A Novel Approach for Content based Mri Brain Image Retrieval

Amit Kumar Rohit, N. G. Chitaliya

Abstract: With increasing amount in neuro patients which increases workload on small group of radiologists, a new system is needed that help radiologists for getting essential information like types of image, extraction of tumor and retrieve the similar images for references to take treatment planning for neuro patient. In this paper, a new content based MRI brain image retrieving method is to be designed using Discrete Wavelet Transform based feature extraction, Support Vector Machine based classifier and Euclidean Distance based matching method. New tumor detection method is to be designed using Incremental Supervised Neural Network and Invariant moments.

Index Terms: Content Based Image Retrieval (CBIR); Discrete Wavelet Transform (DWT); Euclidean Distance; Incremental Supervised Neural Network (ISNN); Invariant Moment; Support Vector Machine (SVM).

I. INTRODUCTION

In recent year, with the growing amount of aging population, cancer has become a global public health problem. According to World Cancer Research Fund's latest statistics, each year about 12.7 million people are diagnosed with cancer, and 7.6 million people died of cancer [21]. As a kind of cancer, brain tumor is a very dangerous and harmful disease. It has a high incidence and high mortality, which ranks the fifth in the whole tumors and it is just below the stomach cancer, uterine cancer, breast cancer and esophageal cancer [22]. Diagnosis and treatment of brain tumor cost is very large and it lasts for a longer period. The doctors need to check on the every stage of the disease and takes last examination as referral to develop the treatment plan for the next therapy. As each year, neuro patients are increased which lead to lot of manual workload on small Radiology group. Therefore, a system is needed that provide the Radiologists an essential information like type of images, detection of tumor and similar case images from the large database and take these data as a reference for taking accurate decision for treatment planning for Neuro patients. CBIR is a process of retrieving the most similar images from the large database as per the visual content of the images [1] and gives the essential information like type of images. In this paper, a new CBIR method is introduced that gives the similar images as well as detect tumor in tumorous image. The paper is organized as follows: In section (**II**), other related work to CBIR is described. The proposed method is discussed in section (**III**). In section (**IV**), result analysis of our method is discussed. The conclusion is described at the end in section (**V**).

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II. RELATED WORK

In the recent years, CBIR systems have been developed to organize and utilize the valuable image sources effectively and efficiently for various collections of images [2]. Most of the recent CBIR systems in biomedicine are designed to classify and retrieve images according to the anatomical categories of their content. R. Guruvasuki and A. Josephine [2] have proposed a CBIR method using GLCM based texture features extraction and multi SVM based classification. Here the result show that it gives good result in multiqueries but in single query result is not satisfactory. Hatice Akakin and Metin N. Gurcan [1] have proposed CBIR system which uses a multi-tiered approach for retrieving images. In first tier they classified images using SVM in two main types and K- nearest neighbors are used in second tier for classified the subtypes of the two main types. Here the robustness of the method is increased due to these two classifiers. The method is used only for multi-image query. Here they have not discussed the performance evolution of the retrieval process. Mohanpriya S. and Vadivel M. [3] have proposed a new CBIR system for classified and retrieves the images from the database. They also used two tiered approach for classified the MRI images. Here also the robustness is increased due to the two classifiers. The method is also for multi image query and cannot be used for single query. Hashem K. et. al. [8] have proposed the MRI image classification method and compare the classification results using two different classifiers, KNN and SVM. They classified the images in eight different classes and concluded that SVM gives better classification result than KNN. Yudong Z. et. al. [6] have proposed a hybrid method for image MRI image classification. They extracted texture features using wavelet transform and classified MRI images using Back Propagation Neural Network. The result of their method is good. Chaplot S. et. al. [7] have proposed the MRI image classification method for classified the images in normal and abnormal class and compare the classification result using different classifiers. They also concluded that SVM classifier gives better result than ANN.

