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# "A Comprehensive Review of Automatic Brain Tumor Detection using Convolutional Neural Networks (CNNs)"

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***Abstract:*** Medical science has incredibly grown and become Successful in modern years. Technology is altering the world of medicine. The main objective of our project is to detect the brain tumour by using Convolutional Neural Network (CNN). A Convolutional Neural Network is a classification of deep neural networks. CNN is mainly used for Image Processing, by which we will capture the image and compress it. The tumor detection is major challenging task in brain tumor quantitative evaluation. In recent years, owing to non-invasive and strong soft tissue comparison, Magnetic Resonance Imaging (MRI) has gained great interest. MRI is a commonly used image modality technique to locate brain tumors. An immense amount of data is produced by the MRI. The goal of brain tumor segmentation is to generate accurate delineation of brain tumor regions. In recent years, deep learning methods have shown promising performance in solving various computer vision problems, such as image classification, object detection and semantic segmentation. A number of deep learning based methods have been applied to brain tumor segmentation and achieved promising results. Considering the remarkable breakthroughs made by state-of-the-art technologies, we provide this survey with a comprehensive study of recently developed deep learning based brain tumor segmentation techniques. More than 120 scientific papers are selected and discussed in this survey, extensively covering technical aspects such as network architecture design, segmentation under imbalanced conditions, and multi-modality processes. We also provide insightful discussions for future development directions.

***Index Terms: Deep Neural Network, Brain Tumor, Magnetic Resonance Imaging (MRI), Datasets, Filter, CNN***

## I. INTRODUCTION

Medical imaging analysis has been commonly involved in basic medical research and clinical treatment, e.g. computer aided diagnosis, medical robots and image-based applications. Medical image analysis provides useful guidance for medical professionals to understand diseases and investigate clinical challenges in order to improve healthcare quality.

Among various tasks in medical image analysis, brain tumor segmentation has attracted much attention in the research community, which has been continuously studied. Glioma is one of the most primary brain tumors that stems from glial cells. World Health Organization (WHO) reports that glioma can be graded into four different levels based on microscopic images and tumor behaviors. Image segmentation plays an active role in gliomas diagnosis and treatment. For example, an accurate glioma segmentation mask may help surgery planning, postoperative observations and improve the survival rate.

To quantify the outcome of image segmentation, we define the task of brain tumor segmentation as follows: Given an input image from one or multiple image modality (e.g. multiple MRI sequences), the system aims

to automatically segment the tumor area from the normal tissues by classifying each voxel or pixel of the input data into a pre-set tumor region category.

This grading system features 4 distinct grades which help in treatment decisions.

Grade I: In this tumor grows at a slow speed and rarely spreads into nearby tissues hence there is a possibility to completely remove the tumor.
Grade II: Here tumor grows at a steady speed and flourish into nearby tissues.
Grade III: In this tumor develop rapidly, and cells look very dissimilar from normal cells.
Grade IV: Here tumor cells circulate very rapidly, and appear different from normal cells.

## II. Diagnosis of a Brain Tumor

- CT scan – It provides a more detailed scan of our body . It employs a special dye by which contrast is achieved.
- MRI scan – MRI (Magnetic resonance imaging)[2] is different from a CT scan because it does not employ radiation, and give comprehensive pictures of the structures of the brain itself. MRI generates image of the brain in any plane whereas CT scans are limited to one plane.
- Angiography
  It inject dye into artery which allows doctors to see images of blood supply of the tumors.
- Skull X-rays
  It identifies breaks or fractures of the skull due to brain tumor, and specific X-rays can demonstrate if this has occurred.
- Biopsy
  It categorise tumor cells are benign or malignant. Also it determine whether the cancer originated in brain or differ part of body.

