An Efficient Deep Learning based Approach for the Detection of Brain Tumors

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***Abstract*— Deep learning has stretched out its roots even more in our daily lives. As a society, we are witnessing small changes in lifestyle such as self-driving cars, Google Assistant, Netflix recommendations, and spam email detection. Similarly, deep learning is also evolving in healthcare, and today many doctors often use it more comfortably. Using deep learning models we can detect severe brain tumors with the help of MRI scans, in fact in the Covid era, deep learning evolved majorly to detect the disease with the help of Lung X-Rays. Magnetic Resonance Imaging (MRI) is used when a person has a brain tumor to detect it. Brain tumors can fall into any category, and MRI scans of these millions of people are needed to determine if they have the disease and if so, which category they belong to. Determining the type of brain tumor can be a rigid task and deep learning models play an important role here. For the proposed deep learning model, we have implemented convolution neural networks (CNN) through which our model has achieved a testing accuracy of 96.5%. Also, along with this, the libraries of Keras and Tensorflow have been explored by the authors in this research.**

Keywords*— *Deep learning, Neural networks, CNN, Brain tumor, Keras, classification, accuracy.

I. INTRODUCTION

The brain tumor is a serious disease that also needs to be dealt with as soon as possible. The different types of tumors at each stage make it difficult for the health system to identify them at the right time, and it is very important that the patient shall receive fair treatment. During a brain tumor, rogue cells grow in the nervous system [1]. Medically recognized, there are three main types of brain tumors identified: glioma, meningioma, and pituitary, some of which are prone to cancer and some are invulnerable. According to a survey by the International Association of Cancer Registries (IACR) in 2018, this disease was ranked as the 10th most common type of disease. Every year more than 28,000 cases of brain tumors are detected in India and this number is increasing day by day. More than 24,000 people die from this disease annually [2]. In a 2019 NITI Aayog report presented by Dr. Vinod Paul, the number of brain tumor specialists also identified as neurologists in India is only 2,500, which is only nearly 9 percent of the total number of reported cases of the disease [3]. The ratio of the total number of cases to the total number of neurologists to treat is appallingly small, which is our devastating reality [4].

The typical technique used by neurologists to identify brain tumors and their stage or type is generally done with a magnetic resonance imaging (MRI) scan, which usually uses a huge, round-shaped machine that uses magnetic beams to create a complete scan of the inside of the patient's body. body. Compared to computed tomography (CT) scans, MRI is quite often performed by neurologists because CT scanning machines use a rapid chain of X-rays that are assembled to create a complete image of a patient's organ [5, 6]. The complexity of CT scans degrades it compared to MRI. And the person who performed the MRI scan was often called the radiologist who communicates with the neurologists about any patient's scan. Now the real challenge also begins where the above-discussed ratio of neurologists to tumor cases comes into play, because according to the "Cleveland Clinic" after obtaining the MRI scans, they go to a radiologist who analyses them and later forwards them to a neurologist. He then studies these scans. It takes him at least a day to come to a conclusion. Nowadays, the time to treat the patient is wasted and it may happen that the tumor reaches the central nervous system of the patient [7, 8].

We cannot change the process of obtaining MRI scans, we cannot produce more neurologists in a short period of time, and we cannot change the treatment tactics of these surgeons. So, what we can do is nullify the time between getting the MRI scans and the neurologist giving the verdict, which takes days in real-time. This process can be largely replaced by deep learning, which takes minutes to predict the type of brain tumor or whether or not a brain tumor is present on an MRI scan. There are often irregularities in brain size and tumor types that are difficult to identify, and efforts must be made to identify the exact tumor from these scans. The lack of qualified neurosurgeons in developing countries is also a major reason why the sector is trying to replicate this process using some advanced technology that is apparently cost-effective, accurate, and fast. The rise of efficient algorithms and neural networks, which have taken a significant step in introducing artificial intelligence to the world, has been made possible by advances in durable hardware that utilizes the Graphics Processing Unit (GPU) and developments in libraries that are essential for machine learning and deep learning from multinational companies like Google. They developed and released TensorFlow publicly, and the AI society witnessed new dawn of well-organized intelligent models [9, 10].

The outline of the paper is arranged as follows: section II gives the view of other authors that have worked on similar problems. Section III gives us an understanding of the dataset we have used. Section IV deep dives in the methodology proposed for building the deep learning model using convolutional neural networks. Section V tells us about the results that we have obtained so far using our model on various parameters, and section VI concludes our proposed model.