III. PROPOSED METHOD

We propose new methodology for Content Based Image Retrieval (CBIR) for MRI Brain Image based on single query system. The architecture of proposed method is shown in **Fig.1**. Here, user query image is given the preprocessing step for noise removal. After preprocessed the image is projected onto the feature space by extracting the texture features using wavelet transform. Categorization of query image is done by means of SVM classifier.

The database images are also classified in the same way for refining the searching. Euclidean Distance matching algorithm is utilized for searching the relevant images for the large database that helps radiologists to take the clinical decision for treatment planning of the neuro patients. After that if any query image is detected as tumorous, the tumor is detected using Incremental Supervised Neural Network (ISNN) and invariant moments. Our method is divided in two different scenarios. In First scenario MRI image is classified in two different categories: Normal and Tumorous. In second scenario if any tumorous image is detected by classifier, the system detects the tumor in image. At last similar image is retrieved.

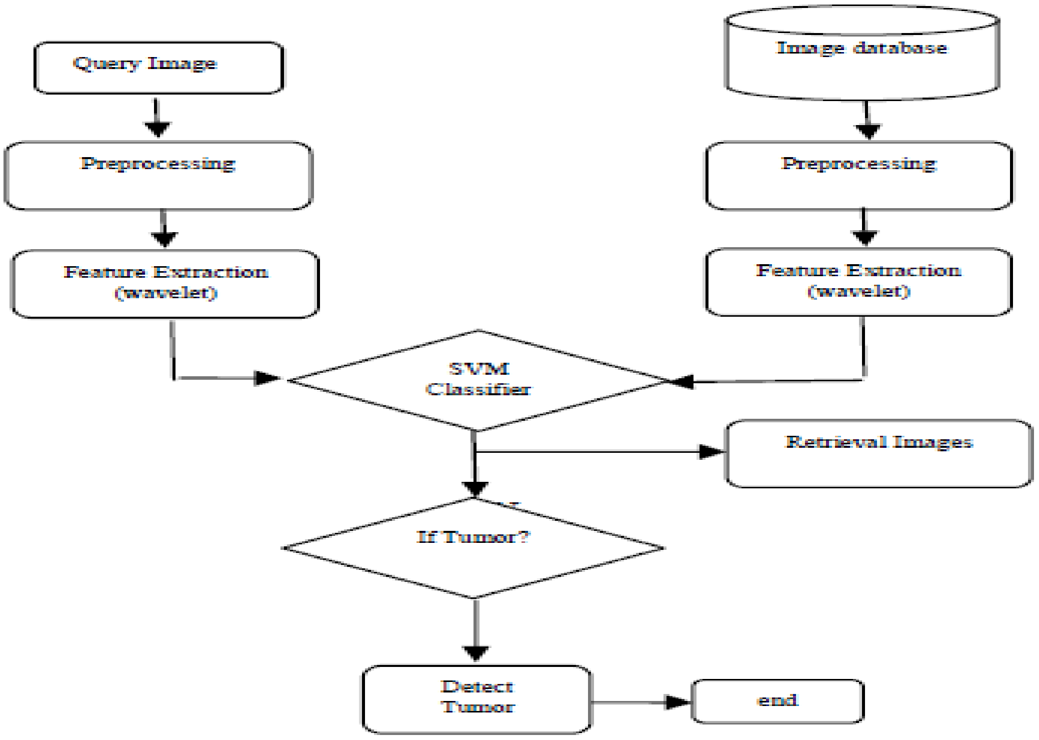

Fig. 1 Proposed Method

Prepocessing

Prepocessing step is noise removing step. Most of the MRI images are passed through many sources. Therefore noise should be removed before extracting the features. Median Filter is used for noise removing because it remove the noise as well as preserved the edge information in images where low pass filter remove the noise but also blur the edge information in image [2]. Median filter does not shift the boundary as can happen with conventional low pass filter. Since it takes a median value of the empty mask, the extreme value is easily removed using median filter.