## III. Architecture

**How can we implement the problem?**

- Using Traditional Classifiers
- Using Convolution Neural Network based detection

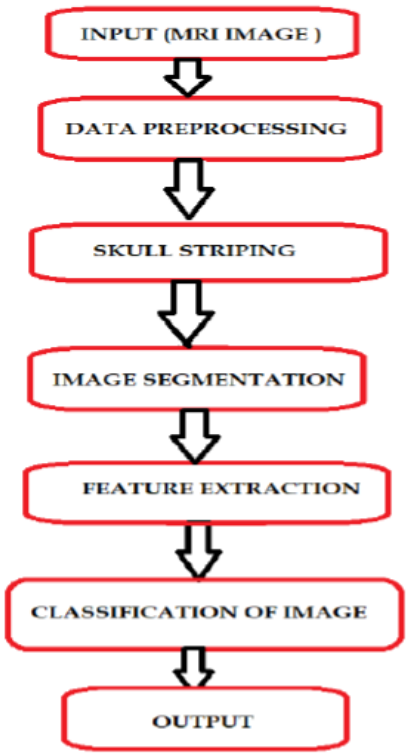


**Fig 1: Flowchart of Brain tumor detection model using traditional classifiers**

## 3.1 Input Images

Tumor detection is performed on MRI scans as shown in Fig 1, which helps to locate tissues, water content and it is safer for patients as it is radiation free. More accuracy is procured by multi view of MRI scan image as shown in Fig 2 in tumor location .For better area detection of tumor instead of multisensory fusion as it is exorbitant multi-planar image fusion of MRI scan is used**.**

