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Brain Tumor Detection, Classification and Feature Extraction from MRI Brain Image

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ABSTRACT
Nowadays the use of automatic computer aided technology for the extraction of brain tumor by image segmentation process becomes greatly important. To improve the performance and reduce the complexity, the combined K-means and fuzzy C-means (FCM) clustering are investigated based on segmentation for brain tumor detection and support vector machine (SVM) is used for the classification of tumor types. Furthermore, to improve the accuracy and quality rate of the support vector machine (SVM) based classifier; relevant features are extracted from each segmented tissue of brain MRI images. The experimental results of the proposed method have been evaluated and validated for performance and quality analysis on magnetic resonance brain images, based on accuracy, sensitivity, specificity. The experimental results achieved 94.37% accuracy, 98% specificity, and 98.19% sensitivity, demonstrating the effectiveness of the proposed method for identifying normal and abnormal(i.e. Benign or Malignant) tissues from brain MR images.

KEYWORDS*-MRI, Brain Tumor, Segmentation, K-Means Clustering, Fuzzy C-Means Clustering, Support Vector Machine (SVM), Feature Extraction etc.*

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I. INTRODUCTION

Brain tumor is one of the major causes of death among other types of cancerous diseases. Tumor segmentation from MRI data is an important but it is time consuming and difficult task very often performed manually by novice medical assistant and radiologists. This paper mainly deals with the concept of brain tumor detection and feature extraction. Firstly, the MRI image data is taken for the entire process. The MRI image is more useful than CT image for diagnosis. It is not harmful for human body. Because it doesn't use any radiation.[1]. In this paper, the k-means and fuzzy C-means algorithm is used for segmentation of tumor rather than other existing methods. The main objective of the present research work is an efficient segmentation method which is used to detect and extract the tumor region in MRI images. The overview of the work is given below:

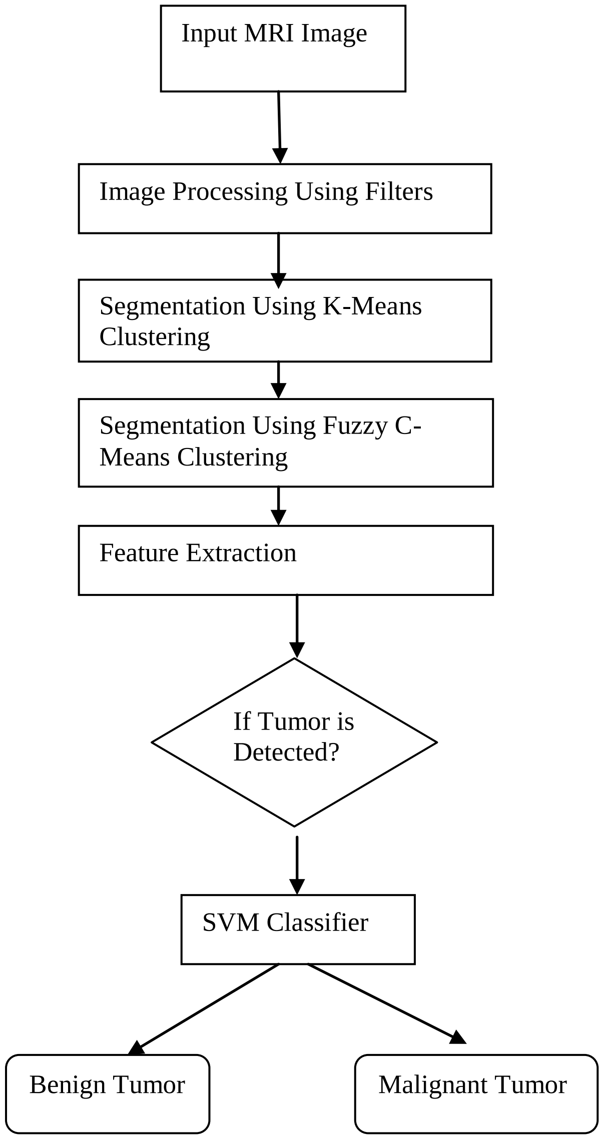


Figure (1): Overview of the work.

