A Progress Report

on

Brain MR Image classification using genetic algorithm with back propagation neural network

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Abstract

Brain Tumor MRI segmentation is among the most challenging and difficult tasks in the field of medical science. A Brain Tumor is a group of tissues that is formed gradually with the growth of anomalous cells and tissues. MRI is considered to be a powerful imaging method for determining the different pathologies. In this paper, we are presenting a novel approach for the segmentation and classification of MRI Brain images as normal or abnormal using Genetic Algorithm using Back Propagation Neural Network. This paper focuses on attempting two main targets, first is to achieve maximum accuracy for the classification of different images. Secondly, it strives to minimize the total number of features that are required for the classification purposes. Genetic Algorithm played a very important role for feature selection while the neural network was used as a classifier. Genetic Algorithm was used for the research to overcome the problem of setting hyperparameters. With Genetic Algorithm, our model can automatically learn the best hyperparameter. Hence, Genetic Algorithm was very useful with our proposed neural network model. The proposed model was able to achieve an overall accuracy of 90% but it must be noted that less images were used due to computational limitations.

Keywords: Tumor Detection, brain Tumor, Magnetic resonance imaging(MRI), Genetic algorithm, Neural Networks, Back Propagation, VGG-16 Classifier

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1.Introduction

Nowadays Computer based decision systems are widely used in the field of medical science. Specially for the classification and detection of Brain MR Image. The same thing can be done manually by a human observer but due to time constraints it is no longer feasible. So this leads to the motivation for development of some automated system that can classify the MR Image with high accuracy. We have gone through the twelve research papers for the Brain MR Image classification, but all methods suggested in those papers have their own limitations.

A Brain Tumor is a group of tissues that is formed gradually with the growth of anomalous cells and tissues. MRI is considered to be a powerful imaging method for determining the different pathologies. In this paper, we are presenting a novel approach for the segmentation and classification of MRI Brain images as normal or abnormal using Genetic Algorithm using Back Propagation Neural Network. This paper focuses on attempting two main targets, first is to achieve maximum accuracy for the classification of different images. Secondly, it strives to minimize the total number of features that are required for the classification purposes. Genetic Algorithm played a very important role for feature selection while the neural network was used as a classifier. Genetic Algorithm was used for the research to overcome the problem of setting hyperparameters. With Genetic Algorithm, our model can automatically learn the best hyperparameter. Hence, Genetic Algorithm was very useful with our proposed neural network model. The proposed model was able to achieve an overall accuracy of 90% but it must be noted that less images were used due to computational limitations.

1.1 Related Work

1.1.1 Mary Joans et al.,2017[1] proposed a genetic algorithm for the classification of Brain MRI Scanned Images with the help of Random Forest Classifier. They found out that Random Forest Classifier has improved the classification accuracy with the help of least number of features. They proposed that without the feature selection process the performance of the classifier was very weak and genetic algorithms boosted the training time to many folds. Their work could be extended for detecting Glioma with tumour, Herpes encephalitis with a tumour and Multiple sclerosis with a tumour. Genetic algorithms work really well for feature selection because they can deal with large search spaces efficiently and hence the chances of local optimal solutions are rare. Genetic algorithms were able to obtain optimal solutions after performing many iterative computations.

1.1.2 Parasuraman Kumar et at.,2019[2] proposed a back propagation neural network model using Ensemble Classifier form the Brain Tumor MRI Segmentation. In their work, brain tumor was identified using image processing techniques. The required filter algorithms for pre-processing, and ensemble classifications used for feature extraction. They made ensemble classifiers using many combinations of feed forward neural network and Support Vector Machine. Ensemble was able to achieve a very high accuracy and had a less execution time and can be very efficient as compared to other classifiers. Ensemble classifier was chosen to be the best for training based on the F1 score generated among all the training algorithms taken for classification purposes.

1.1.3 N. Periyasamy et al.,2015[3] proposed backpropagation Fuzzy Neural Network (BPFNN) technique to classify the benign and malignant brain tumor in Brain MRI images.Principal Component Analysis (PCA) is used in the preprocessing stage in extracting the main features.In the proposed work Fuzzy clustering is used to segment the digital images into different segments from which it is easy to get the information.The proposed Back Propagation Neural Network achieved 90% classification accuracy in brain tumor image taxonomy. Brain Tumor MRI image classification with feature selection and extraction has limited successful results in previous work.The method applied in this work gives faster and accurate classification than the other neural network models.In future this approach may be implemented with the large amount of the dataset.

1.1.4 Anup Chandrahasan et al.,2014[4] proposed backpropagation Neural Network to classify the brain tumor in brain MRI images.This research work mainly focuses on preprocessing the dataset.So that the preprocessed dataset has no impurities and is easy to classify.In preprocessing part it does feature extraction and dimensionality reduction.This proposed work uses image processing toolbox and ANN toolbox of MATLAB 2012 for better accuracy.We used

eigenvalue decomposition and wavelet decomposition for feature extraction.This method can also be used for pointing out the suspicious regions in the brain images that has the similar properties as brain tumor.The eigen value decomposition feature vector give an accuracy of 70% to 75% and wavelet decomposition achieved 80% to 98% accuracy.

