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BRAIN TUMOR DETECTION USING CONVOLUTIONAL NEURAL NETWORKS AND DEEP LEARNING CONCEPTS

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ABSTRACT

Deep Learning is a new machine learning field that gained a lot of interest over the past few years. It was widely applied to several applications and proven to be a powerful machine learning tool for many of the complex problems. In this paper we used Deep Neural Network classifier which is one of the DL architectures for classifying a dataset. Brain tumor is a deadlier disease with more fatality rate than the survival rate. Nowadays, with the advent of technology, it is becoming desirable to perform automated computer-based brain tumor image analysis. The two most important tasks covered in literature for brain tumor analysis are tumor segmentation and tumor classification. Deep learning approaches are gaining popularity because of their self-feature learning capability. Especially, in this work MRI images are used to diagnose tumor in the brain. However the huge amount of data generated by MRI scan thwarts manual classification of tumor vs non-tumor in a particular time. But it having some limitation (i.e) accurate quantitative measurements is provided for limited number of images. Hence trusted and automatic classification scheme are essential to prevent the death rate of human. The automatic brain tumor classification is very challenging task in large spatial and structural variability of surrounding region of brain tumor. In this work, automatic brain tumor detection is proposed by using Convolutional Neural Networks (CNN) classification. The deeper architecture design is performed by using small kernels. The CNN (Convolutional Neural Networks) based brain tumor detection is divided into two phases such as training and testing phases. In the training phase, preprocessing, feature extraction and classification with loss function is performed to make a prediction model more efficient. Finally, the convolution neural network is used for brain tumor detection. The brain image dataset is taken from image net. Image net is a one of the pre-trained model. The proposed method accurately detects the tumor based on the trained data by considering less features than the traditional methods. The time complexity of the proposed method is also reduced for predicting the tumor.

Keywords: Brain tumor detection, clustering, data classification, image segmentation, neural networks.

1. INTRODUCTION

Cancer can be defined as a disease which causes cells to multiply uncontrollably with a potential to invade or spread to other part of the body. The tumors are swollen mass in part of the body caused by an abnormal growth of cells[1][2]. The occurrence of tumor in brain led to brain tumors. The tumors can be either of malignant or benign. Malignant tumors are cancerous and they multiply without any control and affects other cells[3][4]. The benign tumor is a noncancerous tumor which means they will not spread to the nearby tissues and hence less risky. Brain tumors are one of the deadly cancers which can last longer and can have psychological impact on patients[5][6]. And the brain tumor needs the most costly care than any other cancers. The brain tumors can be classified into 120 types. And in this work we are dealing with the astrocytoma which is a part of gliomas. The astrocytoma is the most commonly seen brain tumor which affects the glial cell of the brain. The glial cell are neurological cell that present in the brain for providing nutrition to the neurons. Based on the grade of cancer cell the astrocytoma can be classified into 4 types[7][8].

● GRADE 1: These type of tumors grows really slowly and they won't spread to other tissues. They can be cured by surgery.

● GRADE 2: These type of tumors more likely to slow growth and they won't spread to other tissues but there is chance for the return of the tumors.

● GRADE 3: These tumors are more lethal than above types and they are more likely to fast growing and rapid cell dividing.

● GRADE 4: These types are the extreme worse cases of tumors. Here the tumors are actively dividing and they do have blood vessels around the dead tissues.

Brain is one of the most complex organs in the human body that works with billions of cells. A brain tumor arise when there is uncontrolled division of cells forming an abnormal group of cells around or inside the brain. That group of cells can affect the normal functionality of the brain activity and destroy the healthy cells [9][10]. Brain tumors classified to benign or low-grade (grade I and II) and malignant tumors or high-grade (grade III and IV). Benign tumors are non-progressive (non-cancerous) so considered to be less aggressive, they originated in the brain and grows slowly; also it cannot spread to anywhere else in the body. However, malignant tumors are cancerous and grow rapidly with undefined boundaries. They can be originated in the brain itself which called primary malignant tumor or to be originated elsewhere in the body and spread to the brain which called secondary malignant tumor [11][12][13].

