A REVIEW ON PERFORMANCE EVALUATION OF IMAGE PROCESSING TECHNIQUE FOR BRAIN TUMOR DETECTION

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Abstract—Brain tumor is an uncontrolled growth of tissues in any part of the body. Tumors are of different types and characteristics and have different treatments. Detection of tumor in the earlier stages makes the treatment easier. Presently many medical imaging techniques such as positron emission tomography (PET), X-ray, computed tomography (CT), magnetic resonance imaging (MRI) for tumor detection are in use among which MRI imaging technique is more attractive because of its higher resolution and therefore most preferred technique for diagnosing tumor. MRI scan is safer than any other scan as it does not involve any radiations and gives high resolution of image. Paper gives a brief review of different segmentation and classification methods used for detection of tumor from Magnetic Resonance Images (MRI).

Keywords — MRI images, Brain tumor, FCM, Threshold, Watershed, ANN, SVM

I. INTRODUCTION

The Brain tumor is a life threatening disease. The brain contains more than 10 billion working brain cells. Brain tumor can be said as abnormal growth of neurons in brain. The growth of neurons can vary from person to person. According to the type of growth, the tumor may be Benign or Malignant. If tumor is at its origin then it is benign and if part of tumor spreads and grows on another place then it is malignant. Fig. 1.1 shows the presence of tumor in human brain.

![Figure 1.1: The presence of brain tumor](image)

Fig 1.1 shows the presence of brain tumor where in left image tumor invading and destroying normal brain tissue and in right image tumor pressing normal tissue and causing increased pressure within the brain.

Normally brain tumor affects Cerebral Spinal Fluid (CSF) which causes strokes and the physician may give the treatment for the strokes rather than the treatment for tumor [13]. So for the proper treatment detection of tumor is important. The manual analysis of brain tumor which is done by doctors may give different conclusions varying from one doctor to another. Also the tumor size,
position, texture and appearance varies with different patients. To overcome this many techniques have been developed. The overview of some related techniques is given in this literature review.

II. LITERATURE REVIEW

Wanhyun Cho et al [23] worked on "Level-Set Segmentation of Brain Tumors using a New Hybrid Speed Function". In this method to perform image segmentation within the level-set framework a new hybrid speed function have been used which is based on boundary and region information. First, it uses an external force for the active diffusion of gradient vectors of a gray-level edge map derived from the target image. Then, to compute region information, Gaussian distribution is adopted to model the intensity distribution of the inside and outside of the evolving curve partitioning the image domain.

Praveen G.B. et al [17] worked on "Hybrid Approach for Brain Tumor Detection and Classification in Magnetic Resonance Images" In first phase image preprocessing is done which includes noise filtering, skull detection, etc. In second phase feature extraction is done by using gray level co-occurrence matrix (GLCM). Third phase deals with classification of inputs into normal or abnormal using Least Squares Support Vector Machine (LS-SVM) classifier with Multilayer perceptron kernel. Final phase is the segmentation of the tumor part from the brain using fast bounding box. The experiments were carried out on 100 images consisting of 25 normal and 75 abnormal from a real human brain. The classification accuracy on both training and test images was found to be 96.63%. Tao Xu and Mrinal Manda [18] worked on "Automatic Brain Tumor Extraction from T1-weighted Coronal MRI Using Fast Bounding Box and Dynamic Snake" In which FCM-based preprocessing is applied to increase the quality of T1 coronal MR images. Then the fast bounding box (FBB) method using symmetry is adopted to detect the bounding box of brain tumor. The FBB detection performance is evaluated by the missing rate (MR), but obtained missing rate is not satisfactory.

