A Review on Brain MRI Based Image Segmentation Techniques

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***Abstract*— In Medical Imaging, Image Segmentation plays crucial role to extract the useful information from brain region MRI. And it is Segmenting brain image into Multiple Segments to identify organs, tumors, anatomical structure and helps doctor to do correct diagnosis and planning treatment of brain issue. I have reviewed multiple published paper related to brain region MRI, Where I have seen issue of noise interference, cell counting, image tissues etc. In this review paper, we will be discussing image segmentation techniques Such as Support vector machine, Machine learning, Deep Learning, Region-Growing Combined with Level Set, Convolutional Neural Network. So that Noise will be reduced and Image Quality will be improved of Brain Region MRI.**

***Keywords*— *Support Vector Machine, Deep Learning, Machine Learing, Image Binarization, Deep Convolutional Network, Hierarchical Feature Network, U-Nets* .**

I. INTRODUCTION

Object Segmentation performs more complex task in computer Vision techniques. It is partitioning Brain MRI image into multiple region or segment to find our analysis. And it is easier to identify and analyze objects or boundaries within an image. Generally, Image contains group of pixels which is depends on characteristics such as color, intensity, texture. Specific Segment and Object indicating with assigned label to each Pixels. Highlighting of different segments as mask or overlay is indicating to resulted output of segmented image.

There are several image segmentation techniques used for brain MRI such as Traditional based image segmentation & Deep Learning based segmentation. These methods are more efficient for image processing, mathematical operation.

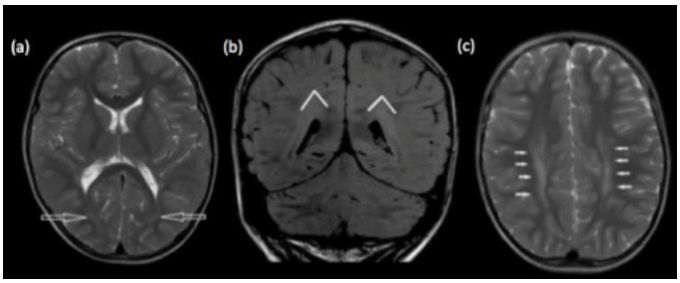

Fig. 1 Input Image of Brain MRI

In Image Segmentation, CNN and low contour method are using local mean fitter & non local mean filter for denoising the brain image and compute weighted normal of pixels [2, 20].

To identifying & detecting the abnormalities in healthcare industry is very complicated task for brain region tumor. So here we have used powerful techniques such as support vector machine and feature extraction, these techniques are categorized malignant, and recurrent brain tumors to effectively detected tumor sections. And as well as enhanced region-oriented segmentation to localize abnormalities in brain tumor MRI [3].

By using manual & automatic segmentation techniques is not useful for detecting the brain tumor in medical imaging. Because its time consuming and require lots of knowledge. So, another prosed technique is used for image segmentation such as Area Expansion & Intensity thresholding technique. And it is applying in first stage of MRI. So that we can get brain tumor extraction accurately. If any discrepancy available in MRI. So region based techniques is not useful so that time we use hybrid approach based threshold techniques to provide accurate result with improve image quality [11,12,14].

Detection and segmentation of brain region MRI are tough phase in medical science. Where we found more variation with size, shape, location of brain images. To find correct diagnosis over Brain image, we used deep learning method to classify and segmented the image in different class label with image pixel. And use morphological operation for features extraction. So that we can get image in normal and abnormal shape, time,

Nowadays the occurrence of diseases is increased but proper solution didn't get successfully after diagnosis the X-ray, CT scan, MRI etc. proposed approach is used for Brain image such as U Net architectures and Feature Pyramid Network (FPN). Collection of images is trained and validated from TCGA-LGG dataset and comparing the dice coefficient. Then we have got expected result of brain MRI Image [18].

II. RELATED WORK

Basically, they have more focused on segmentation method of image processing. Discussed multiple methods with its advantage & disadvantage and have done analysis on different work of brain MRI. Therefore, this complete review is helpful for segment the image for sorted out the tissues problem, noise issue in brain image [1].

Ayushi Sharma used active contour model with CNN techniques to detect the brain region segmentation with high quality inner and outer means, so they have successful done the thesis by adding ACM techniques into input image then it is passes through NLMS filter so that noise cancellation should be done in brain region MRI [2,20].

It has used region propagation & Optimal Hyperplane Classifier method for analyzing and detecting malignant tumour types and area accurately with the help of trained dataset. And this method provides superior computation and high image quality on brain region so that they handle difficulties in accurate brain tumor detection and classification efficiently [3].