Brain magnetic resonance imaging (MRI) is one of the best imaging techniques that researchers relied on for detecting the brain tumors and modeling of the tumor progression in both the detection and the treatment phases. MRI images have a big impact in the automatic medical image analysis field for its ability to provide a lot of information about the brain structure and abnormalities within the brain tissues due to the high resolution of the images [14][15]. In fact, Researchers presented different automated approaches for brain tumors detection and type classification using brain MRI images since it became possible to scan and load medical images to the computer.

Brain tumor is incited because of an ordinary boom of cells [16]. It comes under two categories that are malignant or benign. The benign tumors do not contain cancerous cells while the malignant tumors are comprised of cancerous cells [17][18]. Brain tumors associations classify the brain tumor in four grades where grade I and II are referred to as benign and the remaining III and IV are labeled as malignant. The development rate of benign is relatively low when contrasted with malignant. When the benign isn't dealt with opportune then it is changed into malignant tumor.

Along these lines, early discovery of tumor is desirable[19]. Grade II patients require ordinary treatment and checking through magnetic resonance imaging (MRI) . MRI depicts one of radio imaging types. Some more types include computed tomography (CT) and positron emission tomography (PET) [20] with the help of which brain tumor can be diagnosed in medical imaging[21]. MRI is mostly useful to analyze tumors in general clinical routines. It provides minute information about human cerebrum. One advantage of MRI is its non-intrusive nature and no ionization radiation.

DL is most broadly utilized for brain tumor investigation in numerous scenarios for example, ordinary or irregular cerebrum tumor categorization and segmentation [41] [42]. A convolution neural network (CNN) represents a most famous DL structure utilized generally for characterization and segmentation of brain tumors [43] [44]. This is accomplished by convolving the images utilizing learned channels to assemble a chain of features activations. This deep learning work is done in a few layers to such an extent that the features acquired are interpretation and twisting invariant bringing about the high level of exactness [45].

Brain MRI image is mainly used to detect the tumor and tumor progress modeling process. This information is mainly used for tumor detection and treatment processes.MRI image gives more information about given medical image than the CT or ultrasound image. MRI image provides detailed information about brain structure and anomaly detection in brain tissue [46] [47]. Actually, Scholars offered unlike automated methods for brain tumors finding and type cataloging using brain MRI images from the time when it became possible to scan and freight medical images to the computer [48]. Conversely, Neural Networks (NN) and Support Vector Machine (SVM) are the usually used methods for their good enactment over the most recent few years.[11] However freshly, Deep Learning (DL) models fixed a stirring trend in machine learning as the subterranean architecture can efficiently represent complex relationships without needing a large number of nodes like in the superficial architectures e.g. K-Nearest Neighbor (KNN)and Support Vector Machine (SVM).Consequently, they grew quickly to become the state of the art in unlike health informatics areas for example medical image analysis, medical informatics and bioinformatics.

2. LITERATURE SURVEY

Gliomas are the most well-known brain tumors [22]. Some tumors because of low grade can be less destructive. Patients having such tumor can survive for many years [23]. Where as some tumors of high grade are more destructive and can have survival duration of not more than two years [24]. Even though medical surgeries, which becomes a widely recognized treatment for brain cancers, along with other methods [25] are also the alternate solutions for tumor removal. MRI gives detailed pictures of cerebrum. Segmentation of some tumors, for instance, meningiomas can effectively be performed while it becomes hard to partition many other tumors, for example gliomas and glioblastomas[26]. These tumors are mostly combined with edema (swelling around the tumor region) and have poor contrast and structures [27]. This results in difficulty to fragment the tumor portion accurately. Additionally, images acquisition from different machines and different image sequence types may wind up having radically extraordinary grayscaleesteem when envisioned in various clinics.

A novel method, CNN [28] is presented to deal with selected division by utilizing the deliberation qualities of CNNs. The technique depends on Hough casting, a methodology that takes into consideration completely programmed segmentation. This methodology doesn't just utilize CNN prediction results; however, it likewise performs casting by using the highlights delivered by the deepest segment of system.