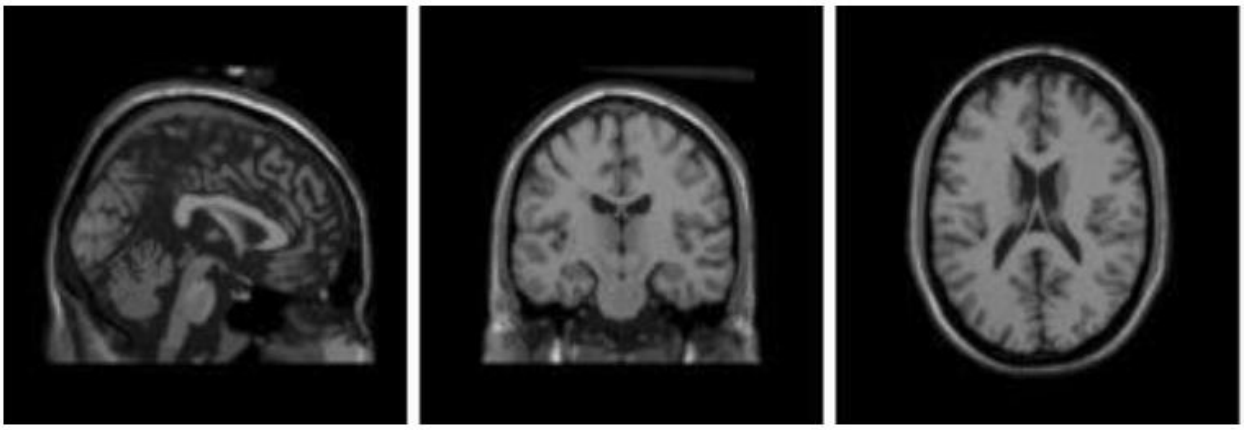


**Fig 2: Multi-planar view of MRI Scan [3]**

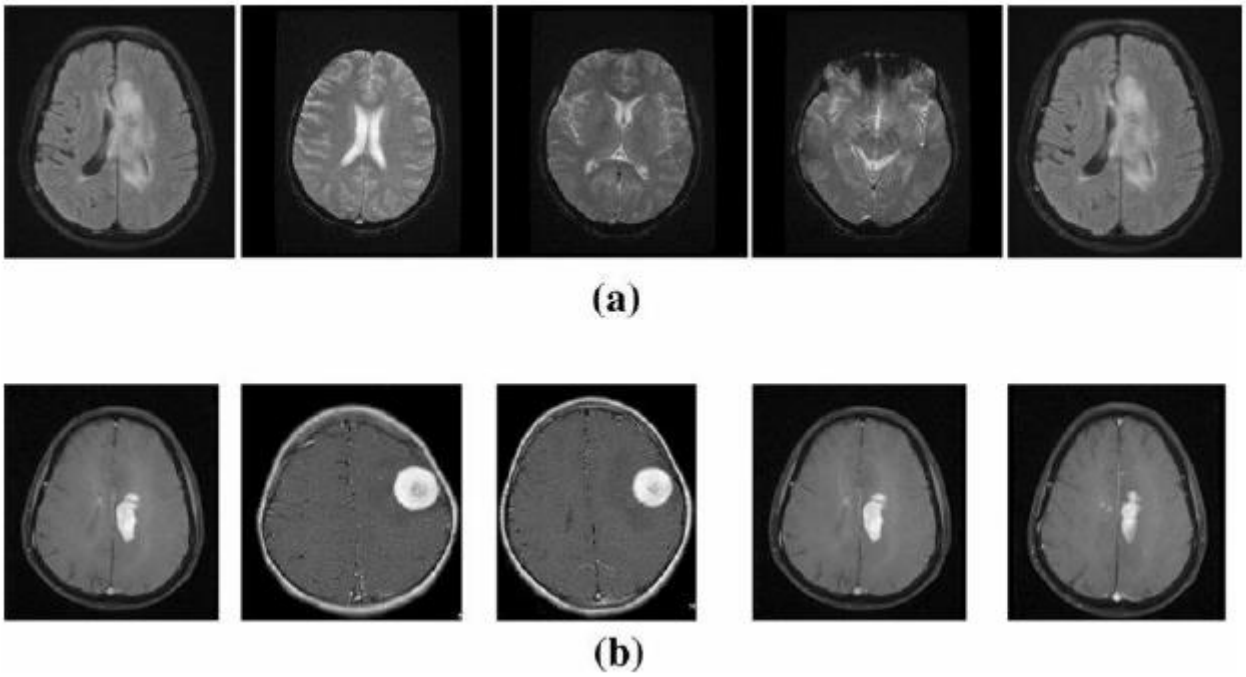


**Fig 3 Brain MRI dataset (a) Normal (b) Tumour [4]**

## 3.2 Data Pre-processing

MRI images is full of noises, in order to obliterate these distortion pre-processing is executed. In preprocessing process noise is eliminated from images. In this process we try to assure that no damage occurs during the noise deletion in the corners, quality & clarity of the image. Various techniques such as are Contour let transform, Gaussian filter, Median filter, Anisotropic Diffusion filter are employed to eradicate noise.

I. Gaussian filter- It is smoothing filters which eradicate noise and blur from image. It mainly extracts Gaussian noise and it reduces edge blurring near the edge by giving higher significance to pixels near the edge. This process is performed by convoluting. Some drawback of this method is that it takes time and also reduces details.

II. Contourlet transform- This two - dimensional transform was proposed by Do and Vetterli in 2002. This transform helps in localization, critical sampling, multi resolution, directionality, and anisotropy. It performs multiscale as well as multidimensional on the images. Limitations includes noise in form of blurring, vague boundaries, contrast between regions is reduced , poor gradients etc.

III. Median Filter- It a non linear filter which is employed for truncating variation of intensity between pixels and by replacing pixel value with median value which is obtained by classifying all the pixel values present in the image in ascending order and then replacing the computed pixel value with the reckoned middle pixel value. It has certain flaws like the effect of a median filter is difficult to tackle analytically and also it destroys details in the image when the impulse noise percentage is more than 0.4%.It is instrumental in preserving sharpness of the image.

IV. Anisotropic Diffusion Filter- It is also called as Persona-Malik diffusion. During smoothening of the image no information is unharmed at the edges.This Filter helps the images remain smoothed in homogeneous region by maintaining edges and too without modifying the anatomy of the image.

## 3.3 Image Segmentation:

It's a method in which digital image is broken down into set of pixels. On the basis of similarity of the regions it separates an image into significant regions. It is employed in copious applications such as investigation of image, detection, recognition & illustration of object, region of interest visualization and many more [8].
In the process of segmentation it actually assigns label to every pixel in an image in such a way that pixels having same label allocate definite characteristics.

It modifies two fundamental properties of image intensity values:

1 Image similarity
2 Image discontinuity

Segmentation can be operated in two ways, 1st pixel intensity in the images are changed ex: edges and corners and in 2nd one the images are categorised into regions.

