss function. The model is generated and trained by providing the training images and the validation images. Once the model is trained, it is tested using the test image set. Next the same dataset is given to the CNN technique. Steps followed in applying CNN on the brain tumor dataset are

CNN

1. Import the needed packages
2. Import the data folder(Yes and No)
3. Set the class labels for images(1 for Brain Tumor and 0 for No Brain Tumor)
4. Convert the images into shape(256X256)
5. Normalize the Image
6. Split the images into the train, validation and test set images.
7. Create the sequential model.
8. Compile the model.
9. Apply it on the train dataset(use validation set to evaluate the training performance).
10. Evaluate the model using the test images.
11. Plot the graph comparing the training and validation accuracy.
12. Draw the confusion matrix for actual output against the predicted output.

The CNN sequential model is generated by implementing different layers. The input image is reshaped into 256x256. The convolve layer is applied on the input image with the relu as activation function, padding as same which means the output images looks like the input image and the number of filters are 32,32,64,128,256 for different convolve layers. The max pooling applied with the 2x2 window size and droupout function is called with 20% of droupout. Flatten method is applied to convert the features into one dimensional array. The fully connected layer is done by calling the dense method with the number of units as 256 and relu as the activation function. The output layer has 1 unit to represent the two classes and the sigmoid as activation function. The architecture of CNN model is shown in the Figure 2. The implementation is done using Python language and are executed in google

0.25 DROPOUT IN THE PROJECT   64 UNITS FOR DENSE   CLASS MODE=BINARY

colab. The model is applied for 200 epoches with the training and the validation dataset. The history of execution is stored and plotted to understand the models generated.
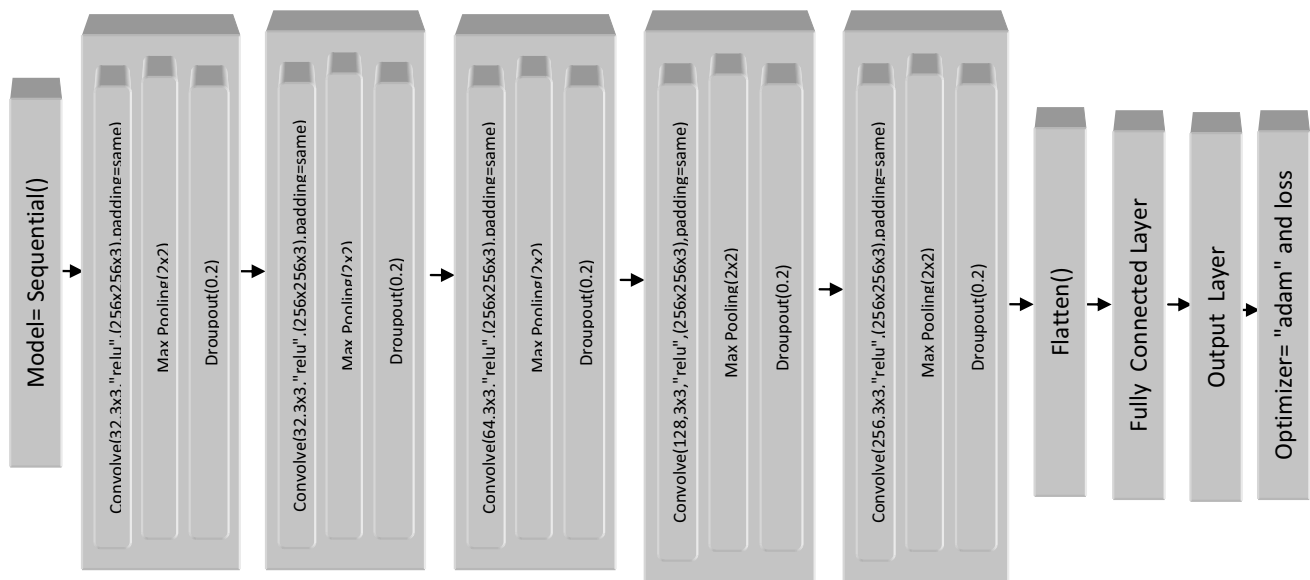

