BRAIN TUMOR DETECTION USING DEEP LEARNING METHODS

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ABSTRACT

Deep learning algorithms are a category of algorithms (under Machine Learning) that are modeled based on neurons of multiple layers which when trained on any dataset (supervised learning) extracts features from it. A Convolutional Neural Network is a type of deep learning algorithm which are specially tailored to extract features from dataset that has high spatial information such as an Image.

A brain Tumor is an abnormal growth of tissue in the brain when uncontrolled becomes cancerous. Diagnosis starts with an MRI scan and is followed by a visual analysis of a skilled radiologist. The lack of skilled professional in a developing country makes it a challenging task, hence computerizing the task of brain MRI classification is an actively researched topic.

In this research work a custom-built CNN (built from scratch) has been developed and trained to detect tumor’s on MRI Images. The model is evaluated for its accuracy and compared with the models built by other researchers.

Keywords: Convolutional Neural Network, Brain Tumor, Deep Learning, Algorithms.

INTRODUCTION

1.1 ARTIFICIAL INTELLIGENCE

Artificial Intelligence is the intelligence demonstrated by machines, as opposed to the natural intelligence displayed by humans or animals. Leading AI textbooks define the field as the study of "intelligent agents": any system that perceives its environment and takes actions that maximize its chance of achieving its goals.] Some popular accounts use the term "artificial intelligence" to describe machines that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving".

Subsets:

Artificial Intelligence is a broader umbrella under which Machine Learning (ML) and Deep Learning (DL) comes. Diagram shows, ML is subset of AI and DL is subset of ML

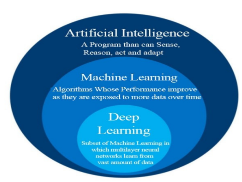


Figure 1: Artificial Intelligence subsets

Machine Learning

Machine learning (ML) is a field of inquiry devoted to understanding and building methods that 'learn', that is, methods that leverage data to improve performance on some set of tasks. It is seen as a part of artificial intelligence. Machine learning algorithms build a model based on sample data, known as training data, in order to make predictions or decisions without being explicitly programmed to do so.

Deep Learning

Deep learning is a family of machine learning methods based on artificial neural networks with representation learning. Deep-learning architectures such as deep neural networks, deep belief networks, deep reinforcement learning, recurrent neural networks and convolutional neural networks have been applied to fields including computer vision, speech recognition, natural language processing, machine translation, bioinformatics, drug design, medical image analysis, climate science, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance.

1.2 BRAIN TUMOR

Brain

The brain is a most important organ in the human body which controls other Sub system and helps in decision making. 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.

Brain Tumor

A brain tumor is a mass or growth of abnormal cells in your brain. Many different types of brain tumors exist. Some brain tumors are noncancerous (benign), and some brain tumors are cancerous (malignant).

According to a study, the incidence of tumors in the central nervous system in India ranges from around five to 10 cases per 1,00,000 population.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body. MRI scanners use strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body. MRI does not involve X-rays or the use of ionizing radiation, which distinguishes it from CT and PET scans.

There exist two different methods for taking MRI scans called T1 and T2. These different methods are used to detect different structures or chemicals in the central nervous system.

MRI Scan of a Patient with a Brain Tumor:

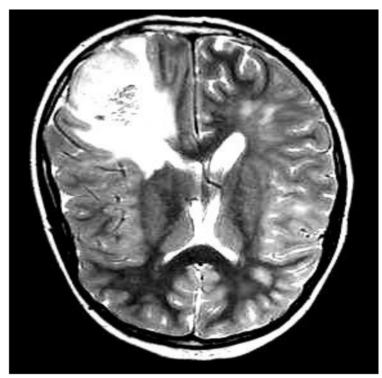


Figure 2: MRI Scan (Tumor) MRI Scan of a Patient with No Brain Tumor

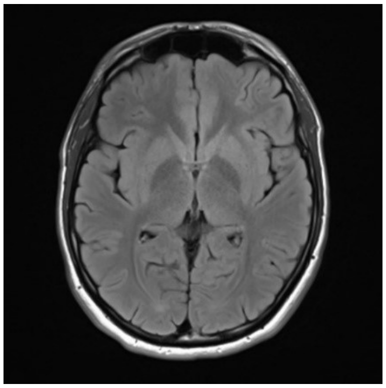


Figure 3: MRI Scan (No-Tumor)

1.3 OBJECTIVES

The Project Work Focuses on Creating a self-defined Convolutional Neural Network. The Created Model is then trained on a Dataset consisting of MRI Scans of Brains with and without Tumor and Evaluated Based on Standard Metrics such as Precision, Specificity, Accuracy and False Positive Ratio. The Model is Then Compared with Other Existing Work.