1.1.5 Prof. Nitin K. Bhil et al.,2014[5] proposed 2 strategies for Brain increase Detection supported artificial neural networks. The networks were classified into feed-forward neural networks and Back propagation neural Network. The cause is to expand equipment for discriminating malignant tumors from benign ones helping identifying in medical diagnosing. The proposed technique makes use of a mixture of these 2 neural community techniques and includes many steps as well as segmentation, characteristic vector extraction and version studying. These two methods will then be used to filter out unsuspecting brain scans likewise mean suspicious regions which have comparable belongings because the boom areas.

1.1.6 Sathya Subramaniam et al.,2015[6] proposed a combined NN with BCO Algorithm which helps to boost the classification rate of the brain tumour detection especially in cancer diagnosis by finding optimal weights. The algorithm enhances the wake edges thus can effectively improve the readability of the image. To improve the quality of the image, a PDE enhancement method is proposed. The image is first converted into a bi-level image after enhancement, which is utilized for filling the gaps and sharpening the regions using Morphological operators. The performance of the classification algorithm is measured using three classification parameters which are accuracy, sensitivity and specificity. They took around 100 MRI brain images to conduct the experiment. NN with BCO algorithm achieves a 76% accuracy while accuracy of NN only is about 74%. Hence the results concluded that the classification algorithm NN with BCO realizes 2% higher accuracy than NN algorithm.

1.1.7 Arti Gujar, 2018[7] proposed a method of brain tumor segmentation using genetic algorithms and optimized k-means. The optimized k-means algorithm will be used for clustering while the Genetic algorithm will be used for classification. At the final stage the MRI images are used for the tumor extraction and to also get its exact position and shape in the grayscale. The performance of the given system is measured in various different conditions for outputs. Multiple images of brain MRI are given as input that are detected by the system. Initially they provide one brain MRI image from the dataset and if the system detects it as the tumor is present then it is considered as true positive. Also, image from different dataset are given where the system detects if the tumor is absent then it is considered as false negative. The performance evolution for the proposed system is having an accuracy of 93%, 87% and 89% in Linear, Quadratic and Polygonal functions respectively.

1.1.8 Girja Sahu et. al 2015[8] proposed a method for classification of MRI Brain images using Gray Level cooccurrence Matrix (GLCM), Fuzzy Logic, Neural Network and Genetic Algorithm. In this paper, they used a Feed Forward Back propagation Neural Network(NN) technique along with the application of neuro-fuzzy systems for MR brain abnormalities. The proposed methodology consists of four steps which includes the data collection, feature extraction through gray level cooccurrence matrix, optimization using Genetic Algorithm and at the end classification through Neuro-Fuzzy model. In order to overcome the drawback of the hybrid neuro-fuzzy classifier, this proposed methodology of Neuro-Fuzzy classifier with Genetic algorithm helps in the high end. In practical work, a database of 100 images were used consisting of 50 Abnormal and 50 Normal MRI brain images. The observable parameters are calculated and they achieved an Accuracy of 98%, Specificity 97.50% and Sensitivity 98.80%.

1.1.9 Prabu Kumar et. al 2017[9] proposed an efficient deep learning neural network based Brain Tumor Detection Detection System. They compared their method with Intuitionistic fuzzy clustering which achieved an accuracy of 95% and Parameter-independent data clustering and image which had an accuracy of 94%. Their proposed method was able to achieve an accuracy of 98%. They have proposed a method which involves pre-processing followed by an anisotropic diffusion filter for removal of noises. Finally, they used a bounding box algorithm for highlighting the tumor which was extracted using one class SVM classifier.

1.1.10 Ahmed Talib et. al 2017[10] .They proposed an improved method for the brain classification of MRI images. They divide the whole process in three phases which are, feature extraction, dimensionality reduction, and an improved classification technique. For the feature extraction phase they used the discrete wavelet transform (DWT). and for Dimensionality Reduction they used PCA (principal component analysis). In the final phase, they developed an improved classifier. In this classifier, the Dragonfly algorithm is used rather than backpropagation for training the artificial neural network (ANN). The results show that their proposed classifier performed better as compared to other classifiers.

