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Brain Tumour Detection Using Deep Learning

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ABSTRACT: The motivation behind this study is to detect brain tumour and provide better treatment for the sufferings. The abnormal growths of cells in the brain are called tumours and cancer is a term used to represent malignant tumours. Usually CT or MRI scans are used for the detection of cancer regions in the brain. Positron Emission Tomography, Cerebral Arteriogram, Lumbar Puncture, Molecular testing are also used for brain tumour detection. In this study, MRI scan images are taken to analyse the disease condition. Objective this research works are i) identify the abnormal image ii) segment tumour region. Density of the tumour can be estimated from the segmented mask and it will help in therapy. Deep learning technique is employed to detect abnormality from MRI images. Multi level thresholding is applied to segment the tumour region. Number of malignant pixels gives the density of the affected region.

Index Terms: Medical Image Processing, Brain tumour, MRI, Artificial neural network, CNN, , Keras

I. INTRODUCTION

The early detection and treatment of brain tumour helps in early diagnosis which aids in reducing mortality rate. Image processing has been widespread in recent years and it has been an inevitable part in the medical field also. The abnormal growth of cells in the brain causes brain tumour. Brain tumour is also referred to as intracranial neoplasm. The two types of tumours are malignant and benign tumours. Standard MRI sequences are generally used to differentiate between different types of brain tumours based on visual qualities and contrast texture analysis of the soft tissue. More than 120 classes of brain tumours are known to be classified in four levels according to the level malignancy by the World Health Organization (WHO) [1].

All types of brain tumours evoke some symptoms based on the affected region of the brain. The major symptoms may include headaches, seizures, vision problems, vomiting, mental changes, memory lapses, balance losing etc [2]. Incidence of brain tumours are due to genetics, ionizing radiation mobile phones, extremely low frequency magnetic fields, chemicals, head trauma and injury, immune factors like viruses, allergies, infections, etc[3]. The malignant tumours, also known as cancerous tumours, are of two types - primary tumours, which start from the brain, and secondary tumours, which originate somewhere and spread to the brain. The risk factors for brain tumour are exposure to vinyl chloride, neurofibromatosis, ionising radiations and so on. The various diagnostic methods are computed tomography, magnetic resonance imaging, tissue biopsy etc.

Better treatments are now available for brain tumours. There is a chance of focal neurological deficits, such as motor deficit, aphasia or visual field defects in the treatment. Side effects can be avoided by measuring tumour size and time to tumour progression (TTP)[4] . Estimation of density of affected areas can give a better measurement in therapy.

Deep learning is a machine learning technique that instructs computers what to do as a human think and do in a scenario. In deep learning, a computer model is able to do classification tasks from images, sound or text. Sometimes human level performance is being exceeded by deep learning techniques. One of the most popular neural networks is an artificial neural network that has a collection of simulated neurons. Each neuron acts as a node and by links each node is connected to other nodes[5].

The aim of this paper is to build a system that would help in cancer detection from MRI images through the convolution neural network. The proposed method was tested and compared with the existing classification techniques to determine the accuracy of the proposed method.

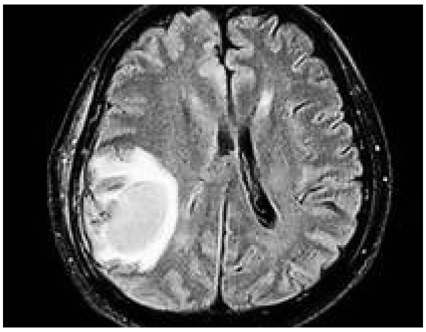


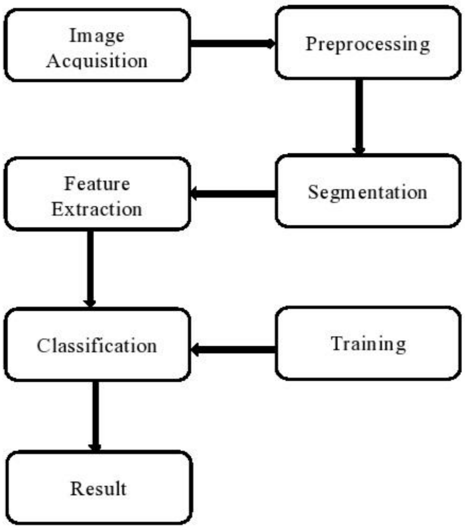
Figure 1: MRI image

II. RELATED WORKS

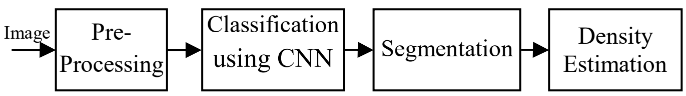
Image segmentation and classification is one of the major tasks in machine learning and it is widespread in clinical diagnosis also. Mircea Gurbin, Mihaela Lascu, and Dan Lascu et al. [6] proposed a method consisting of Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT) and Support Vector Machine (SVM).