II. RELATED WORK

In one of brain tumor classification paper, the author suggests that classifying some types of brain tumor problems can be solved using the same deep learning, but the approach used here transfers learning. They have used GoogLeNet for training their model and it has provided them with an accuracy of 98%.[11]. The author has suggested that every technology is ever required for taking scans of the brain. They have described the use of CT scans, MRI scans, and ultrasound imaging to detect brain tumors. They have used the approach of using CNN for classification and they have achieved 97.5% accuracy by this method [12]. Following another paper, the authors have described the use of recently invented technologies that radiologists often used for the brain tumor scanning task. They have extensively used data augmentation in their project [13].

The authors have prepared a large five-class dataset for their project. They have used two approaches for this 1. CNN, 2. transfer learning-based model using six machine learning classification methods [14]. The author has suggested using a transfer learning approach for classifying brain tumors, where this approach conveys us using ResNet50, DenseNet201, MobileNet V2, and InceptionV3. Also, they have compared the accuracy of every transfer learning approach [15]. The authors of the following paper have written that the brain tumor classification can be done by using techniques like GLCM, CNN, and DWT, and has got high accuracy in their model and also by using advanced techniques of SVM can also help to detect MRI images of brain tumors [16].

Regarding this paper, the author has mentioned the significance of using segmentation for medical imaging classification; they have also used several methods like canny h detector, and region growing algorithms to execute their project. They have also detected and classified other datasets of bone fractures and blood cells [17]. In this paper, the author has heavily discussed the problem of brain tumors. They have also used techniques of data mining, along with CNN, and the approach they have used is segmentation. They have also applied several layers to train their model [18].

The description given by the author suggests that they have used three techniques to classify their brain tumor problem. These steps are nothing but divided into three stages, where the first is pre-processing of the image, the second stage is consisting of the segmentation of pre-processed brain tumor images and the final stage includes morphological operations of the tumor later removing the unused segmented pixels [19].

III. DATASET

The brain tumor dataset used here contains 3000 plus MRI scans that have been converted into JPG images for easy interpretation by the proposed deep learning model. A dataset is the most important part of any deep learning project. This dataset is divided into two components, training and testing. Within these folders are four subcategories named after tumor type, and each type folder contains images of a brain tumor. The number of images each category contains in the training and testing set is given in Table I.

TABLE I. NUMBER OF IMAGES IN EACH CATEGORY

Tumor Type	***Training***	***Testing***
Meningioma	822	115
Glioma	826	100
Pituitary	827	74
No Tumor	395	105

Each image contains 512 x 512 pixels and consists of 3 RGB channels. The RGB channels are the main red, green and blue frames that make up the entire image. This dataset has been intentionally used to maintain a large number of image batch sizes, and when needed to increase the number of datasets, image augmentation comes into play where multiple batches of the same but visually altered images are generated to meet the additional needs of the image dataset. This technique is also used to change brightness, rotate grayscale, zoom in and out, or rotate any set of images to any extent. The same process can be done using OpenCV, which also provides the same feature set and is mostly used in the computer vision domain. Given below are the various images of each category of a brain tumor in Figure 1.

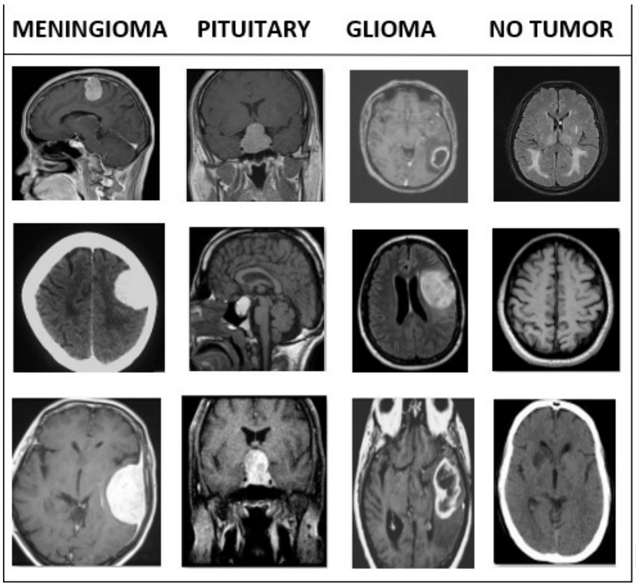

Fig. 1. Different tumor images of each category.