CHAPTER 2

IMPLEMENTATION

2.1 IMPLEMENTATION FLOWCHART

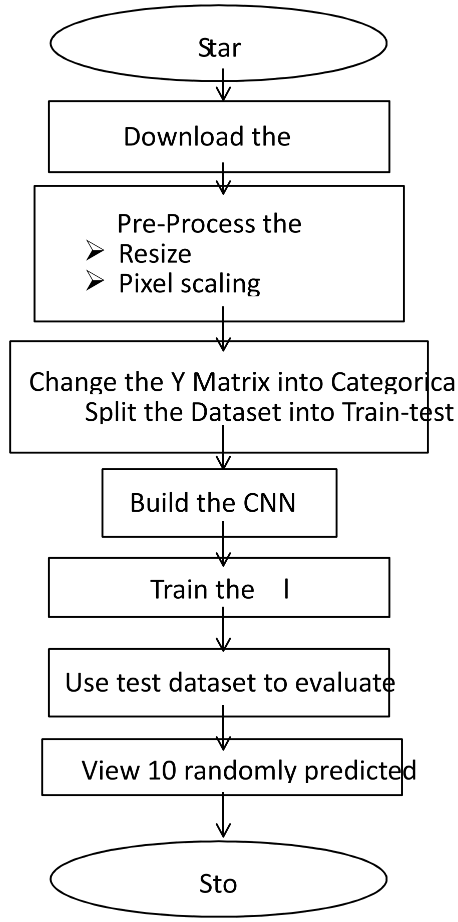


Figure 4 : Implementation Flow Chart

2.2 DATASET

The dataset was downloaded from Kaggle. The dataset contains 3060 brain MRI images with prediction for presence of brain tumor. All the MRI used were in axial plane. These images are in RGB image in jpeg format ranging from 10-25 Kbytes each. The images ranges from 200 – 650 in width and 390 to 1000 in height. They are named accordingly indicating the number and the presence of tumor.

MRI scan with brain tumor(left) and without(right) from the dataset:

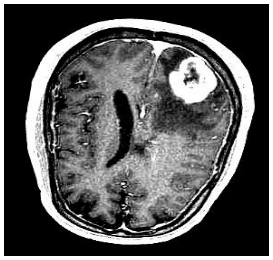


Figure 5 : MRI of brain tumor

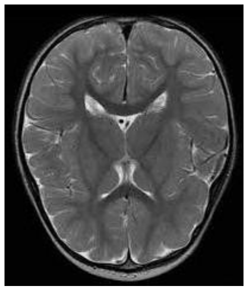


Figure 6 : MRI of Normal Brain

2.3 DATASET PREPROCESSING

A Numpy array called X_DATA is created and these images (which are itself a 3-dimensional matrices) are resized to (256, 256, 3) and added to it, resulting in a multi-dimensional array of (3000, 256, 256, 3).

Correspondingly, a Numpy array called Y_DATA is created and added 0.0 or 1.0 indicating no-tumor or yes-tumor respectively.

The Y_DATA array is reformatted into a categorical format (hot encoded array).

That is, for any random sample *a* from Y_DATA the matrices would contain 2 values (1 x 2 matrix), where the index 0 represents no-tumor and index 1 represents tumor. Thus, the size of the Y_DATA array changes to (3000, 2) from (3000, 1).

The values in the X_DATA array lie between 0-255 for each of the channels and are normalized between 0 to 1. Normalization converts integer into floating point variable which are twice the size of integers and requires excess time to process.

These X_DATA and Y_DATA are then split using sklearn's (a machine learning library) train_test_split method. The split dataset is named as X_TRAIN, Y_TRAIN, X_TEST, Y_TEST.

These test datasets are kept separate and not used for training. These images are plotted randomly and checked if the X and Y array correspond accordingly.

2.4 MODEL ARCHITECTURE

The model is built using the sequential API of Keras. The input image is of size (256, 256, 3). It has 6 layers out of which 6 are convolution layer and 2 are dense layer. The filters used in the convolutional layer are of the same size throughout (3, 3) with a stride 1 and same padding. ReLU is used as activation function for all the convolution layer. The number of filters in each layer varies from 32 to 512 in the 6^{th} layer.