Lakshman [19]et al. introduce the concept of big data for DL in brain tumor segmentation[29][30]. They propose seven-layer CNN architecture and assess their model on seven big MRI based tumor datasets. [23] R.S.M.L et al. present five CNN methods to segment brain tumor. [41] Sk.Reshmi Khadherbhi et al. use CNN with mini kernels, each having dimensions of 3Ã. K.Santhi Sri et al. [22] name their 3D architecture of CNN as DeepMedic. The authors include lingering connections on an early presented work. Cascaded fully CNN is applied for multi-class brain tumor extraction [34]. The anisotropic filters with multi fusion of layers make the approach more robust. U- net, also a variation of CNN, is used for tumor segmentation [35]. It is useful for training few numbers of images. A novel brain tumor division technique is proposed by incorporating a Fully-CNN with Conditional Random Fields (CRF) [36], as opposed to receiving CRF as a post-handling venture of FCNN. The model is prepared in three phases dependent on picture fixes and cuts individually.

In, new brain tumor segmentation is introduced, which is also called multimodal brain tumor segmentation scheme. Also combing different segmentation algorithm in order to achieve high performance than the existing method. But the complexity is high. In, the survey of brain tumor segmentation is presented. Discuss about Various segmentation methods such as Region based segmentation, threshold based segmentation, fuzzy C Means segmentation, Atlas based segmentation, Margo Random Field (MRF) segmentation, deformable model, geometric deformable model, The accuracy, robustness, validity are analyzed for all the methods[37]. In, hybrid feature selection with ensemble classification is applied for brain tumor diagnosis process. The GANNIGMAC, decision Tree, Bagging C based wrapper approach is used to obtain the decision rules[38]. Also simplify the decision rules by using hybrid feature selection, which contains the combination of (GANNIGMAC + MRMR C+ Bagging C + Decision Tree).

In, the fuzzy based control theory is used for brain tumor segmentation and classification method[39]. The Fuzzy Interference System (FIS) is a one special technique, which is mainly used for brain segmentation. Supervised classification is used to create a membership function of fuzzy controller. The performance is high and accuracy is low. In, the adaptive histogram equalization is used to improve the contrast of the image[40]. Then (FCM) based segmentation is performed to separate the tumor from the whole brain image. After that Gabor feature are extracted to filter the abnormal cells of brain. Finally, the fuzzy with K Nearest Neighbor (KNN) classification is applied to find the abnormality of brain MRI image. The complexity is high. But the accuracy is low. In this work, a novel automatic brain tumor classification is performed by convolutions neural network.

3. PROPOSED METHOD

Deep learning (DL) is a subfield of machine learning based on learning multiple levels of representations by making a hierarchy of features where the higher levels are defined from the lower levels and the same lower level features can help in defining many higher level features [11]. DL structure extends the traditional neural networks (NN) by adding more hidden layers to the network architecture between the input and output layers to model more complex and nonlinear relationships. This concept gained the researchers interest in the recent years for its good performance to become the best solution in many problems in medical image analysis applications such as image denoising, segmentation, registration and classification [7], [10], [12], [13].

In the normal neural network, image cannot scalable. But in convolution neural network, image can scalable (i.e) it will take 3D input volume to 3D output volume (length, width, height).The Convolution Neural Network (CNN) consists of input layer, convolution layer, Rectified Linear Unit (ReLU) layer, pooling layer and fully connected layer. In the convolution layer, the given input image is separated into various small regions. Element wise activation function is carried out in ReLU layer. Pooling layer is optional. We can use or skip. However the pooling layer is mainly used for down sampling. In the final layer (i.e) fully connected layer is used to generate the class score or label score value based on the probability in-between 0 to 1.

The block diagram of brain tumor classification based on convolution neural network is shown in Figure.1. The CNN based brain tumor classification is divided into two phases such as training and testing phases. The number of images is divided into different category by using labels name such as tumor and non-tumor brain image…etc. In the training phase, preprocessing, feature exaction and classification with Loss function is performed to make a prediction model. Initially, label the training image set. In the preprocessing image resizing is applied to change size of the image.

