An Algorithm (MSG) for Tumor Detection from Brain MRI Images: Soft Computing Approach

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ABSTRACT - In current scenario detecting tumor is a major problem faced by medical practitioners. A Tumor may lead to cancer, which is major leading cause of death worldwide. Presently the medical experts for correct diagnosis are dependent on imaging owing to its accuracy and less computation time. Automatic detection of tumor through MRI of brain is effective and consumes lesser time this reduces physician's problem by providing useful imaging for diagnosis purpose. This paper presents an efficient segmentation and classification method for detecting tumor from MRI images of brain. This approach is hybrid of two techniques (i) K-means clustering technique (ii) Fuzzy C-means algorithm. The system is carried out in three phases. In first phase called preprocessing, image quality is enhanced. In second phase, feature extraction through GLCM (Grey Level Co-occurrence Matrix) and reduction is done. It extracts high dimensionality feature which leads to higher recognition rate. The third phase classification is done followed by performance analysis.The proposed hybrid method needs lesser computation time from K-mean and provides better accuracy compare d to FCM. It detects brain tumor accurately and performance analysis evaluated by comparing the results of existing algorithm. A performance criterion is based on accuracy, computation time, sensitivity and specificity. The affected part of brain and size of tumor from MRI image is identified with the help of MatLab R2013b. Large data-set has been considered for verification and evaluation of the proposed algorithm.

Keyword: MRI, Morphological operator, GLCM, Genetic algorithm, K-mean, FCM, ANN

I. INTRODUCTION

Brain is responsible for controlling all functions of human body, provides awareness of environment even it controls the muscles movements. MRI and CT scans are diagnostic modalities used to show the internal structure of brain. In this paper MRI images are used for finding affected area in brain. MRI is noninvasive so it is much popular among people and commonly used for determining size, shape and type of tumor. Unwanted cell grows in brain which may cause death of the human being. Abnormal cells in the form of lump, it found in brain is called brain tumor. In Normal process of brain, new cells are created an old or damaged cells die. When this process is not working old or damages cells often create a piece of mass tissues called tumor. There are two types of tumors primary and secondary. **Primary brain tumors** can be benign or malignant. Primary tumor commonly found in children and it originates from cells of the brain that support nervous system. **Secondary brain tumor** can be metastatic. It originates from cells of the other body parts and spreads to one and more areas. There are three stages:-1) **Benign:** In this type normal tissues are not affected by abnormal tissues and it does not spread to other parts. It is primary brain tumor. 2) **Malignant:** It is cancers cell cause to death and it grows rapidly. It is primary brain tumor. **3) Metastatic:** It starts in other body parts (lungs and breast) and reaches brain through the bloodstream. This growing form called secondary or metastatic brain tumor. It is very difficult to extract information from medical images of this type of tumor due to low contrasts, noise, and misplaced or diffusive edges [1]. Image segmentation is used to retrieve information from medical images for better diagnosis. Segmentation algorithms are based on image intensity values such as discontinuity and similarity [2]. There are many segmentation techniques such as based on histogram, based on edge, based on region (region splitting, growing, and merging), and based on clustering (Fuzzy C-means clustering, K-means clustering etc) [3–5]. In this paper an hybrid technique has been developed for tumor detection which is based on K-mean clustering and Fuzzy C mean algorithm followed by artificial neural network for tumor classification. Hybrid technique helps physician to detect tumor at an early stage. The detection of tumor at an early stage using

hybrid technique doctor can take correct decision and consequently the death ratio can be decreased.