Each convolution layer is followed by a MaxPooling and a dropout in order to avoid saturation. The convolution layer is then flattened and connected to a dense layer of size 256 having ReLU activation function.

The final layer has 2 nodes and uses a softmax activation through which the probability of the image being tumor (class 2) and non-tumor (class 1) is output.

The loss function used is categorical_crossentropy. The model is configured to split a part of its training dataset into validation dataset and use it for calculating accuracy. The model is then trained for 30 epochs (30 full iteration over the training dataset).

The Architecture of the ConvNet is Shown below:

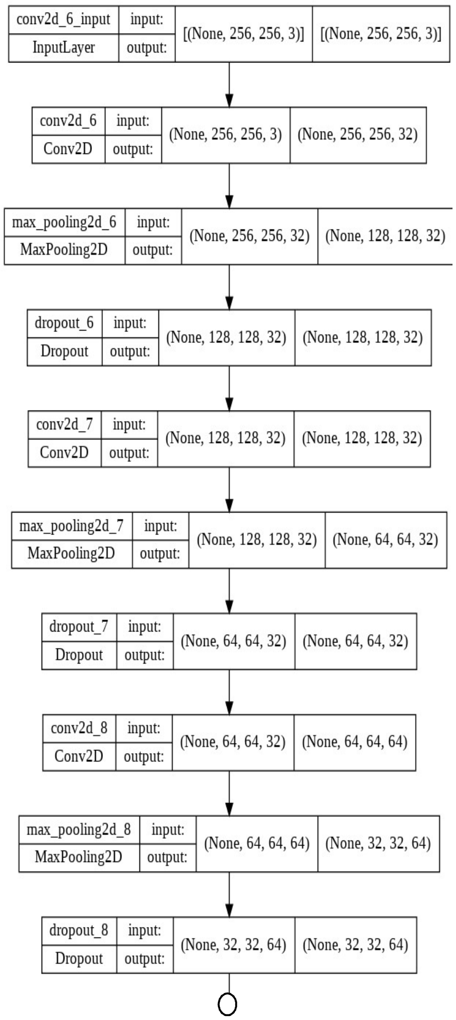


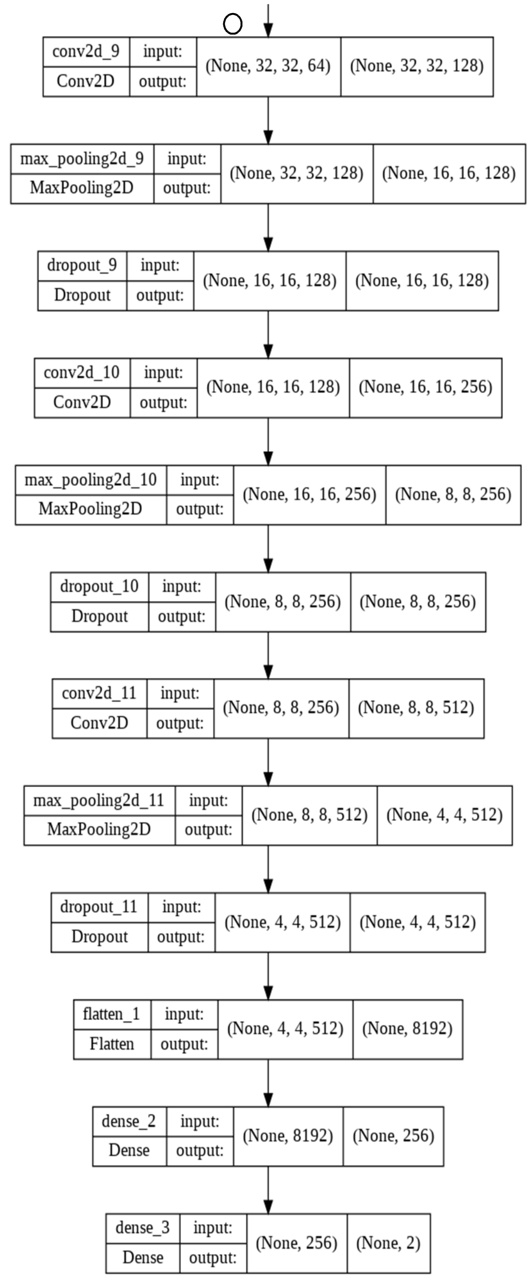
Figure 7 : CNN Architecture

The Architecture in Total has 3,675,746 Trainable Parameters for 2 Classes.