IV. PROPOSED METHODOLOGY

A. *Why deep learning?*

The term neural network was first coined by Warren McCullough and Walter Pitts in 1944. These neural networks had parameters and weights, but there wasn't much development in this field. The first neural networks were designed by keeping the human brain in mind, like how each neuron in our brain is connected to each other and passes information. Later with advancements in technologies with time, the backpropagation algorithm was developed which proved to be futuristic. This algorithm was the base of all upcoming artificial intelligence applications because of the ability to learn from its mistakes. This ability of neural networks used in deep learning makes it unique from other elementary machine learning algorithms. Deep Learning is a subset of Machine Learning and ML is a subset of Artificial Intelligence. The role of these technologies has evolved due to efficient hardware, large amounts of data, and an understanding of the importance of neural networks.

B. *Data Preprocessing*

Any deep learning model built always accepts the input data as an array because the model cannot process straight images. Each image comprises pixels and pixel values range from 0 to 256. The color scale of the image is determined by what pixel value is present. Just as the black part of any image is more like 0 and the white part is more like 256. Since pixel values range from 0 to 256, leaving zero will have a range of 255. So the division of all 255 values is in the range of 0 to 1. Before the training model, each image is converted to an array by dividing by 255. This process is called normalization, which is mainly done to reduce computational effort. The most important part for later prediction and overall model training depends on the labels assigned to the images. The four brain tumor labels for each relevant image are most likely in English and cannot be processed by a deep learning model. Data must be entered in integer format only. So here we have done One Hot Label Encoding which simply assigns an integer label to each image category. It makes it easy for us to prepare Y-train and Y-test data to make predictions and train neural networks accordingly. We used the Scikit Learn library to split the data into training and test sets, getting back X-train, X-test, Y-train, and Y-test, where X-train consists of the training image data and Y-train consists of from their respective labels and the same happens with testing one. After this process, we use NumPy functions to convert all the X-train and X-test data consisting of images into a set of arrays. Here, data augmentation is also performed to create slightly different sets of modified image data, created using existing image data. Model accuracy is improved by using data augmentation in the process. The hyperparameters defined during data augmentation were zoom range, rotation range, horizontal flip, width shift, and many more.

C. *Convolutional Neural Networks.*

Convolutional neural networks (CNN) are mainly used for tasks like image classification, because of their ability to extract features from any image and decide whether the given image belongs to which class without any human intervention. For example, we have been given a dataset containing images of Pandas and we have to train our model for the image classification. The old engineering process would take effort as it would simply scan all images, which could take days, and even if it did that, any other image slightly different from the normal image would be rejected by it. In the deep learning method, though Artificial neural networks could be a solution they can classify images containing RGB value 0 i.e., black and white images. But, the image with 3 RGB channels containing thousands of images isn't a huge task for CNN, as it detects features within an image. In the case of pandas, CNN detects pandas' ears, mouths, eyes, black patches, etc. Based on these features, it could easily identify which of the following is a panda. As discussed above, neural networks were originally inspired by the human brain. Like a normal human brain identifies almost any animal from some significant features like ears, eyes, mouth, skin, hair, etc. The same process is carried out by CNN. For feature extraction, CNN uses a kernel. It's nothing but a filter used to extract the features of any image. These convolutional filters are trained to extract features of any image. Also, each step of our model starting from feature extraction to predicting image class is given below in Figure 2.