## 3.4 Image segmentation Techniques

The following techniques for image segmentation are described on the basis of approaches and the type of processing that is needed to be incorporated to attain aim:

I. Threshold Method [9]
In this method the pixels of image is compared with a threshold value and then get divided. i.e Pixels value are assigned 1 if its values are greater than threshold value and 0 if its value is less than threshold value. Finally image is transformed into a binary map which is termed as binarization. This technique is instrumental when the variation in pixel values between the two target classes is very high. Threshold value is denoted by T which is regarded as a constant.

II. Edge Based Segmentation
This process is instrumental in detection of edge pixels in an image. And this technique can be implemented using operators such as Sobel operator, Canny, Laplace operator. Based on various discontinuities in texture, colour, brightness, saturation, grey level this technique helps to detect edges in an image. Edges incorporates meaningful features and carry indispensible messages. By using this process, we try to attain atleast a partial segmentation, in which all the local edges are categorized into a new binary image in which only edge chains emulate the existing objects or image. One of the benefits of this method is that it provides clear contrast between object and background. Some of the drawbacks of this technique is that it's noise immunity is delicate, also it does not operate well on low contrast and smooth transition images.

III. Region Based Segmentation
This technique is based on similarity and homogeneity i.e image is fractionate into numerous components based on similar characteristics to fabricate segments. It uses approaches such as region growing, thresholding, region merging/splitting & clustering in free space.

V. Classifiers/supervised Method

a) Support Vector Machine
It is based on Supervised Learning technique .This technique aids in segregating n-dimensional space into classes. It is mostly applicable in large dimensional spaces. It is also memory efficient as in decision function as it employs subset of training points memory efficient . Estimation of probability is not provided directly, therefore five-fold cross-validation are employed for calculation which is a bit expensive

b) K-Nearest Neighbourhood
It is a type of lazy learning because during the time period of classification it first deposit the dataset and then execute actions on dataset, it does not acquire knowledge from the training set. It is employed for both regression & classification. Initially it accumulates all available data and then on the basis of similarity it classifies into new data. Implementation of this algorithm is easier. Also this algorithm is very much effective for large training data. And also its immunity is high against noisy training data. Drawback include high computational cost.[5]

c) Naïve Bayes Classifier Algorithm
It is based on the principle of Bayes theorem and mostly employed in text classification. It helps in fabricating speedy machine learning models which can give rise to rapid forecasting . It operates on the probability of an object.

VI. Clustering/Unsupervised Method

a) K-Means Clustering
It operates faster for multiple number of variables in dataset. In terms of resolution & interpolation it acts smoothly. It is fast, fathom & trouble free and produce best outcomes for distinct dataset. Non linear sets of data are processed slow and also it lacks dealing with noisy data & outliners. It operates only in presence of mean.

b) Fuzzy C-Means
In this algorithm each data point corresponding to each cluster centre, membership is allocated on the basis of difference between the distance between the centres of cluster and data point . It provides much better result for overlapped data set. One of the disadvantage of this algorithm is that as value of β decreases, better results are obtained but number of iteration increases.

VII. Watershed Transform

It is mostly applied greyscale image [11]. It extracts foreground as well as background and then by applying markers, it will run watershed and distinguish precise boundaries. It is instrumental in recognizing touching & overlapping objects in image.

VIII. Artificial Neural Network Based Segmentation

It contains collection of connected units or nodes where each connection has a weight link with it. Fig 4 shows the architecture of ANN. It was setup to test computational analogous of neurons. On the basis of complexity of function which is to be mapped, hidden layers are present in the model. Augmenting hidden layers helps to fabricate more complex relationship like deep neural network. It is robust to noisy data and is competent to separate untrained patterns. It provide better output for continuous valued inputs & outputs.

## 3.5 Convolutional Neural Network:

Convolutional Neural Network (ConvNet/CNN) [13] as shown in Fig 6 is a deep learning algorithm which is instrumental in distinguishing images from the others by allocating weights to numerous objects in the image by. One of the advantage of this algorithm is pre-processing process required in this is much lower as compared to other classification algorithms. [13] Its architecture is similar to connectivity pattern of neurons and it employs a special technique called Convolution, which is a mathematical operation on two functions that produces a third function that demonstrates how the shape of one is modified by the other.