2. Summary of key related research

Authors Name	Title	Year	Journal/Conference Name with publisher	Novelty/Contribution	Limitations
Parasuraman. Kumar, Vijay Kumar	Brain Tumor MRI Segmentation and Classification Using Ensemble Classifier	2019	International Journal of Recent Technology and Engineering	Used neural network and ensemble classifier for brain tumor detection	Used less data for training purposes. Most data should have been used for better research work and it lacks genetic algorithm
Mary Joans, Jayant Sandhiya	A Genetic Algorithm Based Feature Selection for Classification of Brain MRI Scan Images Using Random Forest Classifier	2017	International Journal of Advanced Engineering Research and Science	Used random forest classifier for brain tumor detection	Did not performed very well and had less accuracy in comparison to neural network and lacks genetic algorithm
Chinmayi, Agilan deeswari	An Efficient deep learning neural network for tumor detection	2017	International Journal of Pure and Applied Mathematics	Used fuzzy clustering for brain tumor detection	Their method used was too complex and could not be implemented on large scale and achieved lower accuracy
Girja Sahu	Classification of MRI Brain images using GLCM, Neural Network, Fuzzy Logic & Genetic Algorithm	2018	International Journal on Recent and Innovation Trends in Computing and Communication	Used Neuro-Fuzzy classifier with Genetic algorithm	Required large data set for learning process.

Arti Gujar	Brain Tumor Extraction using Genetic Algorithm	2017	International Journal on Future Revolution in Computer Science & Communication Engineering	abnormality detection using neural network and spotting of tumor using image segmentation .	works on only two types of brain tumor
Ahmed Talib Abdulameer	An Improvement of MRI Brain Images Classification Using Dragonfly Algorithm as Trainer of Artificial Neural Network	2018	Ibn l-Haitham J. for Pure & Appl. Sci.	using dragonfly algorithm as trainer of ANN (DA-based ANN) instead of backpropagation algorithm	Not having good accuracy.
Sathya Subramaniam, Manavalan Radhakrishnan	Neural Network with Bee Colony Optimization for MRI Brain Cancer Image Classification	2015	The International Arab Journal of Information Technology	NN with BCO Algorithm to increase rate of classification of brain tumour detection	Only 2% growth in accuracy from existing algorithm.
N. Periyasamy, Dr. J. G. R. Sathiaseelan	Detection and Classification of Brain Tumor Images Using Back Propagation Fuzzy Neural Network	2015	International Journal for Research in Applied Science & Engineering Technology (IJRASET)	Backpropagation Fuzzy Neural Network (BPFNN) technique	Has Higher Execution Time

S. Josephine, S. Murugan	Brain Tumor Grade Detection by Using ANN	2019	International Journal of Engineering Research & Technology (IJERT)	backpropagation Neural Network	Requires large data set and Latest version of Matlab
Kalyani A. Bhawar, Prof. Nitin K. Bhil	Brain Tumor Classification Using Neural Network Based Methods	2016	The International Journal Engineering Sciences & research Technology	Feed-forward neural networks and Back propagation neural Network	Requires Large dataset of images to train the Network

2.1 Limitations overcome by the project

1) Most of the models used in Brain MR Image Classification did not use Genetic algorithms which can be used for fast training and better accuracy of deep learning models.
2) Most of the models were not trained on enough dataset which can give biased results. Hence, we aim to use more images for proper learning of our deep learning model.

2.2 Objectives of the project

1) Use Genetic Algorithm For Brain MR Image Classification with back propagation neural network.
2) To develop a deep learning model which is robust and can detect tumors in the brain using MRI images.
3) To motivate future work in the medical research field.

3. Research Methodology

3.1 Description of Dataset Used

3.1.1 What is Brain Tumor ?

A brain tumor is formed due to some cells and tissues in the brain which develop abnormal shapes. There are mainly two types of tumors in brains which are mainly known as cancerous tumors(popularly known as malignant tumor) and non-cancerous cells(known as benign tumor). Again, cancerous cells can be further divided into primary tumors which mainly start in the brain and secondary tumors which have spread from elsewhere known as metastasis tumors. Main symptoms of tumor include seizures, vomiting and mental changes. Headache can be worse in the morning but it can get away as day passes. If a person does not take immediate treatment, then he is prone to unconsciousness in later stages of this tumor.

3.1.2 MRI Scans and Sequences

MRI scans have a particular advantage that it can provide the images of the in all planes, that is in all 3 planes, which are Axial, Coronal and Sagittal.

There are mainly 2 types of MRI sequences:

1) T1 - Weighted Images: Short Time to Echo(TE) and short Repetition Time(TR) are used for their creation. The properties of the T1 tissue are used for determining the brightness (or the contrast) of the image. It can be seen that the Cerebrospinal fluid is dark.

2) T2 - Weighted Images: Longer Time to Echo(TE) and short Repetition Time(TR) are used for their creation. The properties of the T1 tissue are used for improving or determining the brightness (or the contrast) of the image. It can be seen that the Cerebrospinal fluid is bright.

T1- and T2-weighted images can be easily differentiated by looking at the CSF. CSF is dark on T1-weighted imaging and bright on T2-weighted imaging.

	TR (msec)	**TE (msec)**
T1-Weighted (short TR and TE)	**500**	**14**
T2-Weighted (long TR and TE)	**4000**	**90**
Flair (very long TR and TE)	**9000**	**114**

TR and TE times are shown above of some most common sequences.