Finally, the convolution neural network is used for automatic brain tumor classification. The brain image dataset is taken from image net. Image net is a one of the pre-trained model. If you want to train from the starting layer, we have to train the entire layer up to ending layer. So time consumption is very high. It will affect the performance. To avoid this kind of problem, pre-trained model based brain dataset is used for classification steps. In the proposed CNN, we will train only last layer in python implementation. We don't want to train all the layers. So computation time is low meanwhile the performance is high in the proposed automatic brain tumor classification scheme.

The loss function is calculated by using gradient descent algorithm. The raw image pixel is mapping with class scores by using a score function. The quality of particular set of parameters is measured by loss function. It is based on how well the induced scores approved with the ground truth labels in the training data. The loss function calculation is very

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important to improve the accuracy. If the loss function is high, when the accuracy is low. Similarly, the accuracy is high, when the loss function is low. The gradient value is calculated for loss function to compute gradient descent algorithm. Repeatedly evaluate the gradient value to compute the gradient of loss function.

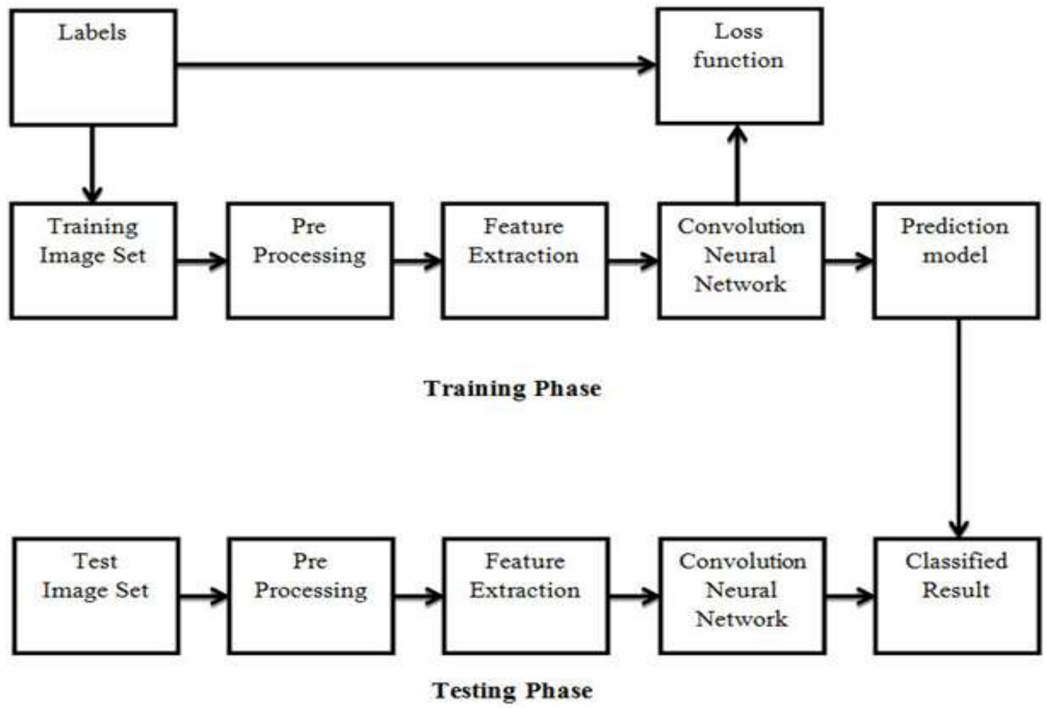

Figure 1: Block Diagram of Brain tumor classification using CNN

Algorithm for CNN based Classification

Apply convolution filter in first layer

The sensitivity of filter is reduced by smoothing the convolution filter (i.e) sub sampling

The signal transfers from one layer to another layer is controlled by activation layer

Fasten the training period by using rectified linear unit (RELU)

The neurons in proceeding layer is connected to every neuron in subsequent layer

During training Loss layer is added at the end to give a feedback to neural network

The brain consists of several connected neurons known as the neural network. A neural network's basic building block is known as a perception. Artificial neurons are a deep neural network. All Deep Neural Networks consist of three different stacks of layers: Input Layer, Hidden Layer and Output Layer The input layer receives all the inputs the hidden layer extracts unique features and the output layer gives the conclusion The number of neurons in the input layer depends on the size of the input data and on the specific application in the output layer. All layers are termed hidden layers in between input and output layer. Each hidden layer in DL network comprises of a stack of certain layers desired for some particular task. The number of hidden layers in the hidden layer stack depends on the complexity of the input data and the application to be used. In deep learning, the number of hidden layers can be increased for doing different functions. As the network is learning itself by extracting uniqueness from the input data, the number on hidden layers required will be very high compared to an ordinary ML neural network. But as the hidden layer increases the network complexity will increase, but the accuracy will also increase. Different Deep

Learning networks are available in literature. Some of them are given in table I. From the above mentioned DL networks for Brain Tumour detection from MRI, CNN (convolutional Neural Network) is the best.