II.RELATED WORK

Drissi & Ajmi[6] developed a hybrid segmentation method. It combined mathematical morphology operators and watershed method for segmentation. They combined the good qualities of both methods; morphological operators extract the tumor while the watershed provides brain structure details. Hybrid method is used for segmentation and then fusion phase is implemented for detecting tumor. They used Peak Signal-to-Noise Ratio (PSNR) and Structural SIMilarity (SSIM) quantitative criteria to present the quality segmentation. Proposed method provides an efficient and reliable result for the tumor extraction. Anitha & Perumal [7] proposed hybrid approach for segmentation of MRI images of brain. They combined an approach for brain tumor detection such as region growing and threshold segmentation technique. Image quality was enhanced using preprocessing. Then hybrid approach combines two processes namely region growing and threshold segmentation. They used centre pixel/fixed seed point for region growing segmentation and single threshold value for threshold segmentation. Finally Performance analysis was measured in terms of various quality metrics such as DICE and Jaccard similarity, accuracy, sensitivity and specificity. It successfully revealed the problem in single seed region growing method through it is not able to extract the holes in the tumor. This is revealed by this hybrid segmentation technique. Deshmukh & Khule[8] implemented a method for automated recognition system for MRI image followed by ANFIS (Artificial neural fuzzy inference system). They combined two methods: fuzzy logic and artificial neural network (ANN) which was called ANFIS for tumor detection. Image segmentation, feature extraction, histogram and filtration were used on input images. Features were extracted from MRI raw images then ANFIS was applied using Feed Forward Neural Network for tumor classification. This method was fast in execution, efficient in classification and easy in implementation. Maksoud et al. [9] proposed a hybrid method using K-means and Fuzzy C-means followed by thresholding technique. It combines benefits of both the method. K-means clustering technique is minimizes the computation time and Fuzzy C-means provides accuracy. The process performed in four steps:-i) Input image ii) Preprocessing (K-means clustering and Fuzzy C-mean) iii) Feature extraction iv) Validation by finding iteration time, accuracy, performance. K-means algorithm worked than Fuzzy C-mean but Fuzzy C-mean present t accurately. They focused on minimal time execution with accurate result. But method was not appropriate for 3D images. Naderi & Zadeh[10] proposed a method using ANN, Genetic Algorithm and Fuzzy logic. It decreased execution time and increases the accuracy for image segmentation using MRI images. This approach uses two steps preprocessing and post processing. In preprocessing followed by histogram equalization for image enhanced and median filter applied for filtration. After that threshold implemented for segmentation and features were selected by genetic algorithm. Finally images are classified by ANN technique. By this method accuracy was improved for detecting tumor in brain.

Sharma & Mukherjee [11] developed a method for brain tumor detection. They used a segmentation and Fuzzy C Mean technique. For feature extraction Artificial Network Fuzzy inference System and genetic algorithm used. They applied equalized histogram, morphological operator and edge detection for raw image. After that Gray Level Co- occurrence Matrix (GLCM) used for capturing numerical feature and twenty relevant features extracted. They were applied genetic algorithm for feature selection. A comparison based on existing technique and found proposed technique shows more accuracy (96.6%), sensitivity (95.3%) and specificity (98.67%). Megersa & Alemu [12] presented a hybrid technique. The proposed method is fully automatic tumor detection. It base on fuzzy Hopfield neural network. For segmentation T1-weighted and T2-weighted images used for detecting tumor. Quantitatively the method validated against ground truth using commonly used validation metrics, i.e., Jaccard similarity index, Dice similarity score, sensitivity and specificity. Syed & Narayanan [13] proposed a method for Brain Tumor Detection based on artificial neural network categorized into Multi-layer perceptron neural network. They used segmentation for feature extraction. They developed this method to discriminate normal and abnormal tissues through MRI scan images. This method helps doctors to analyze stage of cancer and consume less time. They were used preprocessing, histogram, binarization, thresholding, Morphological operation, GLCM based feature extraction and BPN based classifier.

III. PROPOSED METHODOLOGY

In proposed research work a hybrid (clustering and neuro fuzzy) technique used on larger database. MRI images are used for process and finding the abnormalities. Fuzzy inference systems associated with fuzzy-rule-based system if-then else and fuzzy-expert system. Both techniques have their advantages and disadvantages so both techniques combined for better result. Research methodology divided into three parts:

- Pre-processing for image enhancement
- Feature extraction (GLCM), creating rules using fuzzy logics and reduction of features

- Segmentation using hybrid technique (MSG) and classification (artificial neural network)

Terms used in proposed work are as follows:-

3.1 Image Preprocessing- This phase is used to enhance the image quality. Brain images are very sensitive than other images so high quality images are required for diagnosis. Using enhance image physician can extract accurate information in diagnosis. Image quality is enhanced using the following steps:

- Brain MRI image as input.
- **gray** and **histogram equalization.**
- **Removing Noise from** the image.
- **Filter** the image for enhancement.
- **Morphological Operations** applied on the image.