A. Image Classifier

Image classifier part consists of three basic steps: Preprocessing, feature extraction, classification. The explanation of each step is shown below:

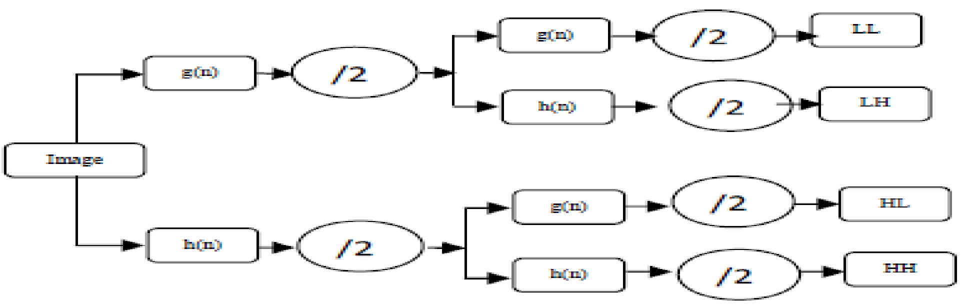

Fig. 2 Wavelet Decomposition

Feature Extraction

When input data is too large to process, it is transformed in reduce set of features (feature vector). Thus process of transforming an input data in set of feature is called feature extraction [2]. Here feature is extracted using wavelet transform. The main advantage of using wavelet transform is that it provides localized frequency information of an image which is useful for classification [6]. Wavelet transform decomposed the signal using mother wavelet signal. In this method we use two levels 2 D Discrete Wavelet Transform (DWT) for feature extraction (wavelet coefficients). Haar basis filters are used for decomposition. **Fig. 2** shows the process of a two-level 2D DWT. In this figure, h[n] and g[n] denote the low-pass and high-pass basis decomposition filters respectively. As shown, at each level of 2D DWT of an image, four sub-bands are obtained: LL (low-low), LH (low-high), HL (high-low), and HH (high-high). LL sub band is considered as the approximation (low pass) component of image, while LH, HL and HH subband represents vertical, horizontal, and diagonal detail components of image. Here the second level approximate coefficients are only extracted as feature vector. So for 256 x 256 size image, after 2D DWT of second level 4096 features are extracted from single image.

SVM Classifier

Support Vector Machine (SVM) is a binary classifier based on supervised learning. It classifies the images by creating an optimal hyperplane between the data points of two different classes [14]. Soft margin SVM (C-SVM) with radial basis function (RBF) kernel is used for classification of images. The expression of RBF kernel is: $\exp(-\gamma \|X_i - X_j\|^2)$ where γ is the variance. Here the images are classified in normal and tumorous category. In order increase the performance of SVM classifier the optimum value of γ is found using 10 fold cross validation method. Using this method best accuracy is achieved when value of γ is 33. **Table 1** shows the classification performance of proposed method.

Table 1 Classification Result From Support Vector Machine

Method	No of Images in Training		No of Images in Testing		Images Misclassified		Classification Accuracy (%)
	Normal	*Tumor*	*Normal*	*Tumor*	*Normal*	*Tumor*	
SVM With RBF Kernal	30	30	30	30	1	0	98.33%
Total	60		60		1		98.33%

B. Tumor Detection

Tumor detection method basically divided in two types [9]:

1) Mid Sagittal Plane Extraction
2) Segmentation

Here for detection of tumor, these two methods are combined. So tumor portion along with its position in particular segment is known. **Fig. 3** shows the block diagram of tumor detection method where MRI brain image is first segmented in seven classes (six different head tissues and background). Seven classes are given labels as per no of pixels it contained. The background contained highest number of pixel so it is given a first label. By discarding the background pixels, the head region is extracted. Symmetric axis in that head region is found by using moment properties. After that any asymmetry on both the side of symmetry axis is found by using invariant moment. Any asymmetry detected in the head region indicates the tumor in MRI Brain image.