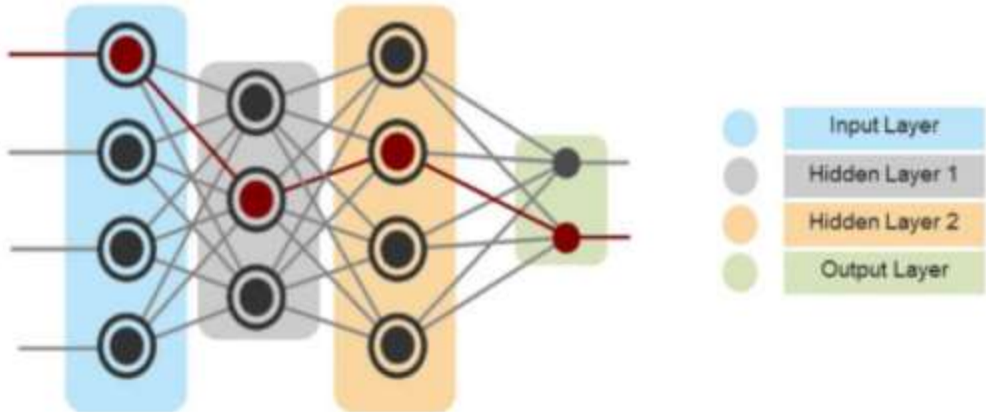

Figure 2: Deep Neural Network

In the typical neural network, all neurons in the in input layer are connected to neurons in the first hidden layer, but in CNN, the some neurons in the input layer are connected to the neurons in the hidden layer in small regions of the kernel size. These are called local repetitive fields and are translated from the input layer to the hidden layer through an image to create a feature map. This will reduce the dimension of the parameter space.

Now, Brain MRI image is sent as an input to the input layer and the network will identify whether brain tumor present or not. Here the input layer is acting as a buffer for passing the input data from the outside world to the first set of hidden layers. The first set of hidden layers known as Hidden layer 1 contain kernels that can extract the low level features of the input data like edges of the brain images based on the difference in contrast levels. The output from the first hidden layer is given to the next set of hidden layers that is Hidden layer 2, where the various mid-level brain features are extracted.

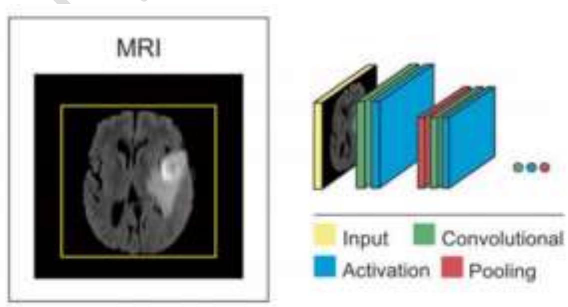

Figure 3: CNN Architecture of Proposed system

In this proposed method, we have used transfer learning for detecting brain tumor via classification of input data into one with tumor and the other without tumor. All the three above said networks are trained for classification purposes and the number of classes are 1000. Here, in our method we have only 2 classes: images with tumor and without tumor. Therefore, by using transfer learning we have created another network which can classify the input data into 2 classes. From the classified output we have

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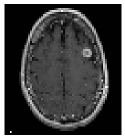
checked the classification accuracy and detection accuracy.