Terms used in pre processing are as follows:-

- Image is input to the developed system for processing. Image is converted into gray scale.
- Histogram equalization is applied to improve the image quality.
- Noisy Image -im = imnoise (Image, 'salt & pepper');
- Filtered Image- In median filter, the pixel value of a point p is replaced by the median of pixel value of 8-neighbourhood of a point 'p'. The basic operation of filter can be represented as:
  $m(p) = median\{f(p), where\ p \in N_8(p)\}$(1)

- **Morphological Operations-** It is very useful for sharpening regions and also fills gaps in image. Morphological operation is implemented for comparing corresponding pixels in the input image with its neighbors Erosion is used in proposed work which helps to turns object smaller. Mathematically it can be expressed as:
  (A_B)(x)={x∈ X, x=a+b: a ∈A b∈B} (2)

3.2 Feature extraction and selection – It is a procedure for extracting feature from pre processed image for separating normal image and abnormal image. Many techniques used for feature extraction like GLCM, Gabor and Fractals etc. These features are used for creating rules using fuzzy logics. Fuzzy inference system and genetic algorithm is used for feature selection. Genetic algorithm is implemented for feature optimization. GA reduced the features and select relevant data from image. Best features are selected for images segmentation. The aim of feature selection and reduction is to select relevant features from image. High dimensionality features increases system complexity which leads to higher recognition rate.

GLCM= graycomatrix(image,'Offset',[2 0;0 2]); (3)

Graycomatrix function is available in MATLAB.

Feature Selection- Fitness max represents maximum threshold value for a feature subset. Following features are selected from extracted features.

Table 1 Equation for selected Features for image

Feature Name	Mathematical equation
Contrast (Con)	$con_m = \sum_{i,j} \left\|i-j\right\|^2 p(i,j)$ (4)
Correlation (Cor)	$Cor = \sum_{i,j} \frac{(i-\mu i)p(j-\mu j)(i,j)}{\sigma_i \sigma_j}$ Were $\mu_x \mu_y$ and $\sigma_x \sigma_y$ are the mean and standard deviations of probability matrix GLCM (5)
Engery(E)	$E = \sum_{i,j} p(i,j)^2$ (6)
Homogeneity (HOM)	$HOM = \sum_{i,j} \frac{p(i,j)}{1+\left\|i-j\right\|}$ (7)
Entropy (En)	$En = \sum_{i=1}^{n}\sum_{j=1}^{m} p(i,j)\log_2\{p(i,j)\}$ (8)
Mean	$ME = \frac{1}{i*j}\sum_{j-1}^{i}\sum_{i=1}^{i} p(i,j)$ (9)
Standard deviation	$st = \sigma_j = \frac{\sqrt{\sum_{i=1}^{M}\left\|\mu_{i,j}-\mu_j\right\|^2}}{M-1}$ (10)
Skewness	$sk = \frac{E\left(p_j-\overline{p}\right)^3}{\sigma^3}$ (11)

Kurtosis	$k = \frac{E\left(p_j - \overline{p}\right)^4}{\sigma^4}$ (12)

3.3 Tumor segmentation In this phase hybrid technique MSG is used for classification based on K-mean clustering integrated with FCM. Classification is done using Neuro fuzzy system followed by performance analysis. Hybrid method combines the advantages of FCM and K-mean both are clustering algorithm. The proposed hybrid method adapts minimal computation time from K-mean and more accuracy from FCM. Hybrid technique is developed called MSG to detect tumor from MRI images.