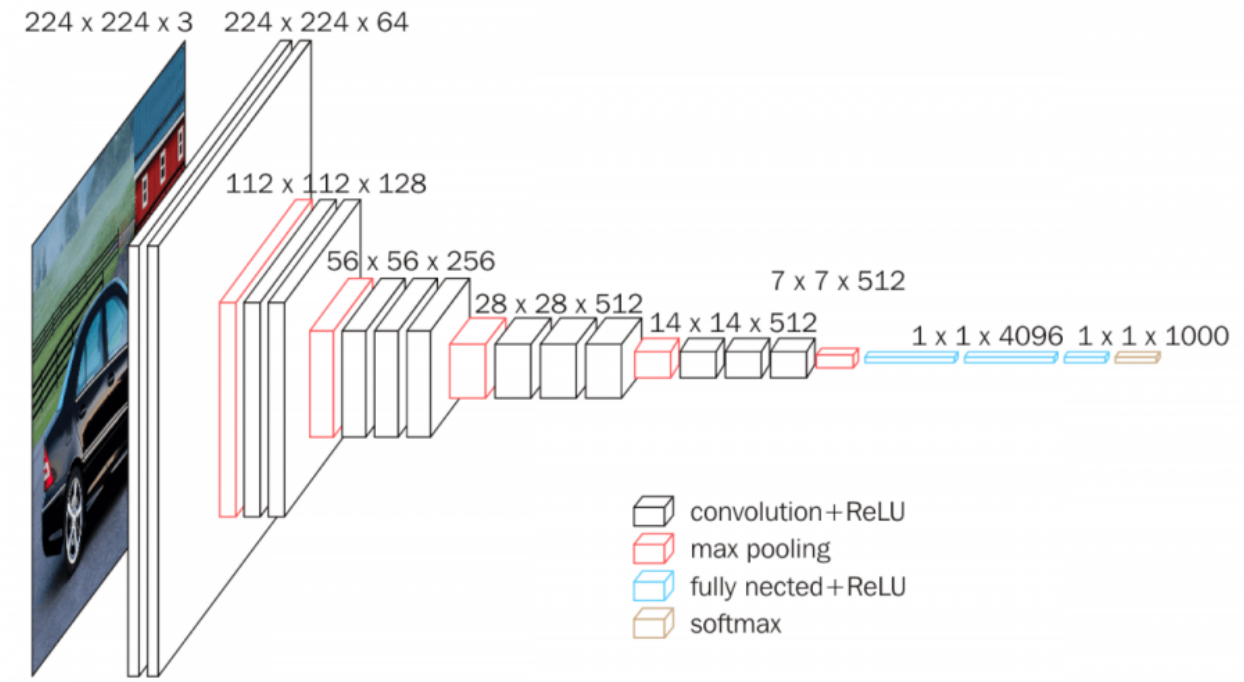
3.1.3 Dataset

For our research purpose, we have taken the Brain MRI Images for Brain Tumor Detection Dataset. It mainly consists of MRI scans of 2 classes, NO and YES, for no tumor and tumor respectively. We have taken 193 images for training purposes and 10 images for testing purposes. We have also taken 50 images for the purpose of validation. This dataset mainly consists of glioma tumor cases. This dataset contains both the cases of benign as well as malignant cases.