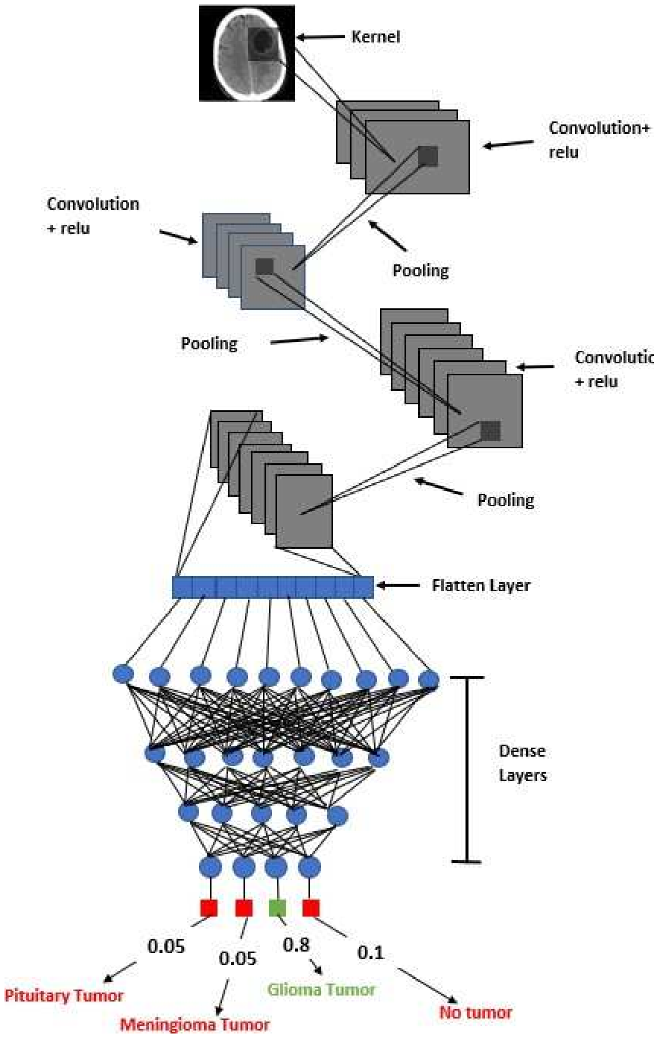

Fig. 2. Step-by-step Explanation of Model.

V. RESULTS

Before training the model, there are some hyperparameters that contribute extensively throughout the training process. These hyperparameters were:

1. Batch Size: It is nothing but a number of representatives that shall pass through the network at the same time. Depending upon the learning rate, the batch size should be

decided, as it affects the training procedure time. In this case, we have opted for the batch size of 20.

2. Epochs: It is simply a number that would decide how many times a training algorithm would work through a single dataset. In our model, they are 25.

3. Validation Split: Validation data is a type of unseen data apart from training data, which is used to evaluate the hyperparameters during the training process. The validation split we have assigned to our model is 0.10. After training the model for 25 epochs, we got a training accuracy of 99% and the validation accuracy was 96%. From these obtained numbers, we can say that there is no overfitting in our model. We have specifically used the dropout layer to overcome this problem. Both the accuracies are no doubt, indicating to us the great result ahead. Take a look at our model's loss results in the Figure 3.

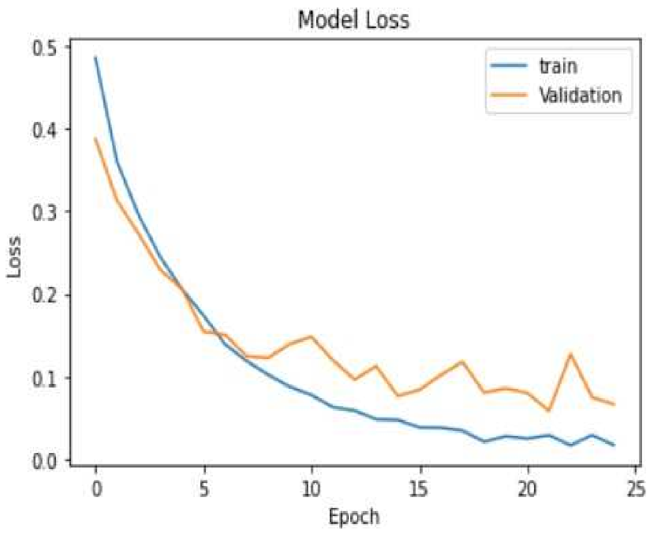

Fig. 3. Loss vs Epoch Graph.

And now, we will see the model's training and validation accuracies with each other in the Figure 4.