It uses different levels of wavelets, and by training, the cancerous and non-cancerous tumours can be identified. The computation time is longer for the proposed method.

Somasundaram S. and Gobinath R. et al. [7] explains the present status of detection and segmentation of tumour through deep learning models. For deeper segmentation, 3D based CNN, ANN and SVM is used. Damodharan S. and Raghavan D. et al.[8] address segmentation of pathological tissues (Tumor), normal tissues (White Matter (WM) and Gray Matter (GM)) and fluid (Cerebrospinal Fluid (CSF)), extraction of the relevant features from each segmented tissues and classification of the tumor images with Neural Network (NN).



(a)



(b)

Figure 2 : System architecture of brain tumour detection (a) Conventional Method (b) Deep learning

G. Hemanth, M. Janardhan and L. Sujihelen et al.[9] states that with the appropriate use of data mining classification technique early detection of tumour is made possible. It uses an automatic segmentation method based on CNN. Reema Mathew A. and Dr. Babu Anto P. et al. [10] stated that by the segmentation of MRI tumour region can be identified. With the help of radiological evaluations, the size and location of tumours can be identified. Here the segmentation is done manually and it is time consuming. The pre processing is done using anisotropic diffusion filters. The segmentation and classification is done using support vector machines. Wei Chen, Xu Qiao, Boqiang Liu, Xianying Qi, Rui Wang and Xiaoya Wang et al. [11] propose a novel method based on the features of separated local squares. Super pixel segmentation, feature extraction and segmentation model construction are done on this proposed method for brain tumour segmentation.

III. PROPOSED METHOD

System architecture of the proposed system is shown in figure 1. The components are image acquisition, pre-processing, segmentation, feature extraction and classification.

A. Image Acquisition

Different bio-medical image records are available for the study of brain tumour detection. Conventional methods are Computer Tomography (CT) and Magnetic Resonance Imaging (MRI). Positron Emission Tomography, Cerebral Arteriogram, Lumbar Puncture, Molecular testing are also used for brain tumour detection. But these are expensive. MRI is working with the principle that both the magnetic field and radio waves can create an image of the interior of the human body by detecting the water molecule present. Portable and miniaturised MRI machines are developed now to avoid the complexity of conventional scanning methods. MRI has a better resolution and contains rich information. The MRI dataset from the kaggle uploaded by Navoneel Chakrabarty has been used here[12].It contains 98 normal brain images and 155 abnormal images. In this dataset, ‘yes’ means tumour images and ‘no’ means healthy images. The augmentation process is also applied here to increase the number of samples. Augmentation step contains a rotation range of 10 degrees, width shift range of 0.1, height shift range of 0.1, brightness range of (0.3,1.0), horizontal and vertical flip. A total of 2530 images were selected from the augmented data. The final dataset contains 980 normal and 1550 abnormal images.

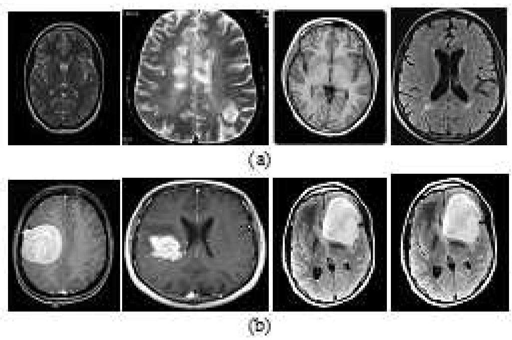


Figure 3 : Brain MRI dataset (a) Normal (b) Tumour

B. Pre processing

The aim of the pre-processing step is preparing the brain images for further processing [13].This process mainly depends on the data acquisition device which has its own intrinsic parameters. Gray scale or 2D conversion is needed, if the raw data is in 3D. Median filtering is best suited for biomedical images to avoid noise. The dataset contains images in different resolutions. As part of the augmentation process , each image is rotated and scaled to a standard format. Histogram equalisation helps to enhance the image quality. Contrast limited adaptive histogram equalisation algorithm is applied to enhance the images.

C. Image Segmentation

In this step a digital image is partitioned into multiple segments. A particular region of the image is being separated from the background This step is very for feature extraction. Thresholding and morphological operations (erosion, dilation, opening) are the simple steps to segment disease. But in the brain tumour images , the segmentation process at this level will not give the details of tumour regions. The healthy images also have a similar intensity that resembles the tumour region. So the segmentation process can be used to separate the skull of the brain. This Region of Interest (ROI) contains the tumour. OTSU based thresholding algorithm gives a segmented mask of the skull[14].