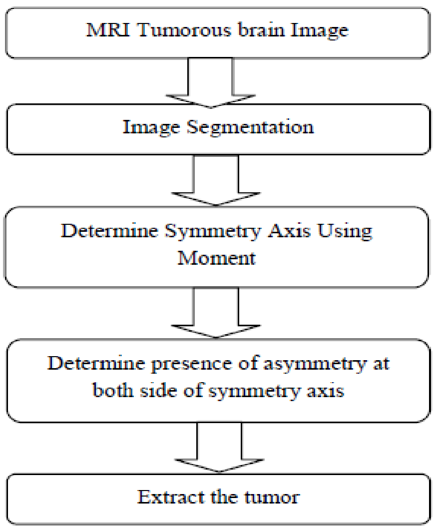

Fig. 3 Block Diagram of Tumor Detection

Image Segmentation

Segmentation is a process of dividing an image into a region [17,18]. Here MRI Brain Image is segmented using Incremental Supervised Neural network (ISNN). The ISNN is a supervised learning method with incremental structure. The input layer nodes of the ISNN are formed by choosing vectors from the training set.

All the vectors in the training set have their own class labels. Learning algorithm of the ISNN computes the Euclidean distances between the first layer nodes of the ISNN and the input vector, and finds the minimum distance, i.e., first layer nodes compete. Counter is given to the every node of first layer.

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The classes of the input node (the node nearest to the input vector) are compared. If their classes are same then weight is updated according to equ. (1). If their classes are not equal new node is included in the first layer and input vector is given as weight vector of that node. Thus the node in first layer is incremented in this way. **Fig. 4** shows the Structure of ISNN.

$$W_{ji}(k+1) = W_{ji}(k) + \mu\, (X_i(k) - W_{ji}(k) \qquad (1)$$

k = iteration number

μ = learning rate = 0.05

Algorithm:

1) Initially choose vectors randomly from the training set as many as the number of classes. Each vector represents only one class. Assign each chosen vector as a first layer node. Initialize the iteration number to zero.

2) Increase the iteration number. If the iteration number is equal to a predetermined maximum value, terminate the algorithm. Otherwise, go to step 3.

3) Choose one vector randomly from the training set. Compute the distances between each first layer node of the ISNN and the input vector, and find the winner node at the minimum distance.

4) Compare the class of the input vector and the winner node. If their class is same, modify the weights of the winner node according equ.(1), increase the counter value and go to step 2. Otherwise go to step 5.

5) Include the input vector in the ISNN as a new first layer node. The elements of the input vector are assigned as the associated weights of the new first layer node of the ISNN. Increase the counter of the new node by one and go to step 2.

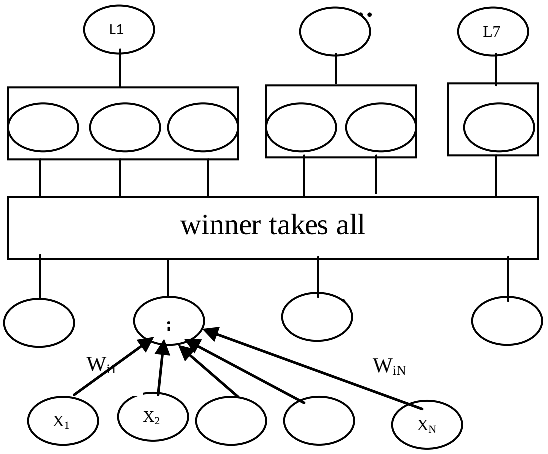

Fig. 4 Structure of ISNN

Node Removing

Each First layer node is assigned a counter. The counter value is increased for every winner node. As the node is incremented as their class is not equal, there are so many nodes that belong to each of the seven classes. Therefore at next stage, node is removed. At node removing stage, all the particular one class nodes are consider and takes any one node which have maximum counter value i.e. all the first class nodes are taken and select the one node out of them whose counter value is maximum. Same procedure is done for all other class. Therefore, at second stage only seven nodes are gotten each represent different class.

Fig. 5 shows the tumorous image as classified by SVM classifier. **Fig. 6** represents the segmented MRI brain image after segmentation done by ISNN algorithm. **Fig. 7 to 13** shows segmented image of class one to seven respectively.