3.2 Techniques Used for Implementation Purposes

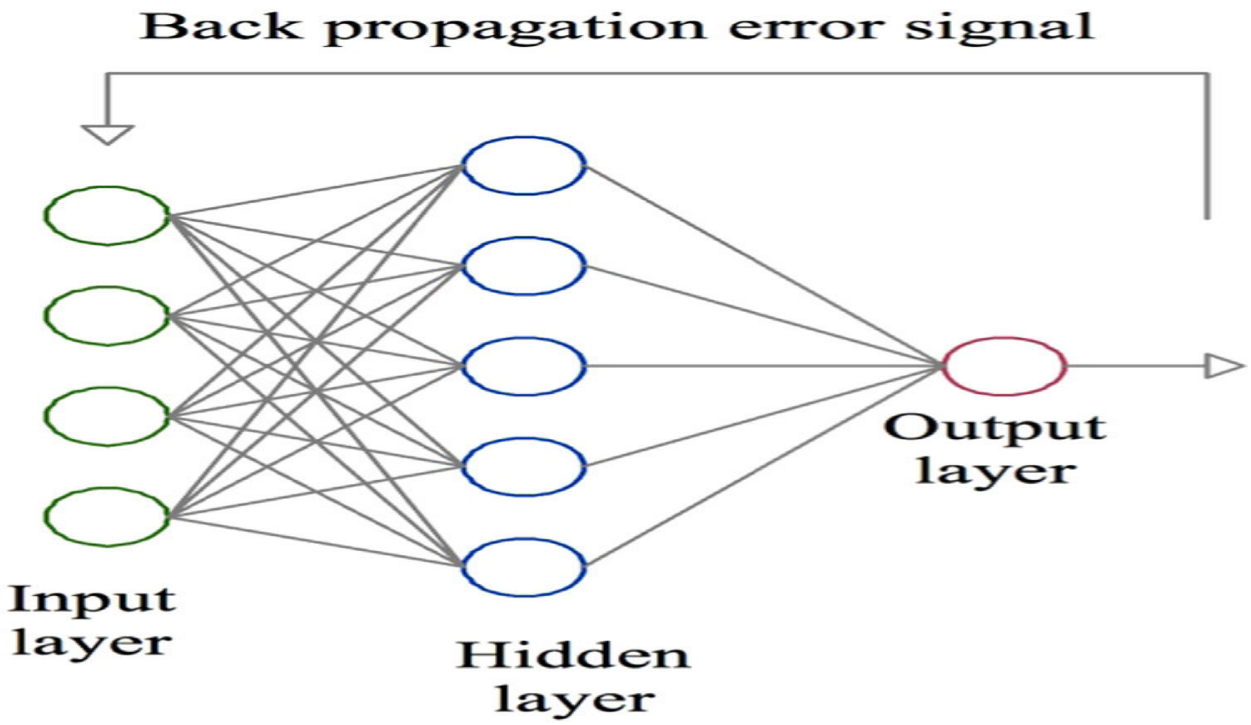
3.2.1 VGG16

VGG16 is a network model that has been trained on a huge dataset of 14 million images which belong to 1000 classes. Figure 2.1 represents an example of using VGG16 for feature extraction. The input to the conv1 layer is of 224 x 224 RGB image size. After this layer, the image is passed through many convolutional layers. There are also 3 FC(fully connected) layers after the convolutional layers. Initial 2 layers have a total of 4096 channels and the third layer has 1000 channels. Last layer has 1 channel for 1 type of prediction to be done. All the hidden layers are equipped with the rectification(ReLU) non-linearity. This model gives the prediction for 1000 classes.



3.2.2 Back Propagation Neural Network

Back-propagation is the flow of error in a neural network which is required so that neurons in the network can learn better to predict the output. It is done by fine tuning the weights of each and every neuron with each iteration. Well, the updation of weights depends on the type of set if input taken(batch, mini, stochastic). It is helpful in making the model more reliable and robust.



3.2.3 Genetic Algorithm

In the field of computer science, these algorithms are motivated by the large natural selection of the biggest classes of algorithms related to evolution. These algorithms focus on doing mutation, crossover and selection of the data on which it is applied inorder to achieve good results for whatever purpose we are using them. They are mainly used for providing good quality algorithmic solutions to complex problems.

The Problem with NNs:

NNs have helped us solve so many problems. But there is a problem of hyperparameter since we need to provide it to the algorithm. Hence genetic algorithms come to the rescue here. These are the only values that can not be learned

Hyper-parameters are values required by the NN to perform properly, given a problem.

We can use genetic algorithms to learn the best hyper-parameters for a neural network. Now, we don't have to worry about deciding the absolute value of hyperparameters since they can be learned using genetic algorithms. Also, we can use this to learn the parameters weights of a neural network as well.

3.2.4 Layer Information

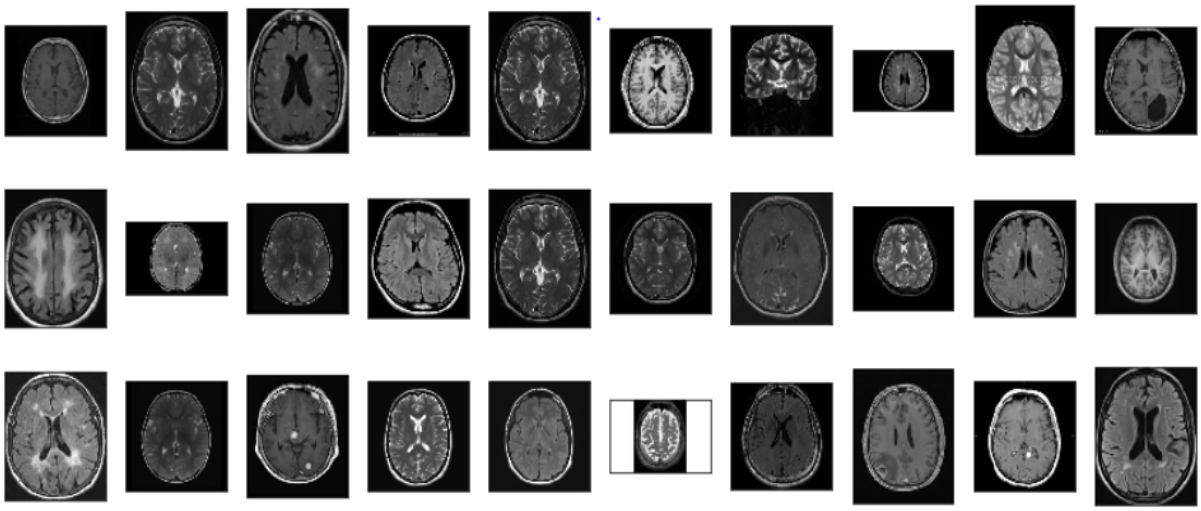
Following image contains information about the details of each and every layer which we have used for our training purposes.