G. Kavitha, S. Ramakrishnan done experiment on Brain Subcortical Regions. They have used distance regularized Multiphase Level Set & FCM clustering techniques. The observation of FCM with three cluster centers segmented with two & four cluster centers for better comparison, The results are evaluated using similarity metrics, which are determined by comparing the segmented images with the ground truth [4].

The user mainly focused on preprocessing step of segmentation process. To reduces noise level, we use original FCM Clustering algorithm and it's enhanced high pixel quality of image with superior segmentation. The outcomes of mentioned algorithms shown performance metrics such as correctness, Dice Similarity Index, detection rate, F-score etc. which is best suited for image segmentation analysis [5].

In this article they have discussed about classification & Segmentation techniques. And they have included supervised unsupervised and deep learning techniques are used to found abnormalities in Brain MRI. Mentioned table shown advantage & disadvantages for each and every particular technique. So that accuracy is improved of brain region segmentation [7,8,11,13].

With help of Cutting-edge methods and tools discovered the new proposed algorithm and name is "Automated neural tumor delineation algorithm". U-Net-based model is employed to achieve potential enhancements in state-of-the-art techniques, including input processing, parameter initialization, and optimized training strategies. So that it can be handle inherent class imbalance problems [9].

Ivana DespotoviT, Bart Goossens, and Wilfried Philips, in this article they have briefly describe challenge's method or application related to brain MRI. Several methods is used but

result get proper in proper way for brain region segmentation like 2D, 3D [10].

D. Anithadevi1 and K. Peruma, more work done on image segmentation by using three methods such as single seed region growing, binary segmentation and hybrid segmentation. Analysis of segmented image showing high precision, Sensitivity, F-score, G-score. And overall performance of hybris segmentation is better than other two methods [12].

The comparison of well known and gray scale image for segments process after done more study on this they found one suitable method is Otsu's thresholding method. With the help of above method, we have successfully detected the tumor in 2D MR Image [14].

This work is indicated to brain tumor segmentation where Histogram equalization, region-merging technique, surface evolution method are used. Histogram equation is determined for best contrast of MRI and region merging techniques used for labeled the brain tumor region and surface level method used for provide the best shape to brain tumor region from previous stage. At least the output of proposed method gives better results from current segmented tumor regions with high contour [15].

Greeshma K V, they have also more focused on open issue of brain segmentation process where it is given brief introduction of segment method or different model that is used for find the abnormalities automatically cancer diseases [16].

This researcher targeting the medical imaging segmentation problems. traditional segmentation methods are depended on Connectivity Theory or Template-based Techniques in medical imaging. But researcher employ of a Deep Learning-based 3D Segmentation where it is segmenting the brain region task into two part such as 3 & 9 brain regions and identifying the dice score that is better than previous work. Hence researcher proven that with the help of 3D deep learning techniques we can developed medical image segmentation algorithms easily [17].

III. PRAPOSED BRAIN REGION SEGMENTATION TECHNIQUES

This paper covers multiple proposed techniques which is required for image segmentation. There are following here: -

1. Support Vector Machine: -

It is used classification algorithm. Which is resolving the problem of regression and classification. But basically, main focused on classification problem in machine learning.

The goal of the SVM algorithm is to find the optimal hyperplane that best separates the data into different classes. SVM helps to choose extreme points/vector for creating the best hyperplane. This algorithm is referred to as support vector machine.

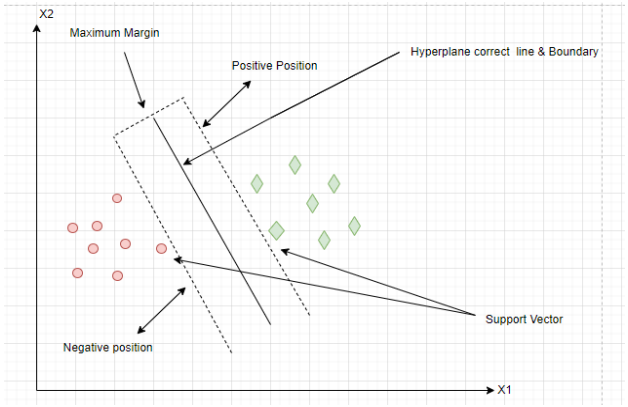

Fig 2 Diagram of SVM Algorithm with Correct Hyperplane

There are two types of SVM following here: -

3.1.1 Linear SVM: - Dividing dataset into two class by using a single straight line that is called as linear separable and sometime it is referred as linear SVM classifier.

3.1.2 Non-linear SVM: - A dataset not separated into two class with help of single straight line that is called as non linear separable and sometime it is referred as Non-linear SVM classifier.