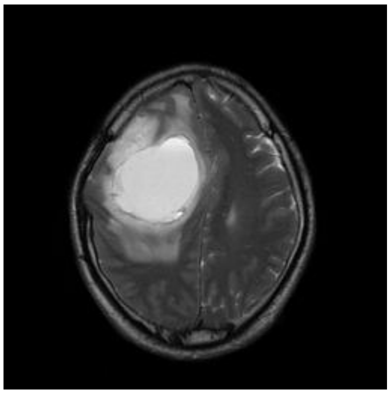

Fig. 5 Tumorous Image

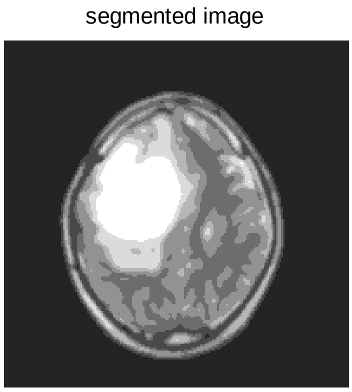

Fig. 6 Segmented MRI Brain Image

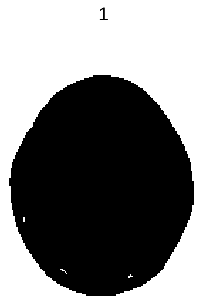

Fig. 7 Segmented First Tissue

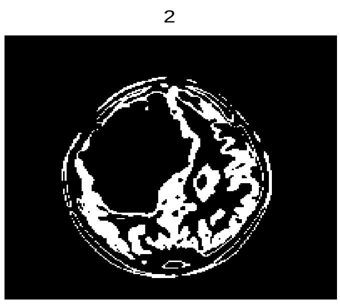

Fig. 8 Segmented second tissue

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Fig. 9 Segmented Third tissue

4

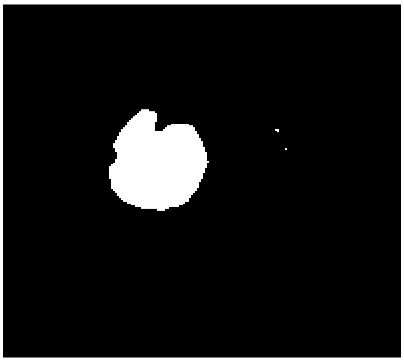

Fig. 10 Segmented Forth Tissue

5

Fig. 11 Segmented Fifth Tissue

6

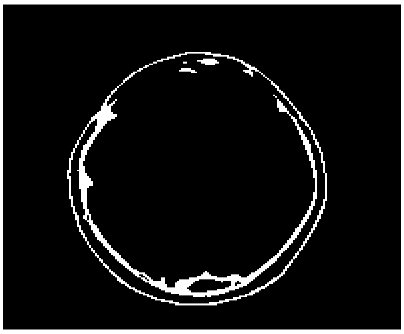

Fig. 12 Segmented Sixth Tissue

7

Fig. 13 Segmented Seventh Tissue

Determine Symmetry Axis Using Moment

MRI brain image is segmented in seven class using ISNN. Now, Tissues (labeled) sequentially as T1 – T7 are given according to number of pixels it contained. So, highest number of pixel with labeled 1 is nothing but background.

Algorithm:

1) Region related to brain is extracted from background by discarding the pixel belonging to T1. Simple assign the ‘1’ value to those pixel in the head and ‘0’ to the background pixels.
2) Angle between the Y axis and the axis passing through the center of mass in head’s direction that is θ_{head} computed by,

$$\Theta_{head} = ½ \arctan |2m_{11}/ (m_{20} - m_{02})| \quad (2)$$

m_{pq} represent the central moment

$$m_{pq}= \sum_{(x,y)} \sum_{\in T}(x - xbar)^p(y - ybar)^q$$

$$xbar = 1/N \sum_{(x,y)} \sum_{\in T} x$$

$$ybar = 1/N\sum_{(x,y)} \sum_{\in T} y \quad (3)$$

3) Symmetry axis (line inclined at an angle of θ_{head} from y axis) is,

$$Y_{sym}=x.\cos(\theta_{head}) + y.\sin(\theta_{head}) \quad (4)$$

x and y are the coordinates of the segmented MRI image.