Hadeel N. Abdullah [1] developed "Brain Tumor Extraction Approach in MRI Images based on Soft Computing Techniques" The algorithm has been tested on thirty two MRI images. To enhance image and remove the noise the wiener filter has selected. Canny edge detection has used to separate the different regions. Global threshold segmentation has used to extract the tumor’s region from the other regions in image. Morphological operation has used to enhance the global threshold segmentation. Watershed segmentation is used to extract feature. This extracted features used to train the ANN with Back propagation algorithm (BP). Performance of this method is calculated in terms of accuracy-96.96%, sensitivity-100% and specificity-95.83%. Anupurba Nandi [27] worked on "Detection of human brain tumor using MRI image segmentation and morphological operators" In which K-Means clustering used where the detected tumor shows some abnormality which is then rectified by the using morphological operation along with basic image processing techniques to meet the goal of separating the tumor cells from the normal cells. By applying thresholding, watershed segmentation and morphological operators the tumor is detected. The Threshold and Watershed segmentation is very simple and popular, the factor used in thresholding is very difficult to determine because the factor used for one image may not work for other image. This factor maybe different for different images. The watershed method has the disadvantage that it is highly sensitive to local minima, since at each minima, a watershed is created. If an image with noise, this will influence the segmentation. so we have not used it directly on input images. This problem is overcome by the application of median filter and high pass filter in the initial stages which is beneficial in removing
noise from the MRI image which were then passed for further processing. William Thomas et al [2] worked on "A review of segmentation and edge detection methods for real time image processing used to detect brain tumor" This paper gives the comparative study of various segmentation methods like seed region growing, threshold segmentation, watershed segmentation, fuzzy means and histogram segmentation with different parameters like complexity, accuracy, sensitivity and specificity and concluded that FCM has less complexity i.e. 5.29 and high specificity i.e. 1.0 while Seed Region Growing segmentation gives the higher accuracy i.e. 92.5% as compared to other segmentation techniques. Said E. El-Khamy et al [3] worked on "An Efficient Brain Mass Detection with Adaptive Clustered based Fuzzy C-Mean and Thresholding" In which brain tumor segmentation is done using FCM and conformad threshold, MRI image is enhanced by extending the difference between the tumor intensity level and the other tissues, and then a rectangular window is used to calculate the number of clusters. FCM is used to calculate the centers of these clusters and the segmentation is done through a conformad threshold. Completeness, correctness and accuracy were evaluated on 15 MRI brain tumor images. The performance is given in terms of Completeness (93.59%), Correctness (99.47%), Accuracy (99.79%) and Running Time (4.91Sec). This algorithm has better correctness and decreases the processing time by 80% compared to the global threshold segmentation technique. Benson. C. C1 et al [10] worked on "Brain Tumor Segmentation from MR Brain Images using Improved Fuzzy c-Means Clustering and Watershed Algorithm" In this method for the initial centroid selection is done by using histogram. Watershed segmentation suffers from over segmentation problem which is overcome by using internal and external markers. This method uses atlas based marker detection and achieved the accuracy of 93.13 and 88.64 of Dice and Tanimoto coefficient values respectively. K. Bhima and A. Jagan[11] worked on "Analysis of MRI based Brain Tumor Identification using Segmentation Technique" In which analysis has been performed on brain MRI to detect brain anomalous regions with marker based watershed segmentation algorithm and accomplished average accuracy is 97.34%.

Ananda Resmi1 et al [21] worked on "Automatic Segmentation Framework for Primary Tumors From Brain MRI Using Morphological Filtering Techniques". Method described a novel framework for automatic segmentation of primary tumors and its boundary from brain MRI using morphological filtering techniques. This method is tested by fifty patients of different tumor types, shapes, image intensities, sizes and produced better results. The results were validated with ground truth images by the radiologist. Mohannad Kadhim Sabir [20] worked on "An Superior Achievement of Brain Tumor Detection Using Segmentation Based on F-Transform". Method describes the detection and extraction of brain tumor from MRI scan images of brain. Asymmetry of brain is used for detection of abnormality, after detection of the tumor. The segmentation based on F transform (Fuzzy-Transform) and morphological operations are performed to delineating brain tumor boundaries and calculate the area of the tumor. The speed of detection is also improved after using asymmetry of brain. By using this algorithm accuracy of 96% and precision of 95% were found in detection of brain tumor.

M.Y.Bhanumurthy [22] worked on "An Automated Detection and Segmentation of Tumor in Brain MRI using Artificial Intelligence" In which a fully automated technique is discussed that uses artificial intelligence to detect and segment abnormal tissues like tumor and atrophy in brain MRI images accurately. The extracted features like energy, entropy, homogeneity, contrast and correlation from the brain MRI images are applied as input to an artificial intelligence system that uses a Neuro-fuzzy classifier which classifies the images into normal or abnormal. The abnormal tissues like
tumor and atrophy are then segmented using region growing method. The accuracy of the segmentation results are assessed with metrics like False Positive Ratio (FPR), False Negative Ratio (FNR), Specificity, Sensitivity and Accuracy. Neuro-fuzzy classifier achieves accuracy of 95.65% in categorizing the images into normal and abnormal.