Term used is this stage is as follows:

- **K-Means clustering** For retrieving information from medical images segmentation is essential. Clustering is used to divide data into groups. K-means clustering is popular method for clustering which is used to partitions of data into a *k* number group of data. There are two phase

a) Calculates the k centroid b) Selection of nearest centroid from the respective data point.

$$S(v) = \sum_{p=1}^{m} \sum_{q=1}^{m_p} \left(\|x_p - v_q\| \right)^2 \quad (14)$$

- **FCM clustering** It is used to separate cluster which are closer at very shortest distance. FCM determines a degree of membership which updates the cluster centers iteratively. Mainly it is following two steps: -
  a) Calculate the current position b) Modifying the current cluster center

The objective function is for FCM as follows:

$$u_{ij} = \sum_{i=1}^{n} \sum_{j=1}^{c} u_{ij}^m \|x_i - c_j\|^2 \quad (15)$$

- **MSG** proposed algorithm includes selection of cluster and centroid, fuzzy membership function, Euclidean distance to overcome the distance between data point and remove noise effect from MRI processed image. Then resultant algorithm is called MSG. The objective function for our proposed algorithm is as follows: -

$$Jm(U,V,T;X) = \sum_{i=1}^{k} \sum_{j=1}^{c} \left(a\mu_{ij}^m + bt_{ij}^c \right) D_{ij}^2 + \sum_{i=1}^{k} \gamma_i \sum_{j=1}^{c} \left(1 - t_{ij}\right) \quad (16)$$

For updating modified distance is: -

$$D\left(x_j, v_i\right) = D_{ij}^2 = \left(1 - \beta_j\right) d_i^2\left(x_j, v_i\right) + \beta_j d_n^2\left(x_j, v_i\right)$$ (i)

Cluster center updating using

$$v_i = \sum_{i=1}^{x} \left(a\mu_{ij}^m + bt_{ij}^x \right) x_j / \sum_{j=1}^{n} \left(a\mu_{ij}^m + bt_{ij}^x \right)$$ (ii)

Algorithm steps are as follows: -

Step 1 Transform the input data for segmentation. Read processed enhanced image and initialize

X={x_1, x_2, x_3……N).

Select cluster 'K' and fuzziness factor 'm'

Step 2 select a center from given data point V={v_i}; i=1,2,3,,4……c randomly and associated it with nearest centroid.

Step 3 when all data point process then create other group of centroid. If there is no new centroid then use objective function:

$$\mu = \sum_{k=1}^{k} \sum_{x=1}^{x} \|x_i - c_j\|^2 \quad \text{(iii)}$$

Euclidean distance calculate between i and j cluster.

Step 4 Calculate modified distance d_{ij}^2 using equation (2)

Step 5 then calculate the fuzzy membership μ_{ij} using

$$\mu_{ij} = 1 / \sum_{i=0}^{n} \left(d_{ij} / d_{ik} \right)^{2/m-1} \quad \text{(iv)}$$

Step 6 Calculate fuzzy center μ_j using $\mu_j = \sum_{i=1}^{n} \left(\mu_{ij}\right)^m x_i / \sum_{i=1}^{n} \left(\mu_{ij}\right)^m$ (v)

And update fuzzy membership for cluster center using equation (3)

Step 7

7. if condition is satisfied Termination criteria is $[\![v_{t+1} v_t]\!] < \beta$

Then select a threshold value

$$m(x, y) = \begin{cases} 1 \; if \; f\; x, y > T \\ 0 \; if \; x, y \le T \end{cases}$$

Stop

Else

Repeat steps 2 to 7 until termination or achieved the minimum j value.

Where

t is termination, β is criteria, ⟦ ⟧ is used to Euclidean distance

Facts about MSG are as follows:

- MSG algorithm takes less computing time so fast, robust and easier to understand.
- Accuracy is increased due separated data points.
- MSG belongs to more than one cluster; provides best results.
- Tumor is detected more accurately then individual algorithm

➢ **Classification** Supervised technique used for image classification followed by ANN and displays the desired results. For classification feed forward back propagation neural network is applied. It presents more accuracy and less computation time as compared with individual technique. Then performance analysis is done for proposed algorithm based on accuracy, sensitivity, specificity and similarity index. ANN function steps:

➢ It computes weights for all neurons apart from the neurons in the input layer.

