Automatic Brain Tumor Detection: A Review

Mohit Srivastava, Manjeet Singh

ECE, NIT Jalandhar

Corresponding author: Mohit Srivastava, Email: mohits.ec.20@nitj.ac.in

Brain tumor is a deadly disease and its detection and diagnosis is a primary concern. Human-assisted manual classification result in inaccurate prediction and identification can result from hence we employ computer-aided technology to aid with diagnosis accuracy. Numerous challenges like: its position in the brain, tumor type, abnormality of cells, image segmentation, etc. are needed for its cure. After segmentation of MRI images, on the basis of variation found in tumor tissue characteristics, the tumor is mainly divided into 2 categories i.e. malignant and benign. Numerous reviews on Brain Tumor segmentation is presented to simplify and help the researchers working in this field. This research also accentuates the advantage and drawbacks of earlier proposed classification techniques. Different types of tumors, their stages, and numerous technique carried out in detection of brain tumor using neural networks are also discussed. Diverse methods and the methodologies presented in this analysis will be advantageous for scholars researching in this domain.

Keywords: - Brain tumor, MRI, Datasets, Deep Learning, Filter, Segmentation, ML, CNN.

2023. In Saroj Hiranwal & Garima Mathur (eds.), *Artificial Intelligence and Communication Technologies*, 319–329. Computing & Intelligent Systems, SCRS, India. https://doi.org/10.52458/978-81-955020-5-9-32

1 Introduction

Brain tumor refers to cells proliferation in the brain in an uncontrollable manner**.** It is mainly classified into two category; cancerous (malignant) or noncancerous (benign). Benign brain tumors expand steadily and can be extracted, and hardly diffuse to the brain tissue but Malignant brain tumors rarely spread beyond our brain or spinal cord[1]. Cancerous tumors can be grouped into primary and secondary brain tumors.

Primary brain tumor initiate in the brain and flourish from brain cells, nerve cells, glands. It is categorised as benign and cancerous whereas Secondary brain tumor start somewhere else in our body and travel to the brain. It begin in one part of the body and disseminate to the brain. It is always malignant. Benign tumors don't proliferate from one part of body to another. Usually brain cancer is graded rather than staged. A grade describes the appearance of cancer cells and tissue .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.

2 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.

3 Architecture

How can we implement the problem?

- Using Traditional Classifiers

- Using Convolution Neural Network based detection

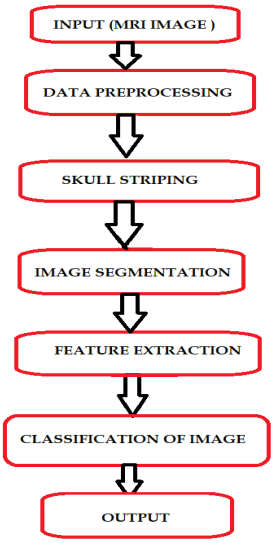
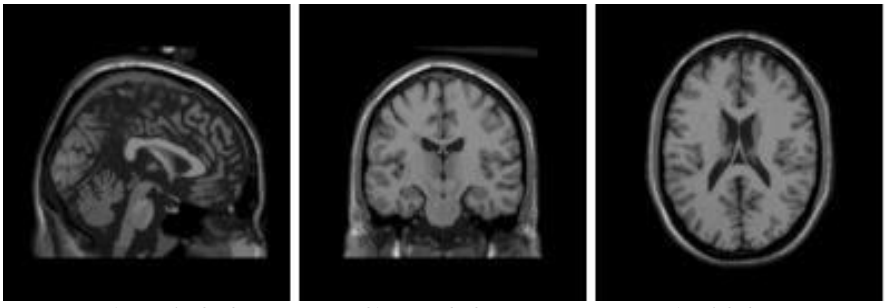


Fig 1: Flowchart of Brain tumor detection model using traditional classifiers

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.



a) Sagittal plane b) Coronal plane c) Axial plane

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

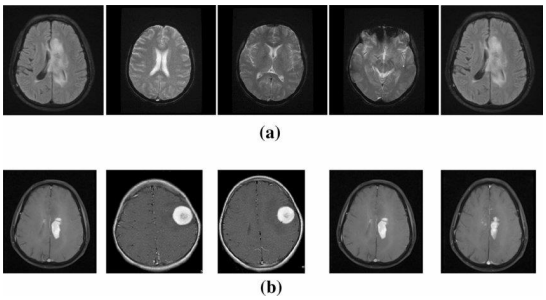


Fig 3 Brain MRI dataset (a) Normal (b) Tumour [4]

3.2 Data Pre-processing

MRI images is full of noises, in order to obliterate these distortion pre-processing is executed. In pre-processing 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 filter 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.