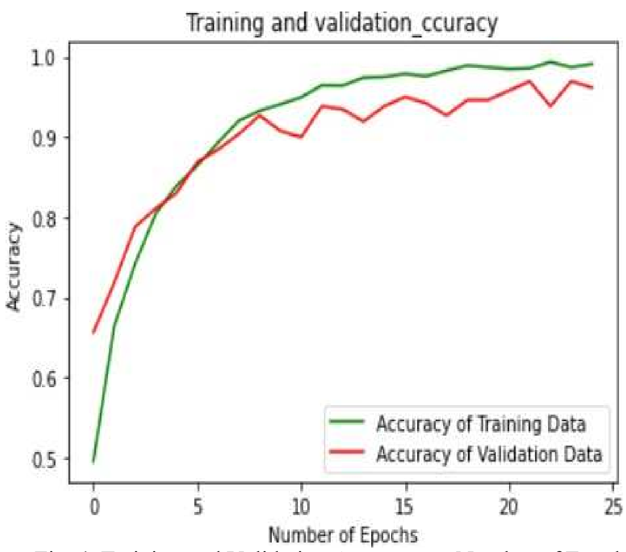

Fig. 4. Training and Validation Accuracy vs Number of Epochs Graph.

Now, in terms of testing accuracy, we are just evaluating how our model will perform for the testing data which is hidden from the model during the training phase. And for this phase, the testing accuracy achieved was 96.5%. We have also prepared a classification report stating how our model performs on each benchmark of evaluating metrics in Table. II.

TABLE II. ALL METRICS' PERFORMANCE FOR OUR MODEL.

Tumor Type	*Precision*	*Recall*	*F1_Score*	*Support*
Meningioma	0.98	0.92	0.95	86
Glioma	0.97	0.98	0.97	97
Pituitary	0.86	0.96	0.91	26
No Tumor	0.99	1.00	0.99	78

1. Precision: The first evaluation metric of machine learning states how good a model is in predicting a specific kind of set, which is a tumor in our case. This is calculated as per eqn.1:

$$\text{Precision}=\frac{\text{True Positive}}{\text{True Positive+False Positive}} \quad (1)$$

2. Recall: In this case, if our recall metric is higher, more positive samples are detected. This is calculated as per eqn.2:

$$\text{Recall}=\frac{\text{True Positive}}{\text{True Positive+False Negative}} \quad (2)$$

3. F1 Score: This metric combines the first two evaluating metrics into a single metric with the help of their harmonic mean. This is calculated as per eqn.3:

$$\text{F measure} = \frac{2*\text{recall}*\text{precision}}{\text{precision+recall}} \quad (3)$$

4. Support: This metric states the number of test samples that are found in each category should be true.

Also, there is one more metric that proves to be important while evaluating our model's performance and that is the confusion matrix. In Figure 5. we can understand the situation of the confusion matrix.

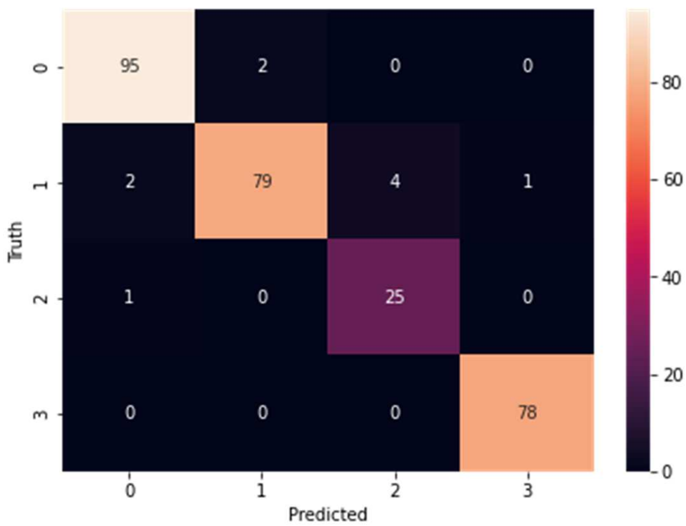

Fig. 5. Confusion Matrix.

In this matrix, the rows are the actual or true values to be expected and the columns are showing the predicted outcome that our model has made. According to this matrix, our deep learning model did a very decent job in predicting testing data.

VI. CONCLUSION

This study reveals the use of several techniques for this model to get accurate predictions. It has given great results to our model and we hope these deep learning models may help doctors to recover patients as soon as possible due to immediate scan results of brain tumors, so it will not take long for doctors as well as patients. We can also make use of new techniques like transfer learning, advanced optimization layers as well as filters to make brain tumor classification models more powerful and helpful. Such a model and applying more features and algorithms in the future will help several health care problems, etc. Deep learning will have tremendous and remarkable benefits ahead.

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