➢ It creates the neural network with the input units.

➢ The calculation of the proposed Bias function for the input layer is:

3.4 Flow chart for proposed methodology is as follows

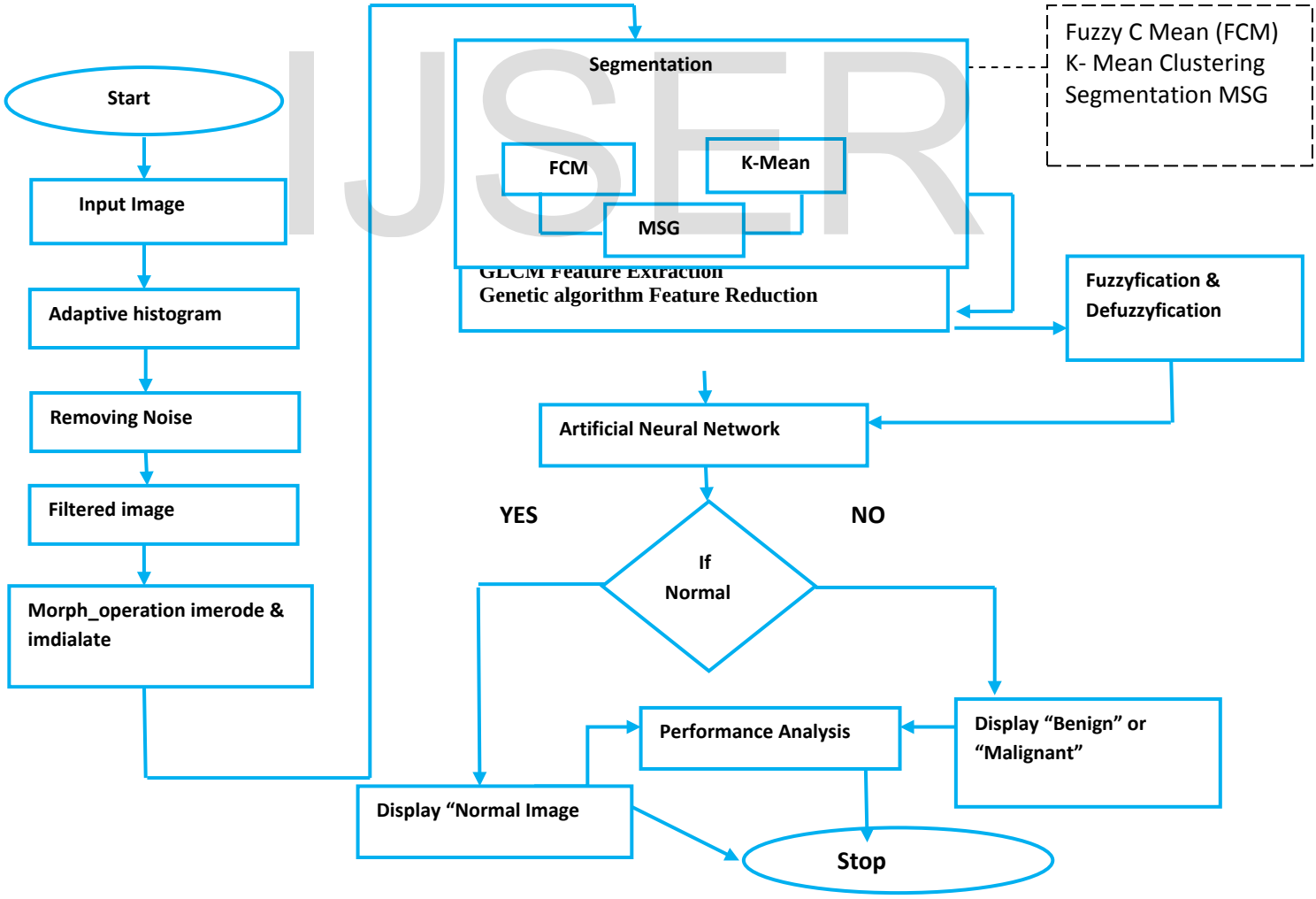


Figure 1 Flow chart for proposed approach

3.5 Algorithm for proposed hybrid MSG with Artificial Neural Network

Step 1start

Step 2 Input MRI image from dataset

Step 3 Images should convert into gray and applied adaptive histogram for enhancement.