Fig. 14 shows the MRI head with symmetric axis that is drawn using geometric moment properties.

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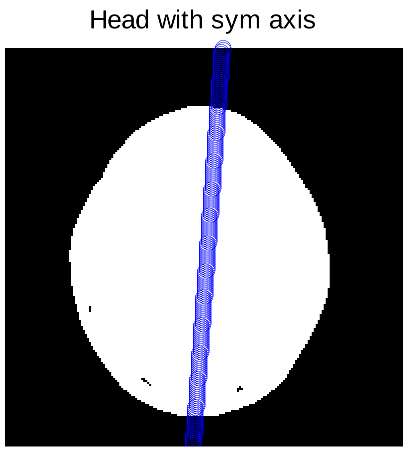

Fig. 14 Head with Symmetry Axis

Determine Presence of Asymmetry at Both Side of Symmetry Axis

After getting symmetry axis, presence of asymmetry on both the side has been check for detection of tumor. So in this step matching on both the side of symmetry axis is found. For that give the label to left and right side of symmetry axis as L and R respectively.

m_{00} = mass of the object = numbers of pixels.

$$m_{Ri,00}= \sum_{(x,y)} \sum_{\in Ri}(x - xbar)^0 (y - ybar)^0 \quad (5)$$

$$m_{Li,00}=\sum_{(x,y)} \sum_{\in Li}(x - xbar)^0 (y - ybar)^0 \quad (6)$$

$$m_{Ti,00} = m_{Li,00} + m_{Ri,00} \quad (7)$$
$$WA_{Li} = m_{Li,00} / m_{Ti,00} \quad (8)$$
$$WA_{Ri} = m_{Ri,00} / m_{Ti,00} \quad (9)$$
$$WA_i = | WA_{Li} - WA_{Ri} | \quad (10)$$

Where $m_{Ri,00}$ and $m_{Li,00}$ indicates the number of pixel on right and left side of symmetry axis and in ith tissue respectively. WA_i is used to to determine tissue with tumor. Based on invariant moment [9,18] computed for the left and right hand sides of the symmetry axis,

$C1_{-6R,i}$ and $C_{1-6L,i}$ component are computed.

$$m_{Ri,pq} = m_{Ri,pq} / m_{Ri,00} \quad (11)$$
$$m_{Li,pq} = m_{Li,pq} / m_{Li,00} \quad (12)$$
$$C_{1R,i}= m_{Ri,20} + m_{Ri,02} \quad (13)$$
$$C_{1L,i}= m_{Li,20} + m_{Li,02} \quad (14)$$

$$C_{2R,i}= (m_{Ri,20} - m_{Ri,02})^2 + 4m_{Ri,11}^2$$
$$C_{2L,i}= (m_{Li,20} - m_{Li,02})^2 + 4m_{Li,11}^2 \quad (15)$$

$$C_{3R,i}= (m_{Ri,30} – 3m_{Ri,12})^2 + (m_{Ri,21} - 3m_{Ri,03})^2$$
$$C_{3L,i}= (m_{Li,30} – 3m_{Li,12})^2 + (m_{Li,21} - 3m_{Li,03})^2 \quad (16)$$

$$C_{4R,i} = (m_{Ri,30} + m_{Ri,12})^2 + (m_{Ri,03} + m_{Ri,21})^2$$
$$C_{4L,i}= (m_{Li,30} + m_{Li,12})^2 + (m_{Li,03} + m_{Li,21})^2 \quad (17)$$