3.4 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. In medical field, as most of the medical images are badly affected by noise, or diffusive boundaries it plays a pivotal role in clinical diagnosis. 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 .

3.5 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 a 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.

IV. 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.

V. 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.

VI. 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.

VII. Artificial Neural Network Based Segmentation

It contain 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.

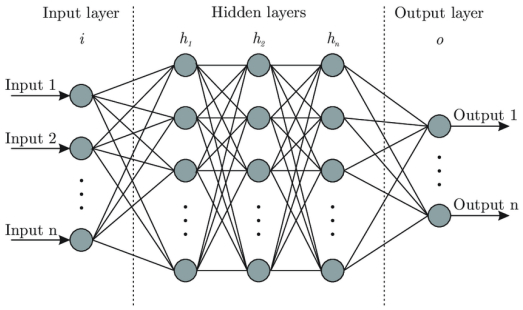


Fig.4 ANN Architecture [12]

3.6 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.

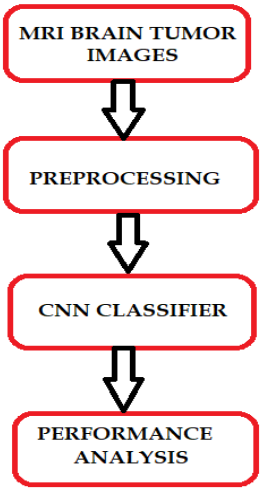


Fig. 5 Flowchart of General Brain tumor detection using CNN classifiers

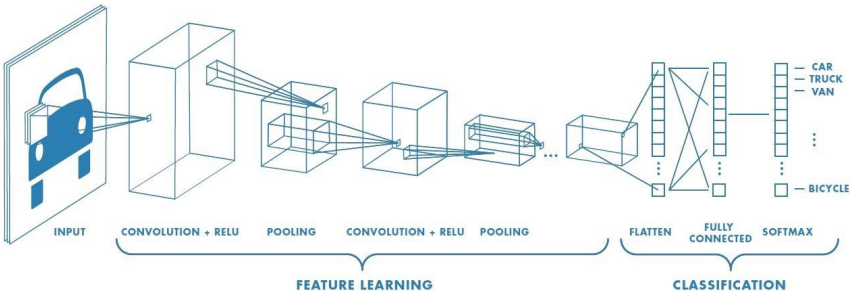


Fig. 6 CNN ARCHITECTURE [14]

Various architectures of CNNs includes

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

3.7 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 Optimised Algorithm in Brain Tumor Detection

Paper Name	**Methodology**	**Inference /Limitations**	**Dataset**
Classificatin of Brain Tumors by Machine Learning Algorithms [16]	LDA(linear discriminant analysis), KNN (k nearest neighbor), SVM(support vector machines) and	90% accuracy rate was acquired by SVM. By considering a notable data set and deducting density-	Rembrandt

	RF(random forest) are employed here for testing data's.	based properties and texture-based properties, accuracy can be ameliorated.	
Brain Tumor Detection Using Convolutional Neural Network [17]	Here Traditional classifiers, Fuzzy C-Means 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 Autoencoders and K-means 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 yield 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 pre-trained 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 Tumour 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 provide better results.	Kaggle

4 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. Once the pre-processing process is completed, the filtered image is segmented into the tumor, white matter (WM), grey matter (GM), and edema regions. Research is carried out on the extracted feature, and in conclusion, using various Machine learning approaches, these extracted features can be further classified as tumor and non-tumor. 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 will act as a bridge to make advancements in the segmentation process for precise diagnosis.