2. Convolutional Neural Network: -

CNN is work on deep learning neural network architecture. Where computer vision techniques are used and it is also part of acritical intelligence. That enables for understand the situation to computer and interpret the image or visual data.

It is consisting of three-layer input layers, hidden layers & Output layer. In first layers, we take the data from human and fed into hidden layers. in second layers we take data from input layers and performed operation or produces result with weightage and fed into output layers. last layers take data from hidden layers show the resultant data in matrix form.

Data is input into the model, and the output from each layer is obtained through the feedforward process. The error is then calculated using an error function, such as cross-entropy or mean squared error. To resolves the mentioned error by using error function back propagation techniques is required. Where we can reduce the minimal losses.

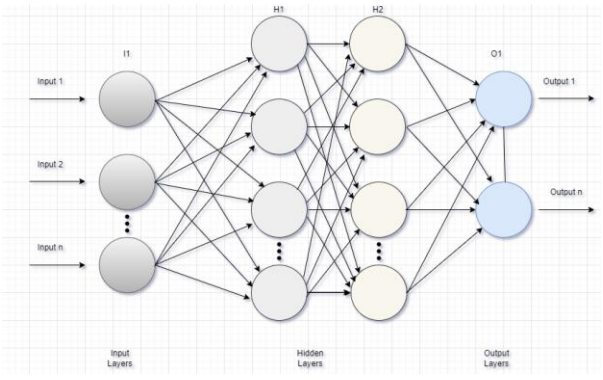

Fig 3 Diagram of Simple CNN architecture

3. Region and Edges Based Segmentation: -

More than one region and objects segmented in an image depend on discontinuity or a similarity criterion that is called as segmentation. Border (Edge) and its Interior drawn by image in region and two representations are equal. There are two methods performing for segmentation that are following here: -

3.3.1 Edge- Based Segmentation: - it is consisting of two part that are following here: -

3.3.1.1 Edge Detection: - In this detection process we search pixels in image that is known as edges pixels. There are many methods use for detection in edges such as Sobel operator, Laplace operator, Canny, etc.

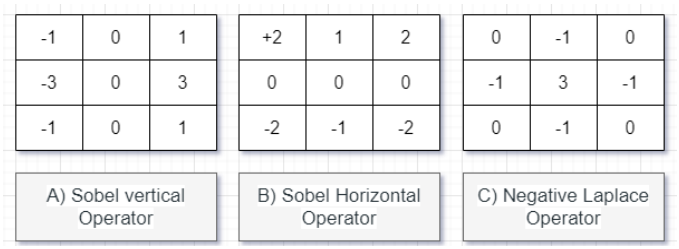

Fig 4 Diagram of Edge Detection

3.3.1.2 Edge Linking: - In this linking process, combine the full object and linking the adjacent edges to refining the edge detection. Edges linking can be performed by using two methods: -

3.3.1.2.1 Local Processing: - Linking the neighborhood edges by using gradient and direction method and two nodes have indicated that same direction then we can see that node are linked successfully.

3.3.1.2.2 Global Processing: - This methos can be useful for Histogram of Oriented Gradients (HOG) transformation. In image processing HOG works as feature descriptor technique. And it is describing shape & appearance when distributing the edge orientations within object. And compute gradient magnitude and orientation of image pixels then separating the image into small cells.

3.3.2 Region- Based Segmentation: - In this segmentation, we focus on neighboring pixels which is similar & connected with other pixels. Then we find similarity measures of gray levels for region with homogeneous gray levels. And we define connectivity to avoid connecting different part of the image.

Region based segmentation contain two part which are following here: -

3.3.2.1 Top – Down Approach: - We define all pixels as a seed pixel or we can choose random pixels. And region grow will perform until all pixels of image that is belongs to the region.

3.3.2.2 Bottom – Up Approach: - we have selected only seed pixels. And region grow will perform only when similarity criterion is fulfilled.

4. Threshold Based Image Segmentation: -

Intensity thresholding is most commonly applied process in computer vision. Which is used to generate binary image and whose pixels value have 0 and -1 and it is require one bit from given grayscale image or distributing into two regions depend on Threshold value. The resulting pixel intensity value is greater than declared threshold value shown as white or 1 in output image and other part will shown as black or 0.

This segmentation is consisting two parts, which are discussing below: -

3.4.1 Global Thresholding: - It is simple image segmentation techniques where we apply single value to entire image and separate image from background. The work of this threshold converting grayscale image to binary image based on intensity threshold value.