Figure 2. Architecture of CNN model

5. Experimental Result Analysis

The image data are added to the variable named data which is of ndarray datatype. The class labels of the images are also generated and stored in the variable data_target which is also an ndarray. The images are then added inside the dataframe. The image dataset is divided into training, validation and testing dataset. Figure 3 represents the accuracy and loss obtained when the ANN model is applied on the training and validation dataset When ANN model is applied on the training data for fifty epochs training accuracy obtained is 97.13% and a validation accuracy of 71.51 %. The same when applied on the testing data gives 80.77% accuracy.
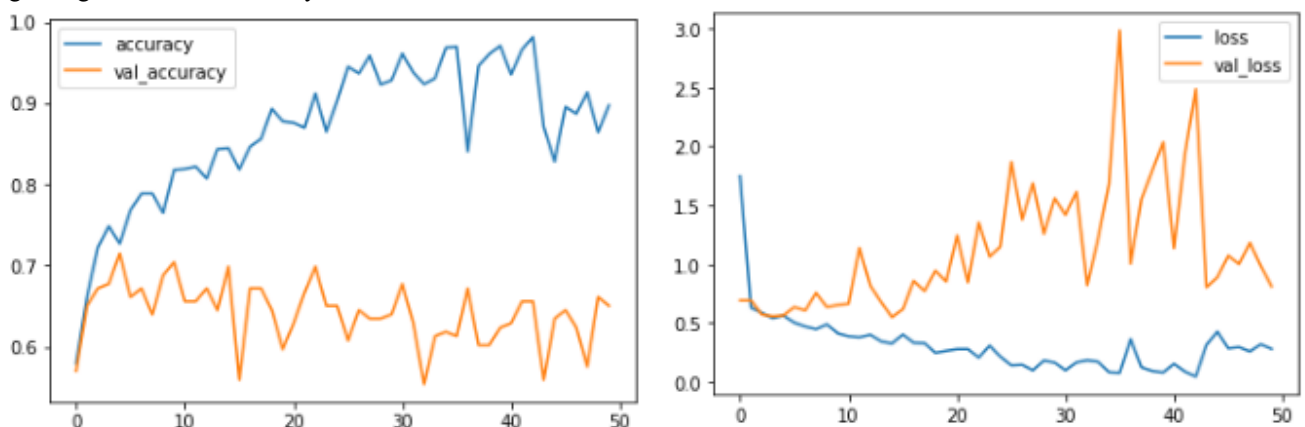
**Figure 3. Comparing training/validation accuracy and loss of ANN model**

The maximum validation accuracy obtained when the model is applied on the training dataset for 200 epochs is 94.00%. The following plot in the figure 4 shows the ratio of the training accuracy against the validation accuracy and the training loss and validation loss.
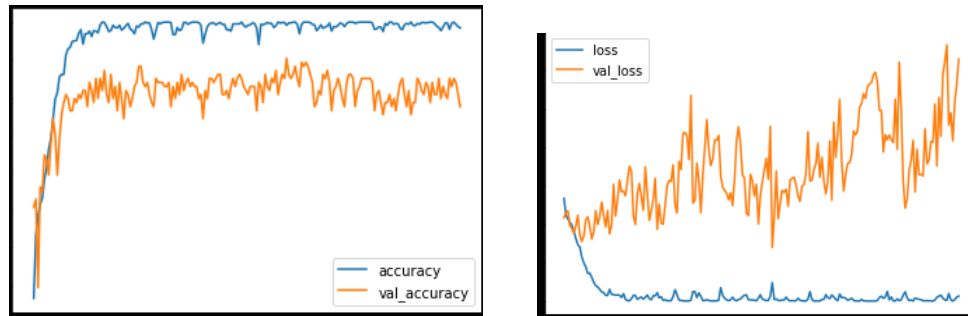
**Figure 4. Comparing training/validation accuracy and loss of CNN model**