II. RELATED RESEARCH WORK

A number of research papers and conference papers related to medical image segmentation methods were studied. Many of researcher conducting research on image segmentation, feature extraction and the classification of the magnetic resonance imaging (MRI) of the tumor in which many authors proposed several methods according to their research work and experiments. Many techniques have been proposed for classification and segmentation of brain tumors in MRI images, most notably methods are fuzzy C-means clustering (FCM), k-means clustering, Support Vector Machine (SVM), artificial neural network (ANN), knowledge based techniques and expectation-maximization (EM) algorithm which are some of the popular techniques used for segmentation and so to extract the important features on information from the medical imaging [2].

III. METHODS USED IN TUMOR DETECTION

A. Image Preprocessing

The preprocessing tasks are used to improve the image quality and its visual appearance. The MRI image are used for the tumor detection and classification to get the result accuracy, preprocessing tasks can be performed by using filters (median, wiener etc.) for noise removal. The improvements increases the image making by transforming the image attribute [2][3].

B. Segmentation Using k-Means Clustering

Image segmentation methods can be classified into three categories: - Edge-based methods, region-based methods and pixel-based methods [4]. The k-means clustering technique is a pixel-based method, it is one of the simplest techniques, and its complexity is relatively lower than other region-based or edge-based methods. Furthermore, k-means clustering is suitable for biomedical image segmentation as the number of clusters is usually known for images of particular regions of the human anatomy [5].

Algorithm for K Means Algorithm:

Step 1: Read the image.
Step 2: Get the number of clusters to be formed.
Step 3: Convert the color image into its corresponding gray image.
Step 4: Resize the two dimensional image into one dimensional array of length **"r×c".**
Step 5: Find the intensity range of the image.
Range = [(Maximum intensity value) - (Minimum intensity value)]
Step 6: Find the centroid value
Centroid 1 = Range/Number of clusters
Centroid 2 = (2 × Centroid 1)
Step 7: Find the difference between the first intensity value and the various centroid values.
Step 8: Based on the minimum difference obtained, group the intensity values into the corresponding clusters.
Step 9: Repeat step 1 & 2 for all the other intensity values of the image.
Centroid 3 = (3 × Centroid 1)
Centroid n = (n × Centroid 1)

C. Segmentation Using Fuzzy C-Means Clustering

Fuzzy C-means is a method of clustering which allows one piece of data to belong to two or more clusters. This method (developed by Dunn in 1973 and improved by Bezdek in 1981) is frequently used in pattern recognition and image processing. During segmentation process only local information is considered in the FCM algorithm. In particular the fuzzy C-means (FCM) algorithm, assign pixels to fuzzy clusters without labels. FCM allows pixels to belong to multiple clusters with varying degrees of membership. The fuzzy C-means clustering algorithm (FCM) is a soft segmentation method that has been used extensively for segmentation of MR images applications recently. Fuzzy C-means has been a very important tool for image processing in clustering objects in an image. FCM clustering algorithm is a soft segmentation methods that has been used extensively of segmentation of MR images applications recently [6].
The main FCM objective function is to minimize

$$G\,(u, v) = \sum_{p=1}^{n}\sum_{q=1}^{k}(\mu_{p,q})^{m}\|X_p - V_q\,\|^2 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where, $||X_p - V_q\,||^2$ is the Euclidean distance between pth information focuses and qthgroup focuses.

Algorithm for Fuzzy-C-Means Algorithm:

The steps of FCM clustering algorithm is sequentially given as follows:

1. Define the number of clusters and initialize the initial fuzzy partition matrix U_i, and also define its Exp.
2. Find initial estimate of Fuzzy membership functions.
3. Square Euclidean distance is calculated.
4. Compute the new membership function.
5. Calculate the objective cost function for FCM.

D. Feature Extraction

In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction. Feature Extraction is helpful in identifying brain tumor where is exactly located and helps in predicting next stage. Transforming the input data into the set of features is called feature extraction [7].
In this paper we're extracting some of the following features of the segmented image by using gray-level co-occurrence matrix (GLCM) are-

- Mean
- Standard Deviation

- Entropy
- RMS
- Variance
- Kurtosis
- Skewness
- Contrast
- Correlation
- Energy
- Homogeneity etc.