Step 4 Pre-processing

4.1 Removing Noise from the image 4.2 Filtered image 4.3Morphological operation erode or dilate.

Step 5 Features are extracted using GLCM for the image

Step 6 Feature Reduction using Genetic algorithm

Step 7 Fuzzy inference systems for selected feature

Step 8 Segmentation using hybrid techniques MSG (Fuzzy C- means integrated with K-mean)

Step 9 Classification using Artificial Neural Network (ANN)

Step 10 Performance analyses based on accuracy, sensitivity, specificity, tumor type and area

Step 12 Stop

Sample dataset for proposed approach collected from web source. System is implemented on large amount of data. Data set is combination of primary and secondary data

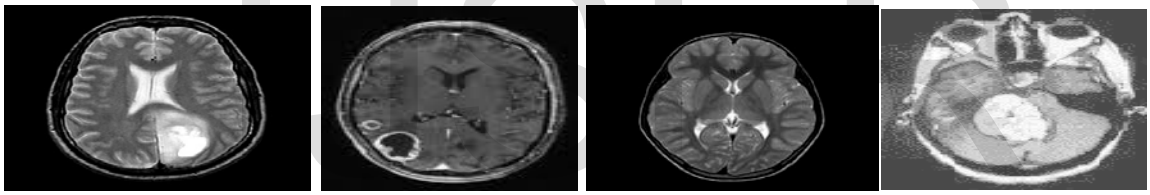


Figure 2 a) Tumor image b) Tumor image c) Normal image d) Tumor image

4. Results and Discussion

Preprocessing of image

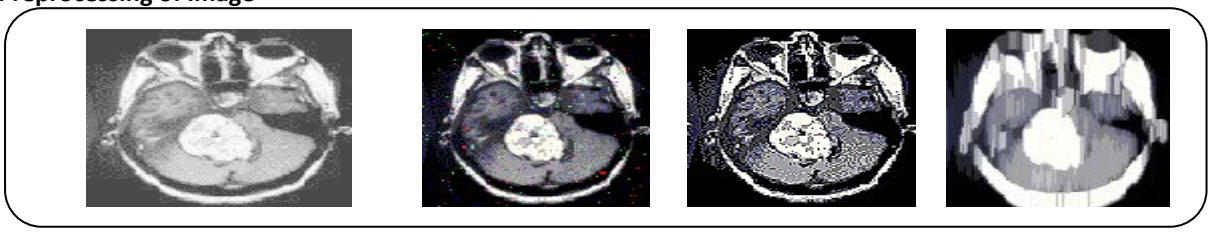


Figure 3 a) original image b) Enhanced image c) Noisy image d) Filtered image e) imdilate image

Segmentation using FCM and K-Mean

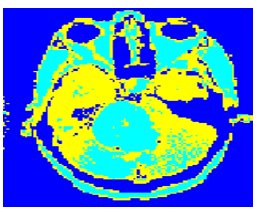
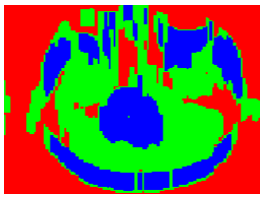


Figure 4 a) FCM **b) K-mean**

Proposed hybrid MSG approach for segmentation



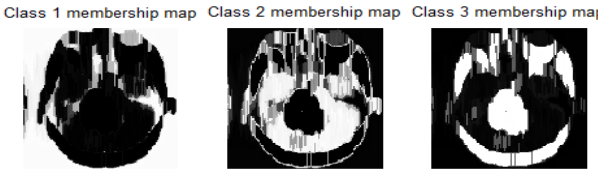


Figure 5 a) segmented image b) segmentation using membership map

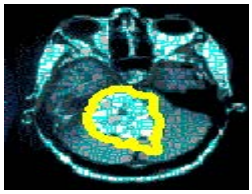


Figure 6 a) Detected Tumor part b) Tumor part within Mri brain Image

4.1 Performance Analysis: - After that performance analysis will be done. Results will compare with existing techniques. And show how much accuracy will appear through our method. It will hope to present better result so it will helpful for diagnosis process.