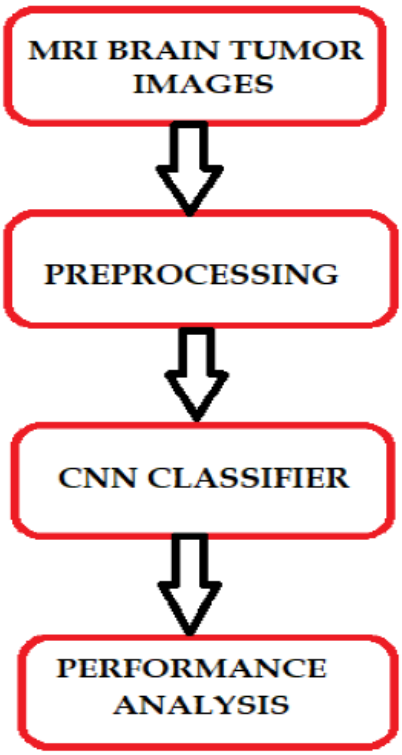


**Fig. 5 Flowchart of General Brain tumor detection using CNN classifiers**

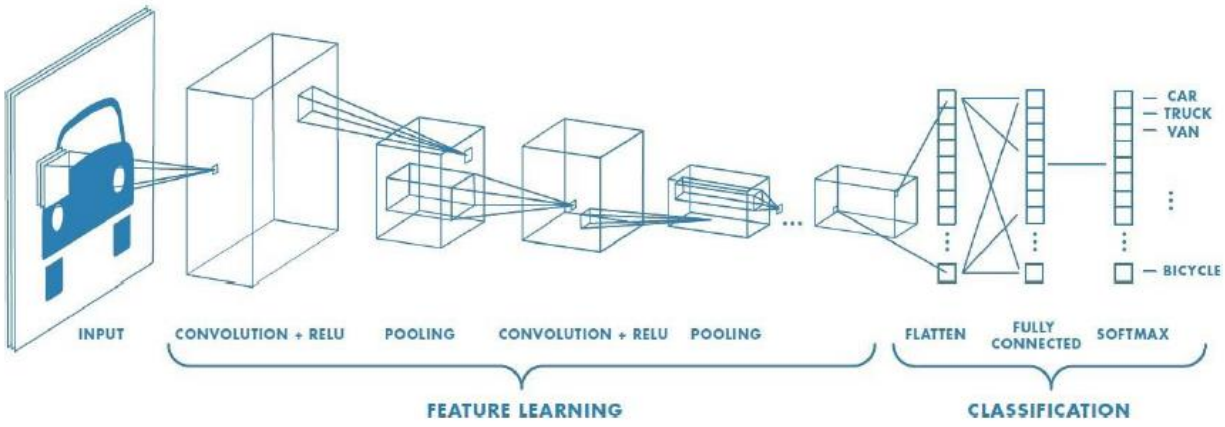


**Fig. 6 CNN ARCHITECTURE [14]**

Various architectures of CNNs includes

1. LeNet
2. ResNet
3. AlexNet
4. VGGNet
5. GoogLeNet
6. ZFNet

## 3.6 Feature Extraction

In the process of feature extraction [15] ,Statistical based features such as Mean, Entropy, Centroid, Standard Deviation, Skewness, Kurtosis and Texture-based features such as Dissimilarity, Homogeneity, Energy, Correlation, ASM are extracted from the segmented MRI Images.