(1)Mean (M): The mean of an image is calculated by adding all the pixel values of an image divided by the total number of pixels in an image.

$$M = \left(\frac{1}{m*n}\right) \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} f(x,y) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

(2)Standard Deviation (SD): The standard deviation is the second central moment describing probability distribution of an observed population and can serve as a measure of inhomogeneity. A higher value indicates better intensity level and high contrast of edges of an image.

$$SD(\sigma) = \sqrt{\left(\frac{1}{m*n}\right) \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} (f(x,y) - M)^2} \ldots\ldots\ldots (3)$$

(3) Entropy (E): Entropy is calculated to characterize the randomness of the textural image and is defined as

$$E = -\sum_{x=0}^{m-1} \sum_{y=0}^{n-1} f(x,y) \log_2 f(x,y) \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

(4) RMS: For a set of numbers or values of a discrete distribution x_i... x_n, the root-mean-square, is the square root of mean of the values x_i^2, namely

$$\text{RMS}=\sqrt{\frac{x_1^2+x_2^2+\cdots+x_n^2}{n}} \text{ or, RMS}=\sqrt{\frac{\sum_{i=1}^{n} x_i^2}{n}} \ldots\ldots\ldots\ldots\ldots (5)$$

(5) Variance (S^2): The variance of a data set tells you how spread out the data points are. The closer the variance is to zero, the more closely the data points are clustered together.

$$S^2 = \frac{\sum(x_i - \bar{x})^2}{n-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where, $x_i$term in data set,$\bar{x}$sample mean and n is sample size.

(6) Skewness: The skewness gives the symmetry of an image. It is defined by the following eqn.

$$\mu^3 = \sigma^{-3} \sum_{i=0}^{Ng-1} (1-\mu)^3 . p(i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

(7) Kurtosis: Kurtosis is any measure of the "peakness" of the probability distribution of a real-valued random variable. For the random variable X, the Kurtosis is denoted as Kurt (X) and it is defined as

$$K_{urt}(X)= \left(\frac{1}{m*n}\right) \frac{\sum(f(x,y)-M)^4}{SD^4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

(8) Energy: Energy is a parameter to measure the similarity of an image. Energy gives the measure of sum of the squared elements. It is defined as

$$E_n=\sqrt{\sum_{x=0}^{m-1} \sum_{y=0}^{n-1} f^2(x,y)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

E. Tumor Classification methods

1. Support Vector Machines(SVM)
2. Artificial Neural Network(ANN)

(1) Support Vector Machine (SVM):

SVM is a supervised classifier with associated learning algorithm .The SVM based on the training samples.The key concept of SVM is the use of hyper planes to define decision boundaries separating between data points of different classes.In this research there are two classified data of normal and abnormal (Tumor) brain images. The hyper planes for SVMs is used to separate these classified data as normal data and tumor data.Support Vector Machines (SVM) works in the two stages- the training stage and the testing stage. SVM trains itself by learning features which are given as input to its learning algorithm [8].

(2) Artificial Neural Network (ANN):

In this technique, the image is mapped into a Neural Network. The neural network works in two phases- the training phase and the testing phase. Firstly the neural network was trained with training examples in the training phase. After training, the neural network is tested on the unknown instances [9].

In general, there are five basics steps are followed in artificial neural network:

Step: (1) collecting data,

Step: (2) preprocessing data,

Step: (3) building the network,

Step: (4) training stage, and

Step: (5) test performance of the model. Collecting and preparing sample data is the first step in designing ANN models.

IV. PERFORMANCE MEASURES OF SEGMENTATIONS METHODS

The segmentation performance measures are used in evaluating the performance of the proposed unsupervised clustering algorithm for segmentation of brain tumor and classifier performance metrics are used to evaluating the accuracy of the classifier.

A. Segmentation Performance Measures

The following most commonly used performance measures are used in evaluating the performance of the unsupervised clustering algorithms for segmentation of brain tumor.

MSE (mean squared error): The process of squaring the differentiated values is indicated by MSE [10]. The average of the sum of the squares of the errors is called as MSE, is obtained by subtraction of the input and the segmented images. MSE can be expressed as

$$\text{MSE}=\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j)-K(i,j)]^2 \;\ldots..\; (10)$$

Where, I (i, j) is the original image K (i,j) is the de-noised image. MSE should be as lowest as possible.