2.5 MODEL EVALUATION

*The loss and accuracy values obtained during the training are plotted against epoch for both training and validation datasets. The

model is evaluated for accuracy and precision using the formulas shown in above chapters.



*The X_TEST and Y_TEST Datasets are Used To build a Confusion Matrix.

CHAPTER 3

3.1 RESULTS

The model after trained on the dataset evaluation metrics such as accuracy, false positive rate, specificity and precision are calculated. The model during its training on each epoch calculates loss and accuracy on training and validation dataset which are then plotted. The trained model is given a test dataset to check for correctness from where the confusion matrix is charted. Finally, a random set of 10 images are given to the model in order to give a visual output.

a) Loss Vs Epoch

The graph below shows the loss over epoch values for both training and validation dataset.

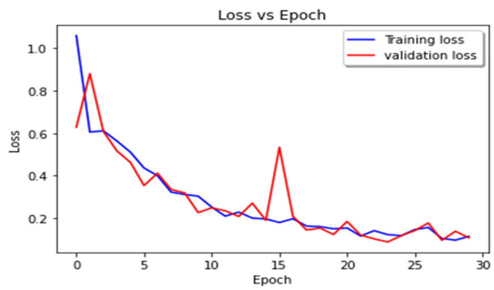


Figure 8 : Loss vs Epoch

b) Accuracy Vs Epoch

The graph below shows the accuracy over epoch values for both training and validation dataset.

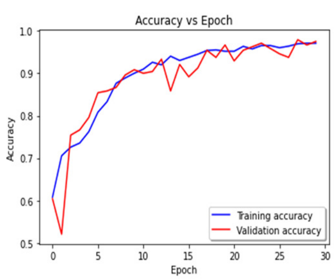


Figure 9 : Accuracy vs Epoch

c) Confusion Matrix

The Confusion matrix plotted using the test dataset is shown below.

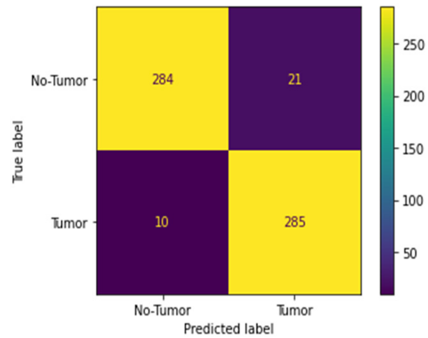


Figure 10 : Confusion Matrix

d) Evaluated Metrics

Test Accuracy = 0.9683

Precision = 0.9313

False Position Rate = 0.0688

Specificity = 0.9311

e) Screenshots

The screenshot below shows the model's prediction over 10 randomly picked MRI scans.

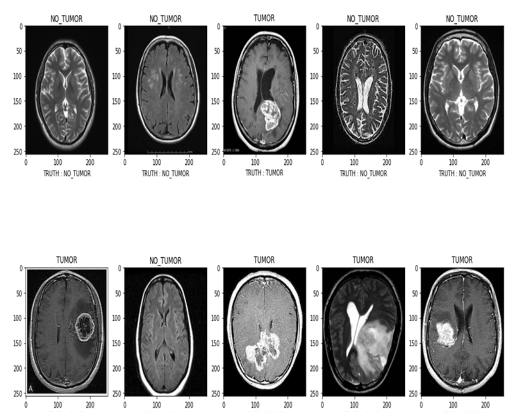


Figure 11 : Screenshots

f) Comparison

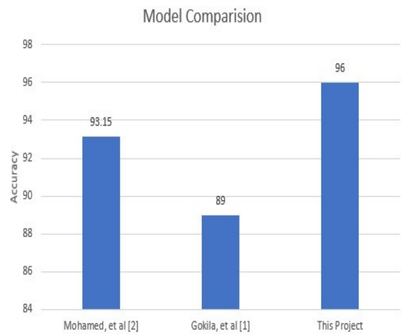


Figure 12 : Comparison of models

CHAPTER 4

CONCLUSION

Convolutional neural networks can be distinguished from Networks for their superior performance with image, speech, or audio signal inputs due to their spatial information retention. It is considered as one of the best techniques to extract local spatial features from an image and combine all the local spatial features to higher-order features. It makes these predictions by reducing the dimension of the image through Convolution without losing the information needed for making predictions. The CNN architecture built here is done based on a trial and error method. In future, better optimization techniques can be used to get a systematically built architecture. As of now for the given dataset the CNN proves to be the better technique in predicting the presence of brain Tumor with a test accuracy of ~96% which are higher than the base models.

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