K.S. Thara et al [32] worked on "Brain Tumour Detection in MRI using PNN and GRNN". In this method input Image is pre-processed, then segmentation is done using K Means clustering method and Fuzzy C Means clustering method. Classification is done by using the supervised neural network called the Radial Basis Function (RBF), Generalised Regression neural network (GRNN), Probabilistic neural network (PNN) and Radial Basis Function neural network produces an accuracy of about 91.31 %, Generalised regression neural network provides an accuracy of 96.31 %, probabilistic neural network provides an accuracy of about 97.29%. Mahmoud Khaled Abd-Ellah et al [19] worked on "Design and Implementation of a Computer-Aided Diagnosis System for Brain Tumor Classification.

Ms. Neha Mathur1 [26] worked on "THE K-MEANS CLUSTERING BASED FUZZY EDGE DETECTION TECHNIQUE ON MRI IMAGES". The K-means clustering approach is used in generating various groups which are then input to the fuzzy inference system. This whole process results in the generation of the threshold parameter which is then fed to the classical sobel edge detector which helps in enhancing its edge detection capability using the fuzzy logic. Results represented that the K-means clustering technique for the generation of threshold parameters in the fuzzy based system improves the edge image for MRI image when it is used with sobel edge operator and also provide good information about tumors. Performance of this method can be improved further by using this method with different edge detector.

Rasel Ahmmed and Md. Foisal Hossain [4] worked on "Tumor Detection in Brain MRI Image Using Template based K-means and Fuzzy C-means Clustering Algorithm". In this paper, Template based K-means and modified fuzzy C-means (TKFCM) clustering algorithm is used. It is used to remove the limitation of conventional K-means and conventional FCM algorithm for brain tumor MRI image. The template is selected based on convolution between gray level intensity in small portion of brain image and brain tumor image. K-means algorithm is used to emphasize initial segmentation through the proper selection of template. Updated membership is obtained from the distance measurement from centroid to clusters, until it reaches to its best. On the basis of updated membership and automatic selected cluster, a sharp segmented image is obtained with tumor from modified FCM technique. The segmented tumor is shown as red marked with their proper detected position. The performance is analyzed through neural network, which shows better accuracy and least error. The accuracy, sensitivity, and specificity show that it is better than other previous conventional methods. Though it is less noise sensitive, but for some images where the gray level intensity difference is very small causes trouble to select perfect template. The performance is measured in terms of Sensitivity (96.67%), Specificity (100%), and Accuracy (97.1%). But use of neural network makes the system poor in case of the time complexity. M. Shasidhar 1 et al [28] worked on "MRI BRAIN IMAGE SEGMENTATION USING MODIFIED FUZZY C-MEANS CLUSTERING ALGORITHM". The application of modified FCM algorithm for MR brain tumor detection is explored. A comprehensive feature vector space is used for the segmentation technique. Comparative analysis in terms of segmentation efficiency and convergence rate is performed between the conventional FCM and the modified FCM. Experimental results show superior results for the modified FCM algorithm. N. Nandha Gopal [7] worked on "Diagnose Brain Tumor through
MRI Using Image Processing Clustering Algorithms Such As Fuzzy C Means Along With Intelligent Optimization Techniques”. PSO with Fuzzy algorithms are used to identify tumor. Particle Swarm Optimization (PSO) with FCM having accuracy 92.3% and error rate 0.1273%, but drawback is that this method requires more execution time as compared to GA (Genetic algorithm) with FCM. Kailash Sinha I et al [29] worked on "Efficient Segmentation Methods for Tumor Detection in MRI Images". This paper presents a comparative study of three segmentation methods implemented for tumor detection. The methods include k-means clustering with watershed segmentation algorithm, optimized k-means clustering with genetic algorithm and optimized c-means clustering with genetic algorithm. Traditional k-means algorithm is sensitive to the initial cluster centers. Genetic c-means and k-means clustering techniques are used to detect tumor in MRI of brain images. At the end of process the tumor is extracted from the MR image and its exact position and the shape are determined. The experimental results indicated that genetic c-means not only eliminate the over segmentation problem, but also provide fast and efficient clustering results. The searching time and area of tumor region were considered as comparison parameters for comparison of various methods. The c-means clustering produced good results and performed better than other optimized clustering methods. Indu Bala [8] worked on "Brain Tumor Detection Using Hard and Soft Computing Techniques". There are main four parts i.e. Preprocessing of image, segmentation using K-mean, on the result of k-mean again segmentation using FCM is done and then applied optimization algorithm i.e. GA (Genetic algorithm). The obtained result according to classification accuracy is 90.3%.