PSNR (peak signal to noise ratio): Noise immunity of an image is indicated by peak signal to noise ratio [10]. More PSNR means that the MRI brain image has very less interference due to noise. In the input MR brain image, the highest pixel value is denoted as MAX_i. The MSE values represent the PSNR.It is defined most easily via the MSE [11]:

$$\text{PSNR}=10\log_{10}\left(\frac{MAXi^2}{MSE}\right)\ldots\ldots\ldots\ldots\ldots\ldots\ldots...\ (11)$$

Where, MAX_i is the maximum pixel value of the image.

B. Performance Evaluation of Classifier

The following performance metrics are used to evaluate the classifier performance [12] like sensitivity, specificity, accuracy, and error rate.

Sensitivity: It can be defined as the true positive rate.

$$Sensitivity=\frac{TP}{TP+FN}*100$$

Specificity: It can be defined as the true negative rate.

$$Specificity=\frac{TN}{TN+FP}*100$$

Accuracy: It can be defined as the number of images which are classified correctly to the total number of input images.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} * 100$$

Error rate: It can be defined as the number of images which are classified incorrectly to the total number of images.

$$Error\ rate = \frac{FP+FN}{TP+TN+FP+FN} * 100$$

Where, True Positive (TP): Malignant rightly classified as Malignant, True Negative (TN): Benign rightly classified as Benign. False Positive (FP): Benign wrongly classified as Malignant. False Negative (FN): Malignant wrongly classified as Benign.

V. SIMULATIONS AND RESULT ANALYSIS

The aim of this paper is to propose segmentation based method for brain tumor detection and classification.
To measure the performance of the method it requires input image. We acquire different samples for brain image from different MRI brain image.
At first the method of preprocessing (filtering) techniques and then segmentation and classification techniques are briefly explained as follows.

1.1 Summary of Preprocessing Techniques

In this section, we have discussed four different types of filters and four kinds of noises (Speckle, Gaussian, Poisson and Salt & Pepper).Finally comparing the performance of four types of filtering techniques for de-noising here summarized the best effective one for our research work.

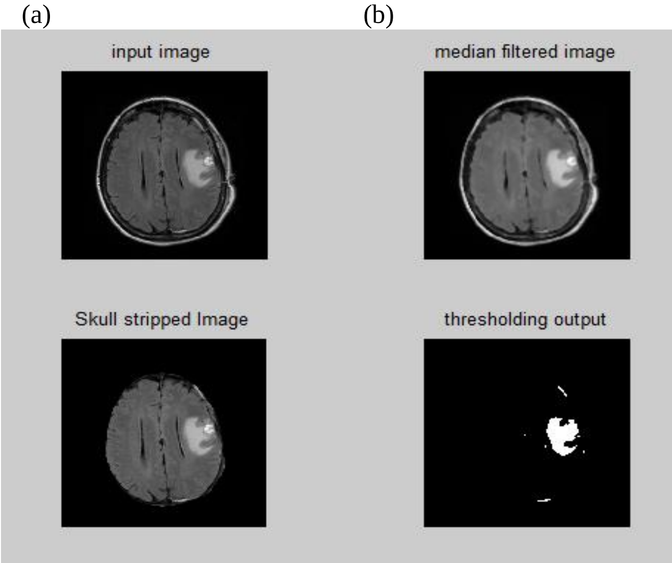
Table 1.1: Best effective filter for Preprocessing

Noise Types	Filtering Techniques			
	Median Filter	Mean Filter	Wiener Filter	Gaussian Filter
Salt and Pepper	X			
Gaussian Noise			X	
Poisson Noise			X	
Speckle Noise			X	

1.2 Summary of Segmentation Methods

Segmentation is the partitioning process of image into different parts having similar features.The different segmentations methods are thresholding approaches, edge based approach, Clustering approaches, Region Growing approaches etc. Here the result of existing segmentation methods are shown as follows.
Threshold segmentation for MRI Brain Image is shown in fig.1.1.