## IV. Comparative overview of various brain tumor detection approaches

Table 1: Literature of Algorithm in Brain Tumor Detection

| Paper Name | Methodology | Inference /Limitations | Dataset |
|---|---|---|---|
| Brain Tumor Detection Using Convolutional Neural Network | skull stripping, filtering and enhancement, segmentation by Fuzzy C Means algorithm | Working with a larger dataset will be more challenging in this aspect, | benchmark dataset |
| Brain Tumor Detection Using Convolutional Neural Network [17] | Here Traditional classifiers, Fuzzy CMeans clustering and CNN are employed | CNN procures the highest accuracy, whereas SVM acquires the highest accuracy among the conventional classifiers. | BRATS dataset |
| Deep Learning Approach for Brain Tumor Detection and Segmentation [18] | CNN model is employed. During segmentation, in Combination of Auto encoders and Kmeans is used. Gaussian blur is employed to curtail noise, and the high pass filter is used for sharpening. | Accuracy of 95.55% accomplished. Here the tumor image is segmented directly with K-means that fabricates a noisy as well as low-grade segmented image. Therefore the combination of Autoencoders along with K-means yields more precise with less noise. | Kaggle |
| Automatic Detection of Brain Tumor Using Deep Learning Algorithms[19] | Detection is carried out by employing CNN architectures such as VggNet, GoogleNet, and ResNet 50 | ResNet 50 attains much better results than GoogleNet & VggNet . | |
| BrainTumor Classification Using Deep Learning[20] | Employed 5 pretrained CNN architectures: Inception, v3,VGG16, Xception, ResNet-50 | Highest accuracy was attained by Xception model with a rate of 98.75% | Kaggle |
| Brain Tumor Detection using Deep Learning and Image Processing[21] | It employed Histogram Equalization, erosion and dilation followed by a convolution neural network | The training model is a combination of CNN with transfer learning. The testing image should be of a good size for better output. | Kaggle |
| Brain Tumor Detection Using Deep Learning [22] | Amplification of the images is carried out by contrast limited adaptive histogram equalization. On dataset, multilevel thresholding, OTSU thresholding, and segmentation algorithms are applied. Segmentation was carried out before and after classification. | Convolutional Neural Network procure higher accuracy results. Performance analysis specifies that, segmentation after the Classification provides better results. | Kaggle |
| Brain tumor detection using CNN, AlexNet & | Remove the area of the image that solely depicts | Can be used for apparent characterization | Brain Tumor Dataset |

| | | | |
|---|---|---|---|
| GoogLeNet ensembling learning approaches | the brain (which is the image's most fundamental piece). Adjust the image's size such that (240, 240, 3) = (picture width, picture height, and the number of channels) is the state: since the dataset's photos arrive in different sizes. | problems, such as recognizable proof of tumor types like Glioma, meningioma, and pituitary or is also acclimated and distinguishes other mind anomalies. | |
| Predictive Modelling of Brain Tumor Detection Using Deep Learning | we have frozen higher layers and trained lower layer using weights of VGG16 architecture. | There is slightly peak is seen in loss during training because of small sample of test dataset which can be adjusted by increasing size of dataset, but as epoch increases the loss decreases and it is in line with validation loss. | |
| Application of deep transfer learning for automating brain abnormality classification in MRI images. | Accuracy on 613 images is 100% | pre-trained CNN ResNet34 | Dataset available Harvard Research Medical School website |
| Brain Tumor Detection using Convolutional Neural Network | Automatic tumor detection of MR images involves inserting the element and separating it using a machine learning algorithm. | Not provide a basic decision on diagnosis, accurate tumor testing, and treatment | |
| CNN Based Multiclass Brain Tumor Detection Using Medical Imaging | CNN model compromises of 6 layers with weight, four convolution layers, 1 fully connected, and one output layer or classification layer. It also has six BN, activation (ReLU), three dropouts, one flatten, and one max-pooling layers in addition to these. | We can classify the data into more class labels with the higher accuracy. | |
| Brain Tumor Detection By Using CNN And VGG-16 | In this VGG-16 the image will undergoes all this steps and later the image will go to classification, in classification the image is classified into Tumor type and NonTumor type. | The model cannot be developed for commercial purposes along with providing more features and privileges for the user. | |

## I. CONCLUSION:

In the review paper, fully automatic numerous segmentation methods are discussed to detect tumors in MRI images. At first, pre-processing is put into effect in which multiple input images are passed through various filters for the removal of noise. In feature based we have study about image processing techniques likes image pre-processing, image segmentation, features extraction, classification. Also, in the above table benefits and drawbacks of used segmentation methods are discussed, which will be convenient and fruitful for radiologists and medical students. Thus this review is act as a bridge to make advancement of the segmentation process for tumor. We have learned so many things and gained a lot of knowledge about development field.

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