The result of binary image shown pixels indicating that object is distinct from background. And mathematically, it its represented as: -

$$B(a,b) = \begin{cases} 1, & \text{if } I(a,b) > T \\ 0, & \text{if } I(a,b) < T \end{cases}$$

Where,

I (a,b) = Intensity Pixel Position (a,b)
T = Global Threshold Value
B (a,b) = Binary Value (0,1)

3.4.2 Variable Thresholding: - it is referred to be as Contextual Thresholding that is employed for image segmentation and here threshold value is not applied globally because it is varies across the image based on local pixel values. Variable thresholding is useful for either lighting condition are uneven or object-background contrast is not consistent.

In this thresholding, we calculate the threshold value for each pixel with surrounding pixel values (neighborhood) depend on varying illumination or texture can be segmented effectively.

Variable thresholding is represented as:

$$B(a,b) = \begin{cases} 1, & \text{if } I(a,b) > T(a,b) \\ 0, & \text{if } I(a,b) < T(a,b) \end{cases}$$

Table 1. Review of Brain Region Segmentation Techniques

Ref. No.	Technique	Advantages	Disadvantages	Remarks
[2]	Active Contour Model	1. It is provided best fit for complex object boundaries and requires detailed boundary extraction. 2. This method is applied for a wide range of objects from simple to complex. 3. It can control both concave and convex boundaries easily.	1. This model provides inaccurate results in poor segmentation. 2. Highly expensive for high-resolution images. 3. This model is time-consuming for solving partial differential equations (PDEs) and other optimization techniques.	Region and edge-based image segmentation techniques are useful for solving object boundary problems.
[2, 20]	Convolutional Neural Network (CNN)	1. CNN automatically learns and extracts similar features from raw input data, reducing the need for manual feature engineering. 2. CNN reduces computational complexity. 3. CNN provides excellent performance on image-based tasks.	1. Requires a large amount of labeled dataset because the network needs more features to generalize unseen data. 2. CNN can overfit with small datasets due to model complexity. 3. Requires data augmentation techniques to avoid overfitting and improve generalization.	Deep learning methods will be useful to overcome the issue of large datasets and also save time and computational cost.
[3]	Support Vector Machine (SVM)	1. SVM provides the best performance in high-dimensional space for text classification. 2. SVM provides high accuracy and robustness. 3. SVM works well with small and medium datasets.	1. SVM is more expensive and time-consuming for large datasets. 2. SVM performs very slowly with large datasets. 3. SVM faces issues with noisy data due to overlapping classes or outliers.	Deep Learning and CNN techniques are useful for solving problems with large datasets and noisy data.

[18]	Feature Pyramid Networks (FPNs)	1. FPN handles large objects and detects both small and large objects efficiently. 2. FPN improves detection performance and robustness, performing better with larger objects. 3. FPN makes the process more efficient by reducing rescaling operations.	1. FPN increases computational costs due to memory requirements and high processing time for large networks. 2. The performance of FPN is limited, and careful selection of the backbone is essential for good results. 3. Handling small objects is difficult as it doesn't provide enough semantic information.	Edge and region-based segmentation is useful for identifying small and large objects and building better pyramid networks.
[19]	Optimized Thresholded Difference Algorithm (OTDA)	1. Simple and easy-to-understand algorithm that detects changes efficiently. 2. Highly efficient optimization with improved filtering techniques. 3. Reduces noise in images.	1. The algorithm's performance is limited as it misses data details and produces false alerts. 2. OTDA is highly expensive, requiring complex operations for large images or video frames. 3. OTDA is more suitable for large changes but less accurate for small changes.	Threshold-based image segmentation and SVM are useful for detecting small and large changes, saving computational costs in image segmentation.

IV. CONCLUSION

Now a days, brain tumor is big challenge to detect brain region with high quality, shape, color etc. in medical field. And I have also reviewed multiple paper related brain tumor and found white tissue and noise in image. Many filters and method are used for brain region detection in paper but not get desired results.

This Paper cover multiple method with brief discussion, types, difference for solving the brain detection problem very efficiently. The most popular image segmentation techniques like Threshold Based Detection, Deep Neural Network, Machine Learning, Support Vector Machine, Region and Edge based Segmentation, Convolutional Neural Network etc.

SVM is provide accurate result for the problem of correct shape, color, positions in brain MRI. And Convolutional Neural Network is used for reducing noise and white tissues of noisy image. Region and Edges based segmentation techniques is used for providing edges and best region to brain MRI. So that detection of brain MRI will also improve. Threshold based segmentation is useful for separating the image into multiple part from entire image. So that we can identify the problem very easily.

Above method are helpful for further research. So that brain region detection will be improved with high accuracy, low cost, less processing time and less noise in image segmentation.

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