4. RESULTS

We created a dataset consists of several thousands of images from the available datasets like OASIS and BRATS2018 challenge. The dataset consists of 2 classes, one with tumor and second without tumor. From these more than 20000 images are selected. Among these, 80% are used for training and remaining 20% for testing purposes. Our Dataset contains tumor and non-tumor MRI images and collected from different online resources. Radiopaedia[13] contains real cases of patients, tumor images were obtained from Radiopaedia and Brain Tumor Image Segmentation Benchmark (BRATS) 2015 testing dataset.

```
Layer (type)                 Output Shape
=================================================================
conv2d_1 (Conv2D)            (None, 62, 62, 32)
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 31, 31, 32)
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 29, 29, 32)
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 14, 14, 32)
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 12, 12, 32)
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 6, 6, 32)
_________________________________________________________________
flatten_1 (Flatten)          (None, 1152)
_________________________________________________________________
dense_1 (Dense)              (None, 128)
_________________________________________________________________
dense_2 (Dense)              (None, 1)
=================================================================
Total params: 167,105
Trainable params: 167,105
Non-trainable params: 0
_________________________________________________________________
```

```
In [12]: training_set = train_datagen.flow_from_directory('train',
    ...:                                                  target_size = (64, 64),
    ...:                                                  batch_size = 4,
    ...:                                                  class_mode = 'binary')
    ...:
    ...: test_set = test_datagen.flow_from_directory('test',
    ...:                                             target_size = (64, 64),
    ...:                                             batch_size = 4,
    ...:                                             class_mode = 'binary')
Found 10208 images belonging to 2 classes.
Found 56 images belonging to 2 classes.
```



```
In [21]: test_image = image.img_to_array(test_image)
    ...:
    ...: test_image = np.expand_dims(test_image, axis = 0)
    ...: test_image
Out[21]:
array([[[[1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.],
         ...,
         [1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.]],

        [[2., 2., 2.],
         [1., 1., 1.],
         [1., 1., 1.],
         ...,
         [1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.]],

        [[1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.],
         ...,
         [1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.]],

        ...,
```

```
        [[1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.],
         ...,
         [1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.]],

        [[4., 4., 4.],
         [1., 1., 1.],
         [0., 0., 0.],
         ...,
         [1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.]],

        [[1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.],
         ...,
         [1., 1., 1.],
         [1., 1., 1.],
         [1., 1., 1.]]]], dtype=float32)

In [22]: result = classifier.predict(test_image)
    ...: result
Out[22]: array([[0.]], dtype=float32)

In [23]: training_set.class_indices
Out[23]: {'Benign': 0, 'Malignant': 1}

In [24]: if result[0][0] == 0:
    ...:     prediction = 'Benign'
    ...: else:
    ...:     prediction = 'Malignent'
    ...:
    ...: print("Detected tumor type is %s"%prediction)
Detected tumor type is Benign
```

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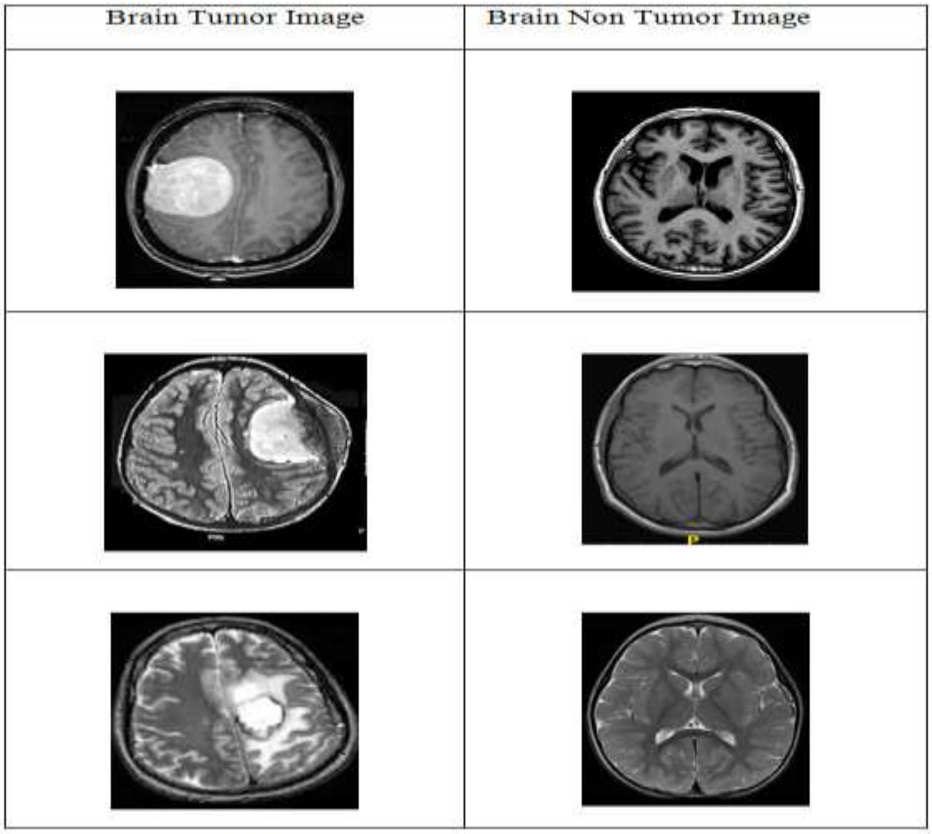