1) In order to feed images to VGG16, they were converted into 224x224 image sizes.
2) The output of VGG16 was of shape 7x7x512. This reduces computational complexity and only extracts important features.
3) After that, this 3 dimensional output was flattened and fed into a neural network.
4) We have used a dropout in our neural network inorder to avoid overfitting and help the network train better.
5) The last layer is a dense layer which predicts whether the person is suffering from a disease or not.
6) The output is a binary output, that is either 0 or 1.

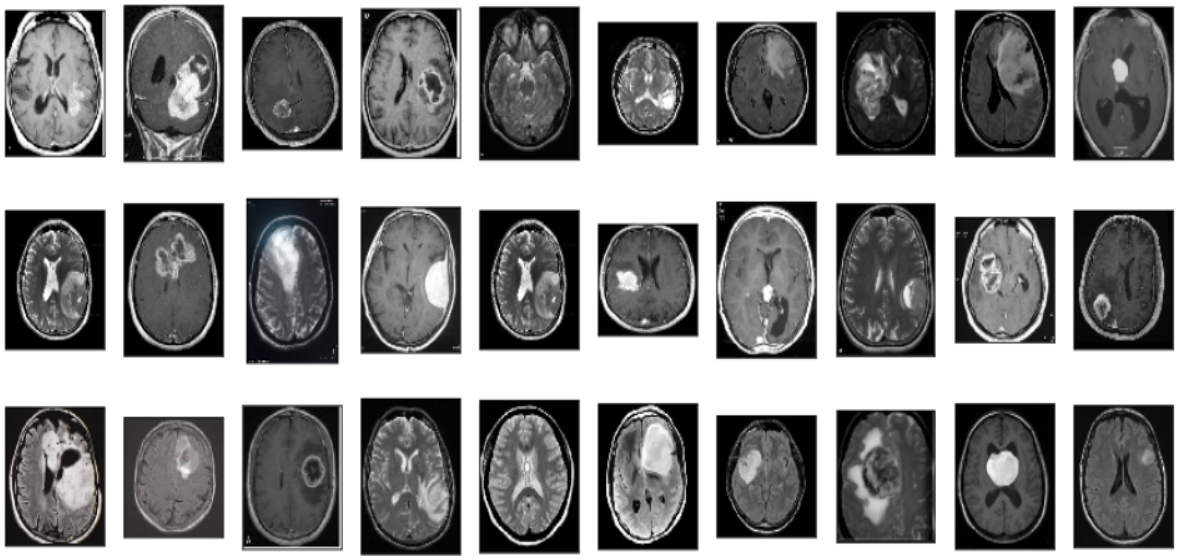
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Model)                (None, 7, 7, 512)         14714688
_________________________________________________________________
flatten_1 (Flatten)          (None, 25088)             0
_________________________________________________________________
dropout_1 (Dropout)          (None, 25088)             0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 25089
=================================================================
Total params: 14,739,777
Trainable params: 25,089
Non-trainable params: 14,714,688
_________________________________________________________________
```

4. Experimental Analysis or Results

Below are some snapshots of our dataset images which we have used for our training purposes. Following images do not have brain tumor:



Following images have Brain Tumor:



Below bar graph shows the amount of images we have taken for training, testing and validating the images for our implementation purposes.

As you can clearly see, the ratio of height and width are different for many images.

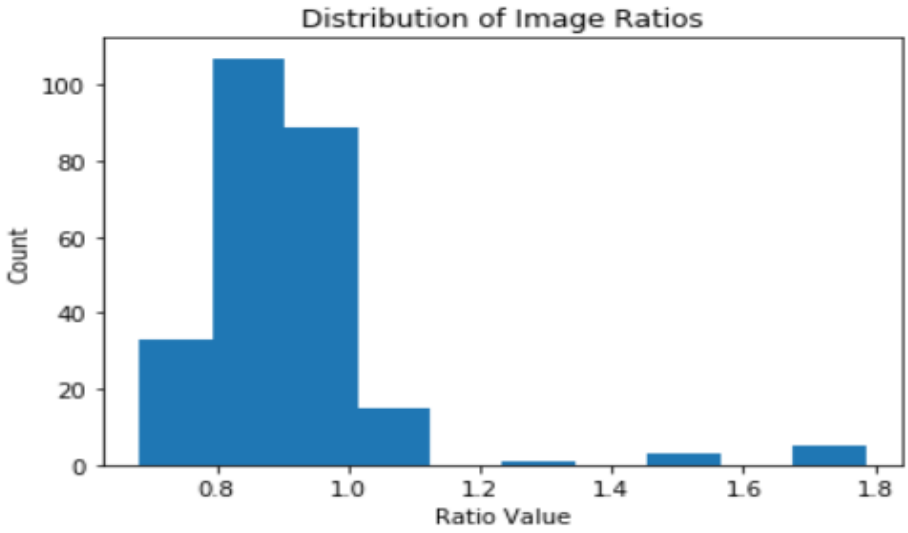
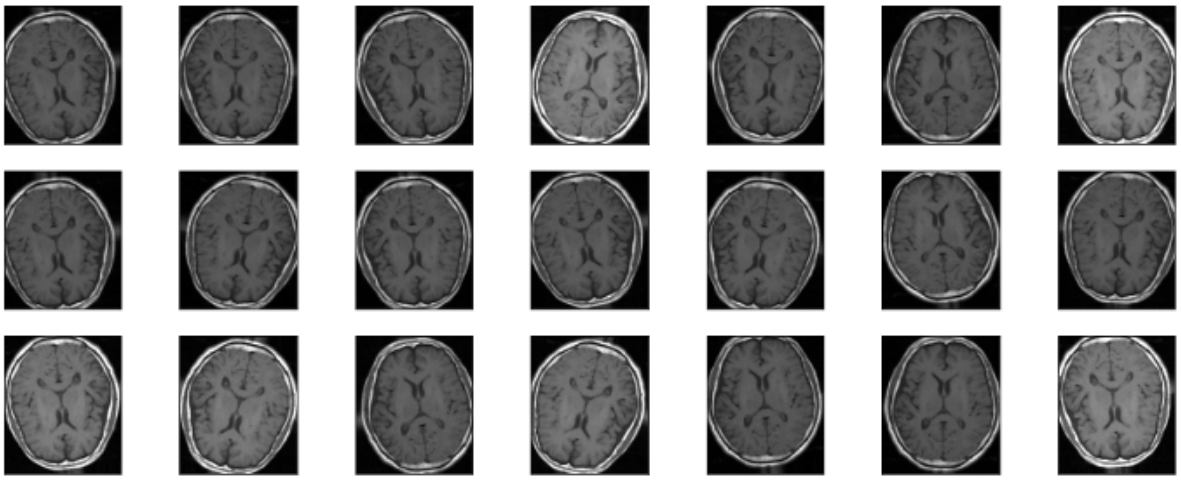
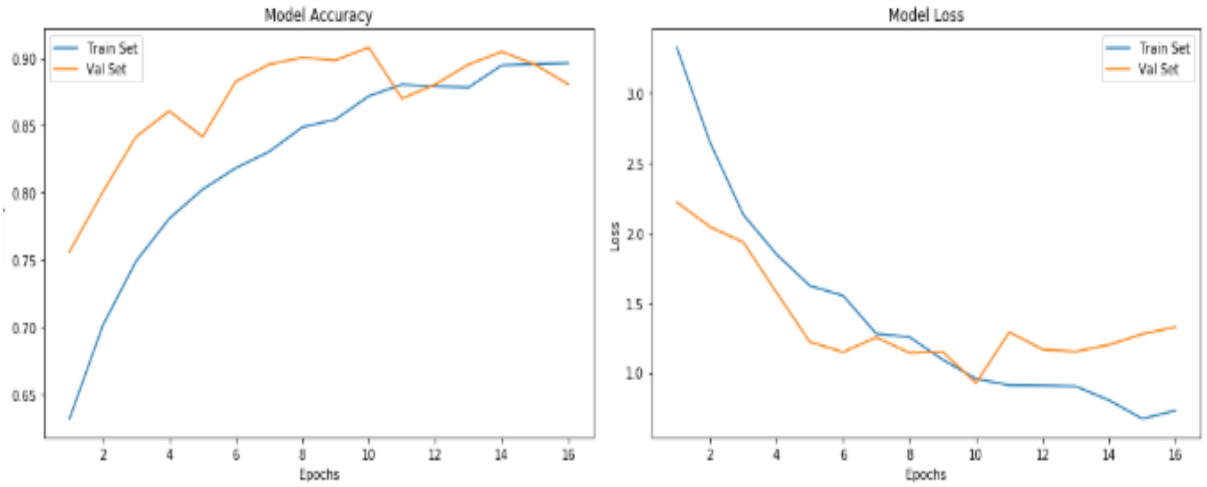


Fig __ : Ratio of images where ratio=height/width

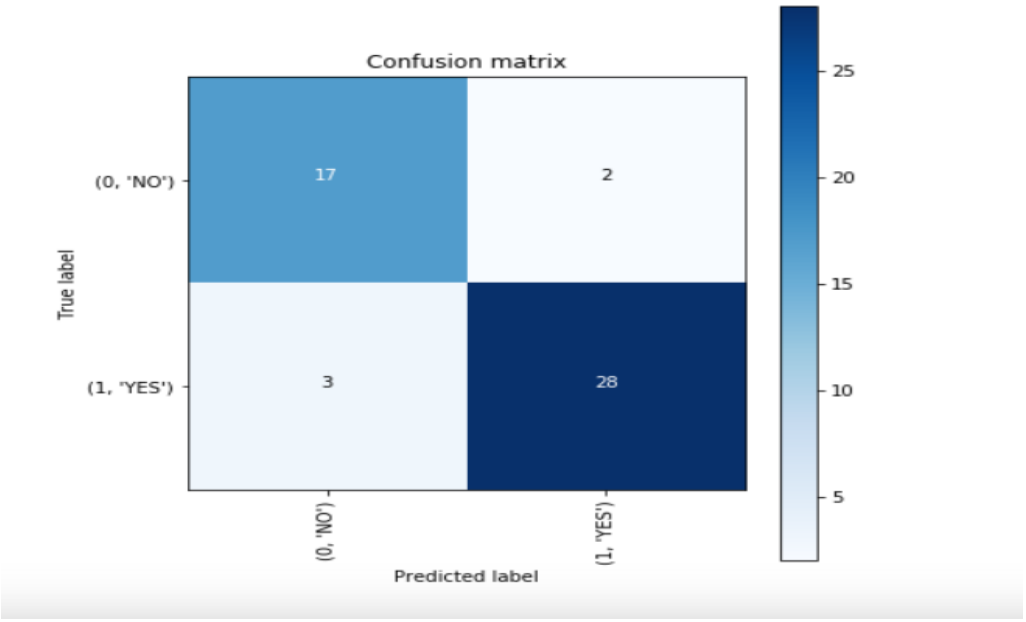
Since we had a small data set, we have used the technique of data augmentation which helps to increase the size of the training set. Below images are made from a single image using image augmentation techniques.



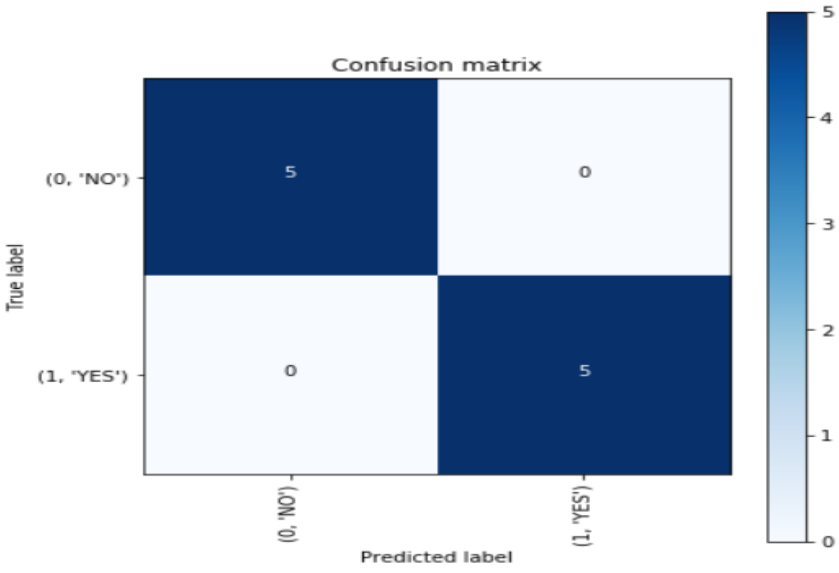
The model was trained using the RMSprop optimizer. Our validation accuracy was approximately 90%.



Below image shows the confusion matrix for the validation images.



Below image shows the confusion matrix for the testing images. We can clearly see that their are no misclassified images.



5. Conclusion and Future Scope

Our model was able to differentiate between tumor and non tumor images very well with the help of genetic algorithms and VGG16 together. We were able to get 90% accuracy approximately on the validation dataset and 100% accuracy on the testing dataset. But it must be considered that we took only 10 images for testing. Hence, our project was a combination of CNN model classification problem and Computer Vision problem.

However, our results can be a bit biased since we have taken only a small amount of images for training purposes. For real results, thousands of images must be taken for training purposes. We were not able to do so due to computational limitations. Hence, more work must be done in this area and genetic algorithms must be used with different machine learning algorithms for determining better results. And more images must be used up for training.

6. Contribution or Novelty of work

Contributions made by us in this research are as follows:

1) The field of genetic algorithms has been gaining popularity widely in recent times and have been used in machine learning algorithms. However, not much research has been down in using genetic algorithms for medical field purposes. Hence, our purpose is to use genetic algorithms with neural networks in order to come up with a robust deep learning model which can be used for detection of tumors in the brain using the MRI images.
2) Our work has provided much better results in comparison to works done by other researchers. Our model was trained on nearly 200 images and it could be made more robust with more number of images for training. We could not use large datasets due to computational limitations.
3) Extensive study of genetic algorithms has been done to make an attempt to come up with a more optimized algorithm which can help in the detection of tumor in human brains.

7. Key References

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