Performance Metrics- To evaluate medical systems, there are several measurements usually used. In this paper, three metrics were used; accuracy, specificity, and sensitivity.

TP= True Positive, TN=True Negative, FP= False Positive, FN= False Negative

The following equations used to measure the performance:-

Table 2 equations used to measure the accuracy, specificity and sensitivity

Performance criteria	**Equation**
Accuracy	$(TP + TN)\ /(TP + TN + FP + FN) * 100$
Specificity	$TP\ /(TN + FP) * 100$
Sensitivity	$TP\ /(TP + FN) * 100$

The True Positive (TP) and True Negative (TN) are correct classification. A False Positive (FP) occurs when the output is incorrectly predicted as yes (or positive) when it is actually no (negative). A False Negative (FN) occurs when the output is incorrectly predicted as no (or negative) when it is actually is yes (positive).

Table 3 Comparison with other Technique

Method	**Accuracy**	**Sensitivity**	**Specificity**
FCM	85%	96%	93.3%
K-mean	87.3%	93.12%	93.10%
Morp_operation +Watershed	89.2%	88.9%	90%
K-mean +GA	91%	89%	90%

MSG	100%	100%	98%

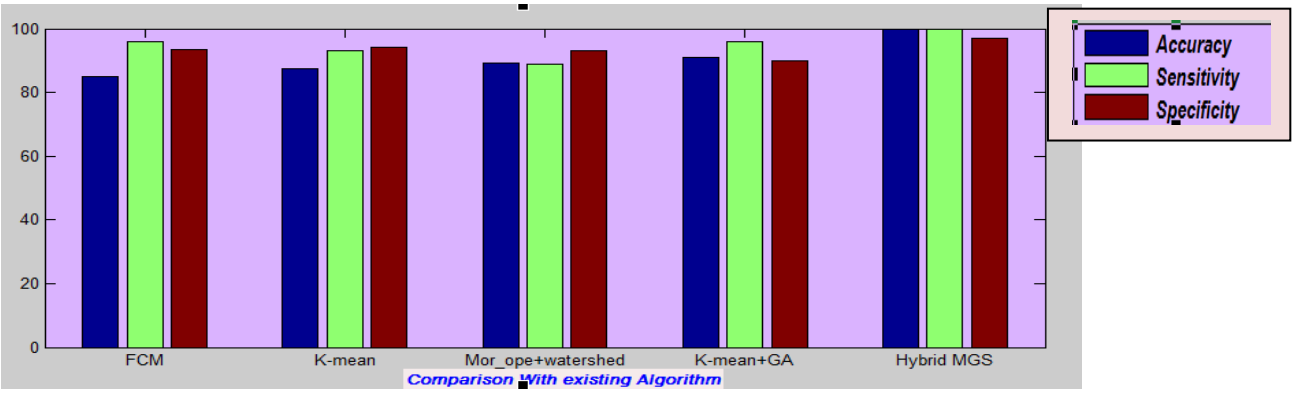


Figure 7 Comparison with existing algorithm

CONCLUSION

For retrieving information from medical images segmentation is used.MRI is popular image model used for diagnostic brain tumor. is noninvasive so it is very much popular among people and commonly used for finding tumor size, shape and type. In this paper a hybrid technique is proposed to detect tumor and for classification. It integrated K-mean clustering with FCM and artificial neural network which is used to detect a brain tumor accurately. So a combined technique is used to detect and classifying tumor from brain MRI images. Proposed work is divided into three phases i) Pre- processing ii) Feature Extraction (GLCM) iii) Tumor segmentation (MSG) and Classification. Experimental results determine the effectiveness of our approach. Proposed algorithm compared with the individual techniques. Performance criteria based on accuracy, sensitivity, specificity, similarity index and computation time.

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