Figure 4: CNN based classification results

In this work, efficient automatic brain tumor detection is performed by using convolution neural network. Simulation is performed by using python language. The accuracy is calculated and compared with the all other state of arts methods. The training accuracy, validation accuracy and validation loss are calculated to find the efficiency of proposed brain tumor classification scheme. In the existing technique, the Support Vector Machine (SVM) based classification is performed for brain tumor detection. It needs feature extraction output. Based on feature value, the classification output is generated and accuracy is calculated. The computation time is high and accuracy is low in SVM based tumor and non-tumor detection.

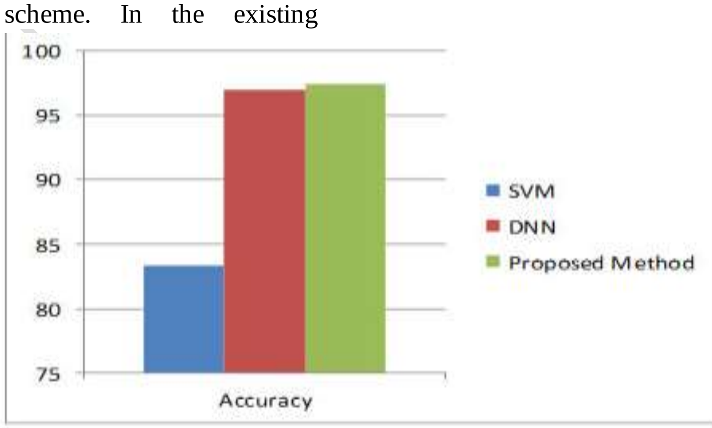

Figure 5: Accuracy of brain tumor classification

In the proposed CNN based classification doesn't require feature extraction steps separately. The feature value is taken from CNN itself. In Figure 4. shows the classified result of Tumor and Non-tumor brain image. Hence the complexity and computation time is low and accuracy is high. The output of brain tumor classification accuracy is given in Figure.5. Finally, the classification results as Tumor brain or non-tumor brain based on the probability score value. The normal brain image has the lowest probability score. Tumor brain has highest probability score value, when compared to normal and tumor brain.

5. CONCLUSION

A lot of work in performed in recent days on brain tumor MRI image segmentation and prediction with deep approaches. Still MRI is a challenging area where room for further research is available. The segmentation and classification both provide the medical experts a major advantage of second opinion based on automated results and a quick time analysis response. This saves a lot of time in manual brain image analysis. At the same time, this domain suffers because of robustness issues in terms of accuracy. This manuscript mainly focuses on existing DL techniques of segmenting and classifying brain tumors. In addition, publicly available datasets are also discussed. The main goal is to design efficient automatic brain tumor detection methodology with high accuracy, performance and low complexity. The conventional brain tumor detection is performed by using feature extraction and Neural Networks based classification. The complexity is low. But the computation time is high meanwhile accuracy is low. Further to improve the accuracy and to reduce the computation time, a convolution neural network based classification is introduced in the proposed scheme. Also the classification results are given as tumor and brain images. On the basis of this information the best therapy, surgery, radiation and chemo therapy is advised.

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