K. SUDHARANI et al [5] worked on "Intelligent Brain Tumor Lesion Classification and Identification from MRI Images Using KNN (k nearest neighbors) Technique". The KNN algorithm is implemented on the brain tumor images to detect and localize the uncontrollably grown part in the brain tissues. KNN yields excellent results and accuracy depends on how many samples used for training. Using weighted KNN associated stumbling blocks can be overcome but KNN is a slow machine learning process. Ketan Machhale et al [25] worked on "MRI Brain Cancer Classification Using Hybrid Classifier (SVM-KNN)" In this method Support Vector Machine (SVM), K-Nearest Neighbor (KNN) and Hybrid Classifier (SVM-KNN) is used to classify 50 images, it is observed from the results that the Hybrid classifier SVM-KNN demonstrated the highest classification accuracy rate of 98% among others. SVM with Quadratic kernel achieved maximum of 96% classification accuracy and Hybrid classifier (SVM-KNN) achieved 98% classification accuracy rate on the same test set that means SVM-KNN gave better accuracy rate than the SVM. Swapnil R. Telrandhe1 et al [31] worked on "Detection of Brain Tumor from MRI images by using Segmentation & SVM" where K-Means segmentation is used with preprocessing. By using diagonal, antidiagonal masks segmented images get preprocessed and skull masking is done. After skull masking fatty tissues and other unwanted details get smoothen. To make this system an adaptive SVM (Support Vector Machine) used in unsupervised manner which will use to create and maintain the pattern for future use

Chinnu A [9] worked on "MRI Brain Tumor Classification Using SVM and Histogram Based Image Segmentation". The method used Support Vector Machines for classification. Histogram thresholding technique for segmentation. C. Logeswaran et al [6] worked on "Brain Tumor Detection Using Hybrid Techniques and Support Vector Machine". The support vector machine and naïve bayes is used for detection of tumor and no tumor Image. Segmentation is done by fuzzy c-means Method. The Gray Level Co-occurrence Matrix (GLCM) is used as a feature. The obtained result gave 88% of accuracy for 25 MRI images which is not satisfactory. Amiya Halder et al [24] worked
on "Detection of Tumor in Brain MRI Using Fuzzy Feature Selection and Support Vector Machine" where method is divided into two steps. First, a set of feature is generated for accurately differentiating between a normal and abnormal MR scan images. Then, these features are reduced using fuzzy c-means (FCM) algorithm. Further, a Support Vector Machine (SVM) is used to classify the scan images into two groups, namely, tumor-free and tumor affected. Performance of this method is evaluated in terms of the accuracy i.e. 97.89% which is better than K-means clustering-87%, GA Approach-93%, SVM method-92.71% and Neural Network approach-96.33%. Parveen et al [12] worked on "Detection of Brain Tumor in MRI Images using Combination of Fuzzy C-Means and SVM". The technique based on the support vector machine (SVM) and fuzzy c-means for brain tumor classification. Fuzzy c-means (FCM) clustering is used for the segmentation of the image to detect the suspicious region in brain MRI image. Grey level run length matrix (GLRLM) is used for features extraction from the brain image, after which SVM technique is applied to classify the brain MRI images. For training and testing purpose 120 brain MRI images are used and performance of the system is measured in terms of sensitivity, accuracy and specificity for different kernel function. For linear kernel function obtained results is- sensitivity (91.66%), accuracy (83.33%) and specificity (100%).

III. SURVEY DISCUSSION

From above survey it can be concluded that there are number of techniques available for brain tumor detection.

Level Sets method [23] requires initial curves identification. This method yield poor results when there is asymmetrical placement of the curves with respect to object boundary. level-set is much slower than snake in virtue of higher dimensional embedding, level-set produces more false alarms due to the multiple objects capturing ability. By using the bounding box as the initial contour, a dynamic snake with new external force the drawback of level set model are overcomed [17][18].