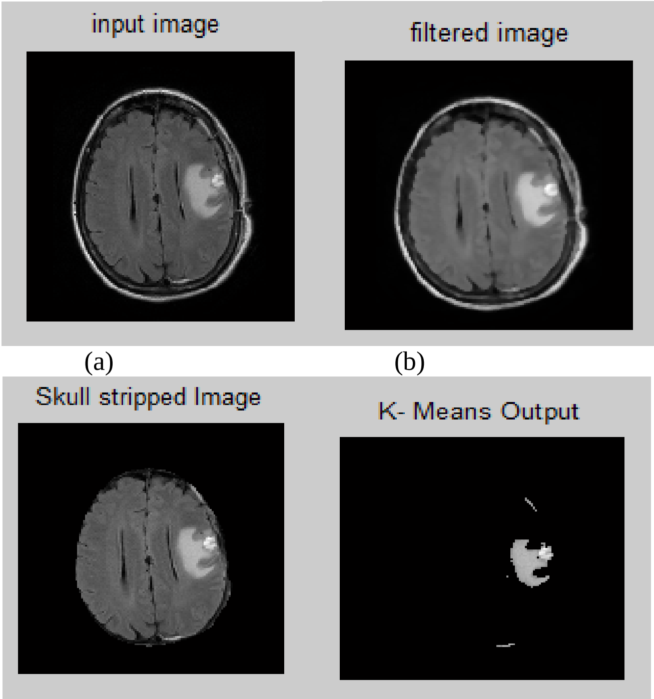
(a) (b)



(c) (d)

Figure 1.1: Threshold based segmentation of the MRI brain image (a) Original image (d) segmented image.

Here the segmentation result of K means and Fuzzy c-means algorithm is implemented.. K means Clustering segmentation for the MRI Brain Image is shown in fig.1.2.



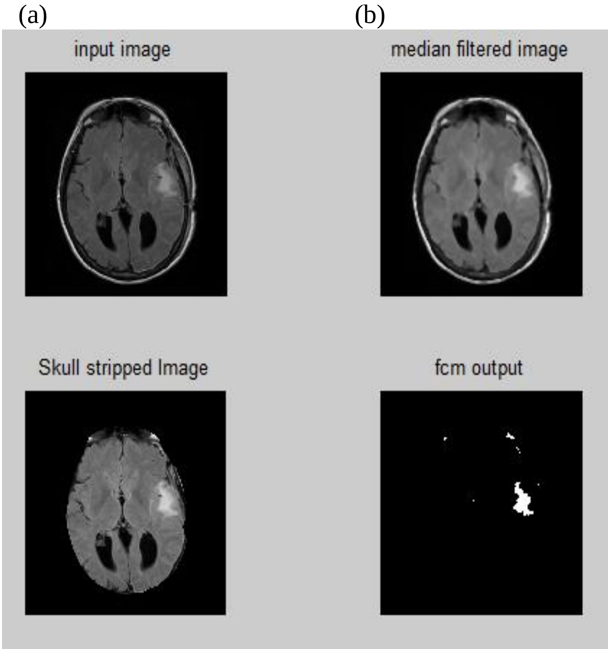
(a) (b)

(c) (d)

Figure 1.2: K-means segmentation of the MRI (a) Original image (d) segmented image.

Fuzzy C Means (FCM) clustering segmentation for the MRI brain Image is shown in fig.1.3.

(a) (b)



(c) (d)

Figure 1.3: Fuzzy C Means (FCM) Clustering segmentation of the tumor brain MRI image (a) Original image (d) segmented image

Parameters obtained for the various segmentation methods used for MRI brain tumor detection is shown in

Table 1.2.

Segmentation Methods	MSE	PSNR	Elapsed Time (s)
Thresholding	5778.1514	10.5129	1.601886
Watershed	37538.6445	2.3860	2.012756
K-Means	5575.1344	10.6683	1.960918
Fuzzy C-Means	3271.5385	12.9833	1.848879
(K-means+Fuzzy C Means)	3172.5434	14.4533	1.783344

So, here after analyzing the above table we can conclude that hybrid (K-means+Fuzzy C Means) methods provides the best performance rather than other methods. Since, it has given lower MSE and highest PSNR.