References

[1] H. E. M. Abdalla and M. Y. Esmail, "Brain Tumor Detection by using Artificial Neural Network," 2018 International Conference on Computer, Control, Electrical, and Electronics Engineering (ICCCEEE), 2018, pp. 1-6, doi: 10.1109/ICCCEEE.2018.8515763.
[2] E. Babu, A. Subhash, D. Rajan, F. Jacob and P. A. Kumar, "A Survey on Methods for Brain Tumor Detection," 2018 Conference on Emerging Devices and Smart Systems (ICEDSS), 2018, pp. 213-216, doi: 10.1109/ICEDSS.2018.8544353.
[3] G. Yogalakshmi and B. S. Rani, "A Review on the Techniques of Brain Tumor: Segmentation, Feature Extraction And Classification," 2020 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2020, pp. 1-6, doi: 10.1109/ICCCNT49239.2020.9225472.
[4] https://images.app.goo.gl/6rkV31qvm1iXE1d7A
[5] V. Sravya and S. Malathi, "Survey on Brain Tumor Detection using Machine Learning and Deep Learning," 2021 International Conference on Computer Communication and Informatics (ICCCI), 2021, pp. 1-3, doi: 10.1109/ICCCI50826.2021.9457019.
[6] E. Babu, A. Subhash, D. Rajan, F. Jacob and P. A. Kumar, "A Survey on Methods for Brain Tumor Detection," 2018 Conference on Emerging Devices and Smart Systems (ICEDSS), 2018, pp. 213-216, doi: 10.1109/ICEDSS.2018.8544353.
[7] https://images.app.goo.gl/CYA6Mv2pavXoaenB9
[8] N. Kumari and S. Saxena, "Review of Brain Tumor Segmentation and Classification," 2018 International Conference on Current Trends towards Converging Technologies (ICCTCT), 2018, pp. 1-6, doi: 10.1109/ICCTCT.2018.8551004.
[9] G. Sethuram Rao and D. Vydeki, "Brain Tumor Detection Approaches: A Review," 2018 International Conference

on Smart Systems and Inventive Technology (ICSSIT), 2018, pp. 479-488, doi: 10.1109/ICSSIT.2018.8748692.
[10] V. Sravya and S. Malathi, "Survey on Brain Tumor Detection using Machine Learning and Deep Learning," 2021 International Conference on Computer Communication and Informatics (ICCCI), 2021, pp. 1-3, doi: 10.1109/ICCCI50826.2021.9457019.
[11] S. P. Archa and C. S. Kumar, "Segmentation of Brain Tumor in MRI Images Using CNN with Edge Detection," 2018 International Conference on Emerging Trends and Innovations In Engineering And Technological Research (ICETIETR), 2018, pp. 1-4, doi: 10.1109/ICETIETR.2018.8529081.
[12] https://images.app.goo.gl/MzxeFsXG4bfYBid16
[13] S. T. Kebir and S. Mekaoui, "An Efficient Methodology of Brain Abnormalities Detection using CNN Deep Learning Network," 2018 International Conference on Applied Smart Systems (ICASS), 2018, pp. 1-5, doi: 10.1109/ICASS.2018.8652054.
[14] https://images.app.goo.gl/P3z3VtMqRStM5ZZD7
[15] [15] Shobana G and R. Balakrishnan, "Brain tumor diagnosis from MRI feature analysis - A comparative study," 2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), 2015, pp. 1-4, doi: 10.1109/ICIIECS.2015.7193137.
[16] G. Çınarer and B. G. Emiroğlu, "Classificatin of Brain Tumors by Machine Learning Algorithms," 2019 3rd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), 2019, pp. 1-4, doi: 10.1109/ISMSIT.2019.8932878.
[17] T. Hossain, F. S. Shishir, M. Ashraf, M. A. Al Nasim and F. Muhammad Shah, "Brain Tumor Detection Using Convolutional Neural Network," 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT), 2019, pp. 1-6, doi: 10.1109/ICASERT.2019.8934561.
[18] G. Raut, A. Raut, J. Bhagade, J. Bhagade and S. Gavhane, "Deep Learning Approach for Brain Tumor Detection and Segmentation," 2020 International Conference on Convergence to Digital World - Quo Vadis (ICCDW), 2020, pp. 1-5, doi: 10.1109/ICCDW45521.2020.9318681.
[19] R. Sangeetha, A. Mohanarathinam, G. Aravindh, S. Jayachitra and M. Bhuvaneswari, "Automatic Detection of Brain Tumor Using Deep Learning Algorithms," 2020 4th International Conference on Electronics, Communication and Aerospace Technology (ICECA), 2020, pp. 1-4, doi: 10.1109/ICECA49313.2020.9297536.
[20] Saleh, R. Sukaik and S. S. Abu-Naser, "Brain Tumor Classification Using Deep Learning," 2020 International Conference on Assistive and Rehabilitation Technologies (iCareTech), 2020, pp. 131-136, doi: 10.1109/iCareTech49914.2020.00032.
[21] S. Methil, "Brain Tumor Detection using Deep Learning and Image Processing," 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2021, pp. 100-108, doi: 10.1109/ICAIS50930.2021.9395823.
[22] Sinha, A. R P, M. Suresh, N. Mohan R, A. D and A. G. Singerji, "Brain Tumour Detection Using Deep Learning," 2021 Seventh International conference on Bio Signals, Images, and Instrumentation (ICBSII), 2021, pp. 1-5, doi: 10.1109/ICBSII51839.2021.9445185.