The model is evaluated by applying the test image dataset. The confusion matrix for the predicted output is given as in the following Figure 5. The output of making prediction for the testing and validation given below.

```
             testing:
array([[ 81,  10],
       [ 12, 104]])
            validation:
array([[85,  9],
       [12, 80]])
```
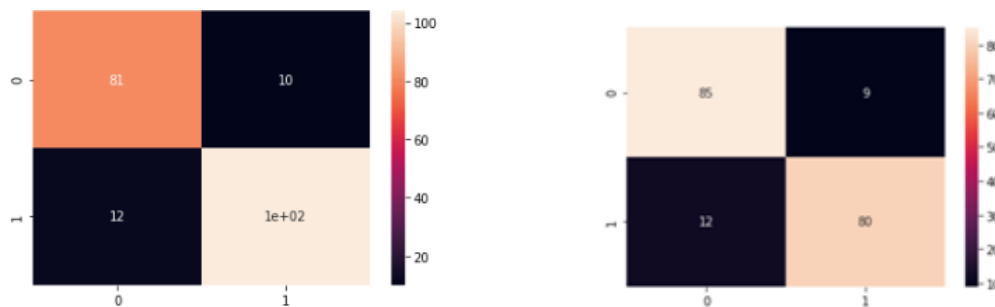

Figure 5. Confusion matrix for the testing and validation dataset using CNN model

The precision, recall and the f1-score of both the models are given in Figure 6.
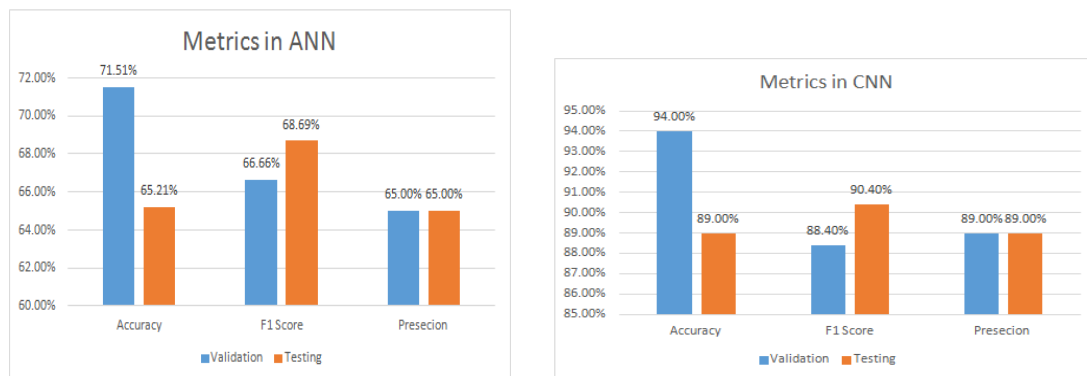
Figure 6. Metrics

The accuracy of the CNN model on applying the testing data is 89%. Having the precision, recall and f1 score in the hand and comparing the performance of ANN and CNN in detecting the presence of brain tumor, CNN proves to be the best supporting technique as it has the maximum precision value.

6. Conclusion

CNN is considered as one of the best technique in analyzing the image dataset. The CNN makes the prediction by reducing the size the image without losing the information needed for making predictions. ANN model generated here produces 65.21% of testing accuracy and this can be increased by providing more image data. The same can be done by applying the image augmentation techniques and the analyzing the performance of the ANN and CNN can be done. The model developed here is generated based on the trail and error method. In future optimization techniques can be applied so as to decide the number of layers and filters that can used in a model. As of now for the given dataset the CNN proves to be the better technique in predicting the presence of brain tumor.

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