1.3 Feature Extraction from MRI image

Large amount of information is needed for represent an image and this information occupies large amount of memory. The features are extracted from the image. The extracted features contains the relevant information about the image. The extracted features are used as input to the classifier for classification shown in the table 1.3.

The extracted features are categorized into two types:
(1) Texture based features (Energy, Contrast, Correlation, Variance, IDM, Entropy etc.)
(2) Intensity based features (Mean, Standard Deviation, Skewness and Homogeneity etc.)

Table 1.3: First-order statistical features for few images.

Images	Mean	Standard deviation	Skewness	Kurtosis	Homogeneity
Image 1	0.00311	0.8976	0.46900	7.3282	0.9351
Image 2	0.00235	0.08978	0.88623	7.9568	3.26983
Image 3	0.00251	0.08977	0.3120	6.23204	0.93249
Image 4	0.00193	0.08979	0.87826	0.340779	0.9331
Image 5	0.00324	0.08970	0.63315	6.27346	0.9262
Image 6	0.0036	0.08974	0.6350	7.33059	0.93288
Image 7	0.0042	0.08971	0.5104	6.061	0.9297
Image 8	0.0057	0.08963	1.3123	13.0402	0.9329
Image 9	0.0042	0.08971	0.5217	5.097	0.92901
Image 10	0.0034	0.08974	0.4003	5.596	0.93079

Table 1.4: Second-order textural features with coarseness and key points for few images.

Images	Contrast	Correlation	Energy	Entropy	RMS	Smoothness
Image 1	0.208	0.199	0.76	3.17	0.089	0.920
Image 2	0.27169	0.09308	0.7621	3.1734	0.0898	0.9204
Image 3	0.216	0.138	0.7598	3.31556	0.0898	0.90324
Image 4	0.2032	0.11258	0.7553	3.65493	0.0898	0.87826
Image 5	0.24416	0.1006	0.7409	3.5797	0.0898	0.92344
Image 6	0.2433	0.09327	0.7612	3.3709	0.0898	0.9314
Image 7	0.2313	0.1072	0.7418	3.5516	0.0898	0.9403
Image 8	0.29254	0.1583	0.7588	2.66218	0.0898	0.95507

Image 9	0.22719	0.1325	0.7438	3.6046	0.0898	0.9406
Image 10	0.23	0.090	0.75	3.67	0.089	0.927

1.4 Accuracy Analysis with Conventional Method

The proposed method of detection and classification of tumor from brain image is compared with other existing method by calculating their accuracy, sensitivity, specificity and error rate.

Table 1.4: Accuracy Comparison with Conventional Method

Algorithms	Sensitivity (%)	Specificity (%)	Accuracy (%)
Thresholding	85	80	81.3
Region Growing	88.46	75	86.47
FCM	86.95	85.7	86.4
SVM	96.2	66.67	88.44
K-means	75	92.85	83.7
SVM+FCM Method	98	98.19	94.37

After analyzing the performance of different methods from the above table we can conclude that for brain tumor detection and classification combined support vector machine (SVM) and Fuzzy c-means (FCM) works best and which gives 94% classification accuracy and works best rather than other.

VI. CONCLUSION AND FUTURE WORKS

In this study k-means and Fuzzy c-means (FCM) algorithm is applied to segment the input brain MRI images and support vector machine (SVM) is used for classification of the given test images into benign and malignant classes respectively. The segmentation results of the proposed algorithm for 20 MRI brain images are obtained and performance parameters like MSE, processing time (s), PSNR value (dB), are obtained and the segmented area is calculated using the proposed methodology. The statistical features are extracted from the MRI images by wavelet decomposition followed by PCA algorithm for dimensionality reduction. The extracted features of the training set of images constitute the training feature database of MRI image. This database is used when a test input image is given to classify the brain tumor into either benign or malignant. Brain MRI Images are used to diagnose such as Benign, and Malignant based on the proposed supervised learning SVM classification algorithm. FCM based SVM classifier gave an accuracy of 94.37%, 98% of sensitivity, 98.19% of specificity, and 1.17% of error rate in experimental results. The future scope of this research is to adopt automated real-time brain tumor detection and classification integrated technique by studying and working with different types of neural network (ANN, CNN, PNN and DNN etc.)[13][14].

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