Active contour method draws the boundary of the enclosed region. Second stage of segmentation can also be applied to the ROI to prepare the mask of tumour region. This method may not give good results in healthy images. This segmented image can be used to study the features of tumour region , which will help in the density estimation.

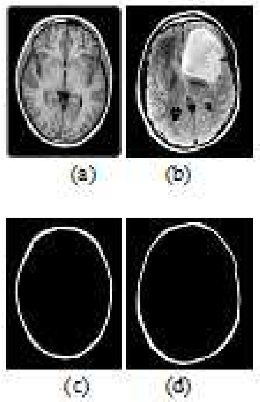


Figure 4 : Skull Segmentation (a) Normal Input image(b) Abnormal Input image (c) Normal Segmented image (d) Abnormal segmented image

D. Feature Extraction

Computing the actual features can be analysed to illustrate the behaviour or symptom of the disease. The classification is mainly influenced with the feature selection. Common features are asymmetry, diameter, and border irregularity[15].

Figure 5 : Segmented tumour region using multiple thresholding

E. Classification

Many machine learning approaches are being implemented in disease detection from brain images. Artificial neural networks can be used here to classify, if the features are extracted in an order[16].An ANN classifier assumes one feature that is not related to any other feature.

Deep learning techniques will be effective here to classify tumour image without segmentation. A deep neural network can be created with Convolutional nueral network algorithm[17]. General architecture of convolutional neural networks is shown in figure 6. In deep learning , the feature is extracted from the entire image automatically. Convolution in the CNN architecture performs this operation. Number of feature maps increases with the increase in CONV layer. Reduction of dimension is required to initiate training. Pooling layer down samples the feature dimension. Fully connected layers manipulate the score of each label. Softmax layers prepare the model with feature and class score.

. The CNN architecture is slightly modified in its dimension for training the brain tumour images. The modified model architecture is listed in table 1.

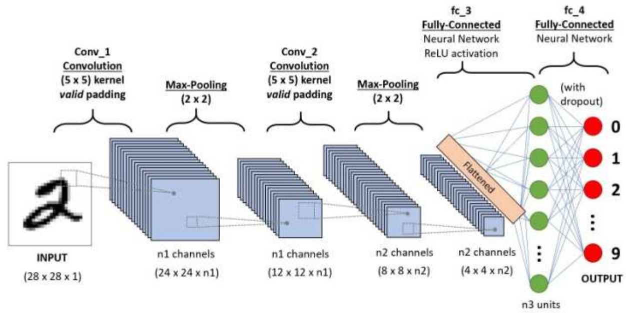


Figure 6 : General architecture of CNN

Model: "BrainTumorDetectionModel"

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	[(None, 240, 240, 3)]	0
zero_padding2d (ZeroPadding2	(None, 244, 244, 3)	0
conv0 (Conv2D)	(None, 238, 238, 32)	4736
bn0 (BatchNormalization)	(None, 238, 238, 32)	128
relu0 (Activation)	(None, 238, 238, 32)	0
max_pool0 (MaxPooling2D)	(None, 59, 59, 32)	0
max_pool1 (MaxPooling2D)	(None, 14, 14, 32)	0
flatten (Flatten)	(None, 6272)	0
fc (Dense)	(None, 1)	6273

Total params: 11,137
Trainable params: 11,073
Non-trainable params: 64

Table 1: Modified Model architecture

The model is compiled in Keras with 'Adam' optimizer and 'Binary cross entropy' loss. Default learning rate of 0.001 is used. The model is trained with batch size of 32 for 24 epochs. For the test images our trained model gives an accuracy of 95.6%.

For those images classified as having brain tumour, the tumour location is detected using a combination of multilevel thresholding, morphological operations and contour extraction.

$$g(x,y) = \begin{cases} 1, & f(x,y) > T \\ 0, & f(x,y) \le T \end{cases} \quad \ldots\ldots (1)$$

Where T is the mean of Maximum to Minimum intensities of the image. Morphological Open function is used to segment the regions. Contours of all regions are plotted and the region with maximum area contains tumour region.