The watershed method [1][27][2][3][10][11] has the disadvantage that it is highly sensitive to local minima, since at each minima, a watershed is created. If an image with noise, this will influence the segmentation. So it cannot be used directly on input images. Considering the advantages and drawbacks of the above methodologies a hybrid approach is developed i.e. combination of region based and texture based methods for brain tumor detection and classification. Region growing method [22] correctly segments regions that have similar properties and produces connected region and its performance is better with noisy images. Drawback of Region growing method is that it involves a manual seed point selection. Depending on predefined conditions, this method removes all pixels connected to the Preliminary seed. It is quite expensive in terms of computation both time and memory.

Fuzzy C-means (FCM) [3][4][6][7][8][10][28][29][40][42] clustering algorithm is superior over the other clustering approaches in terms of segmentation efficiency. It is simple and fast algorithm. This algorithm is more robust to noise and provides better segmentation quality. But the drawback is that it considers only image intensity values. Thus, the modified FCM [28][29] algorithm is a fast alternative to the traditional FCM technique.

The classification can be done by either using Neural network [22][32] or support vector machines (SVM) [24][25][31][9][11]. Both method provides better results, but due to training and testing phase neural network will comes up with some potential overheads i.e. poor in case of time complexity. Gathering training samples is not straight forward and learning phase is slow. Support
vector machines algorithm has high generalization performance. It works well in case of high dimensional feature space. This algorithm works independent of the dimensionality of the feature space. The results given by support vector machines are very accurate.

A short comparison of different segmentation and classification methods are given in below table with their advantages and disadvantages.

| Segmentation/Classification Technique | Advantages | Disadvantages |
|--------------------------------------|------------|---------------|
| Level Sets Approach [23]             | Topological changes are naturally possible | This method yield poor results when there is asymmetrical placement of the curves with respect to object boundary. level-set is much slower than snake in virtue of higher dimensional embedding, level-set produces more false alarms due to the multiple objects capturing ability. |
| Watershed Segments [1][27][2][3][10][11] | multiple regions at the same time, produces a complete contour of the images and avoids the need for any kind of contour joining. | It is highly sensitive to local minima, since at each minima a watershed is created. Image with noise causes Over-segmentation. Poor detection of thin image |
| Region-based[22]                     | Simple, flexible and more immune to noise. It is useful when it is easy to define similarity criteria. It is possible to adjust acceptance criteria as it depends on the shape of the growing region. | Partial volume effect. It involves a manual seed point selection. Depending on predefined conditions, this method removes all pixels connected to the Preliminary seed. It is quite expensive in terms of computation both time and memory. |
| Threshold-based segmentation          | Simple and computationally fast method. No need of previous information, simplest method. | Limited applicability to enhancing tumor areas. It cannot be applied to the multichannel image. Highly dependent on peaks, spatial details are not considered |
| Edge Detection Based Method          | Focused on detecting contour. In vision based analysis, edge is considered as a very good descriptor of contrast. | Fail when the image is blurry or too complex to identify a given border. Inability to produce a reasonable solution in cluttered background. Not suitable for wrong detected or |
| Algorithm          | Advantages                                                                 | Disadvantages                                                                 |
|--------------------|----------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Good for images having better contrast between objects | too many edges | Simple to implement | There is some probability of yielding an erroneous decision if the obtained single neighbor is definitely an outlier of some other class. It is very sensitive to irrelevant or redundant features and they have poor run time performance |
| K nearest neighbors (knn) [5][25][31] | K-nearest neighbors (KNN) is simple to implement | The algorithm also runs quickly enough that real time image segmentation could be done with k means algorithm. |
| K-means            | K-means fairly simple to implement and image segmentation are impressive. As can be seen by the results, the number of partitions used in the segmentation has a very large effect on the output. | Huge computational time required for convergence |
| F-c-means [3][4][6][7][8][10][28][29][40][42] | fuzzy uses partial membership therefore more useful for real problems | For decision making no need to write complex programs. Provide high accuracy. |
| ANN classifier [22][23] | Support vector machines algorithm has high generalization performance. It works well in case of high dimensional feature space. This algorithm works independent of the dimensionality of the feature space. The results given by support vector machines are very accurate. | Learning phase is slow and time consuming process |
| SVM [24][25][31][9][11] | Support vector machines algorithm has high generalization performance. It works well in case of high dimensional feature space. This algorithm works independent of the dimensionality of the feature space. The results given by support vector machines are very accurate. | __ |

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