The Density of the tumour area can be estimated using Gaussian kernel distribution.

$$f(x) = \frac{1}{n\sigma\sqrt{2\pi}} \sum_{i=0}^{n} e^{-\frac{1}{2}\left(\frac{x_i - x}{\sigma}\right)^2} \quad \text{.........} (2)$$

IV. RESULTS AND DISCUSSIONS

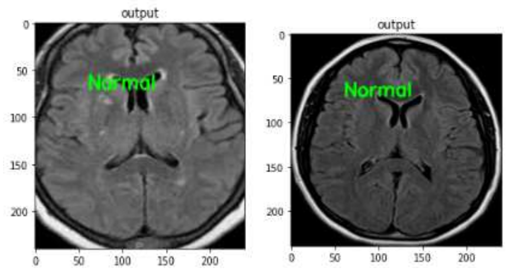
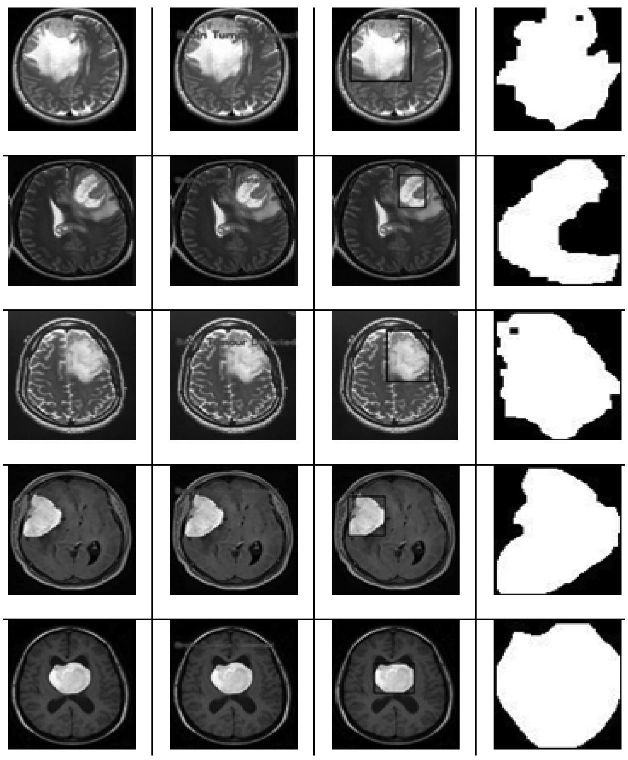


Figure 7 : Normal Images Results



(a) (b) (c) (d)

Figure 8 : Tumour detection results : (a) Input Image (b) Abnormality Detection (c) Tumour region detection (d) tumour mask for density estimation

Objective of the proposed system is to classify malignant brain tumour from the MRI images. 253 MRI images were collected from Kaggle dataset. The count of the data is insufficient for modelling a deep neural network. So 2530 images have been created with augmentation technique. The extracted cropped images are then resized to (240, 240) resolution. Keras (with Tensorflow backend) framework is chosen creating the model. Two types of segmentation at different level are implemented to analyse the performance of the system. Segmentation was done before and after classification. From the performance analysis, segmentation after the classification gives better result.

This algorithm is faster in execution for normal MRI images. If it identifies the abnormal images, it goes to the next step ,ie : segmentation.

ROC curve shows the relation between sensitivity and specificity .

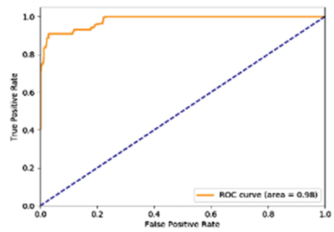


Figure 9 : ROC plot of Normal cases

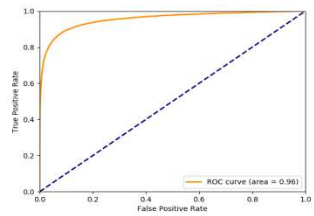


Figure 10 : ROC plot of Abnormal cases

$$Accuracy = \frac{(TP+TN)}{(TP+TN+FP+FN)} = 0.98$$

$$Sensitvity = \frac{TP}{TP+FN} = 0.97$$

$$Specificity = \frac{TN}{TN+FP} = 0.99$$

Table 2: Performance Analysis

Algorithm	**Over all Accuracy**
Nandpuru[18]	96.77%
El-Dahshan[19]	97%
Ibrahim[20]	96.33%
Rajini[21]	90%
Proposed Method	98%

IV. CONCLUSION AND FUTURE SCOPE

This paper provides a new method for detecting brain tumour by deep learning method. The early detection of cancer helps timely and effective treatment. Kaggle dataset contains good quality of MRI images for research purposes. Different segmentation algorithms were experimented. From this , multilevel thresholding and OTSU thresholding are the best methods for the dataset. Convolutional Neural Network with modified approach helped to get a result with accuracy 98%. Density estimation method is also proposed using Gaussian kernel distribution.

This system can be improved to support with a web interface. Detection of different diseases can be also identified from the MRI images. Apart from the density some other parameters can also estimated for therapeutic purposes.

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