$$C_{5R,i} = (m_{Ri,30} - 3 m_{Ri,12}) (m_{Ri,30} + m_{Ri,12})[(m_{Ri,30} + m_{Ri,12})^2 - 3(m_{Ri,21} + m_{Ri,03})^2] + (m_{Ri,03} - 3m_{Ri,21}) (m_{Ri,03} + m_{Ri,21}) [(m_{Ri,21} + m_{Ri,03})^2 - 3(m_{Ri,30} + m_{Ri,12})^2]$$
$$C_{5L,i} = (m_{Li,30} - 3 m_{Li,12}) (m_{Li,30} + m_{Li,12}) [(m_{Li,30} + m_{Li,12})^2 - 3(m_{Li,21} + m_{Li,03})^2] + (m_{Li,03} - 3 m_{Li,21}) (m_{Li,03} + m_{Li,21}) [(m_{Li,21} + m_{Li,03})^2 - 3(m_{Li,30} + m_{Li,12})^2] \quad (18)$$

$$C_{6R,i} = (m_{Ri,20} - m_{Ri,02}) [(m_{Ri,30} + m_{Ri,12})^2 - (m_{Ri,21} + m_{Ri,03})^2] + 4 m_{Ri,11}^2 (m_{Ri,30} + m_{Ri,12}) (m_{Ri,21} + m_{Ri,03})$$
$$C_{6L,i} = (m_{Li,20} - m_{Li,02}) [(m_{Li,30} + m_{Li,12})^2 - (m_{Li,21} + m_{Li,03})^2] + 4 m_{Li,11}^2 (m_{Li,30} + m_{Li,12}) (m_{Li,21} + m_{Li,03}) \quad (19)$$

$$V_{Li} = [C_{1L,i}\ C_{2L,i}\ C_{3L,i}\ C_{4L,i}\ C_{5L,i}\ C_{6L,i}]$$
$$V_{Ri} = [C_{1R,i}\ C_{2R,i}\ C_{3R,i}\ C_{4R,i}\ C_{5R,i}\ C_{6R,i}] \quad (20)$$

$$| V_{Li} | = \sqrt{(C1L,i)^2 + \cdots + (C6L,i)^2} \quad (21)$$

$$| V_{Ri} | = \sqrt{(C1R,i)^2 + \cdots + (C6R,i)^2} \quad (22)$$

$$D_i=\sqrt{(C1L,i - C1R,i)^2+..+(C6L,i - C6R,i)^2} \quad (23)$$

D_i distance is weighted by,

$$WD_i = D_i \times |WA_{R,i} – WA_{L,i}| \quad (24)$$

Extract the Tumor

The T^{th} tissue that the longest weight distance is accepted to contained the tumor. So location of tumor is search with in this tissue. T^{th} tissue is smoothed by median filter. So pixels which do not belong to the tumor in the T^{th} tissue are removed. The highest pixel intensity in image is searched. The coordinates of the highest pixel intensity is taken as seed pixel for region growing process. **Fig. 15** shows the extracted tumor region in Image. After tumor portion is extracted, the area of tumor is calculated by calculating the pixel that contained 255 value in the image.

C. Image Retrieval

After Query image has been classified, the Euclidean Distance [3,11,12] is found between the query image and images in the database in same class as the query image. The Euclidean Distance is defines as,

$$D = \sqrt{\sum_{i=1}^{N}(Xi - Yi)^2} \quad (25)$$

X_i = query image feature vector

Y_i = feature vector of images in database

After calculating the Euclidean distance, it is placed in ascending order. The no of images in the database are retrieved with the smallest distance between the query image and images of same category as query image in the database as per the user requirement. **Fig. 16** shows the five most similar images in database to original tumorous query image (**Fig. 5**).

IV. RESULT & ANALYSIS

A. Dataset

The proposed CBIR method has been implemented on real Human Brain MRI dataset. All the input dataset consist two types of images: Normal and Tumorous in axial plane. The images were collected from Hospitals and from Harvard Medical,School,http://www.med.harvard.edu/AANLIB/home.html) [15] website.

C. Result Of SVM Classifier

We have implemented SVM in Matlab 2013a with the inputs being the wavelet- coded images, using the SVM Matlab toolbox, for our classification. The classification result of our method is given in table. The classification performance is tested with changing the kernals of SVM which is shown in **Table 2.**

The best accuracy of classification is gained using RBF kernel. The comparison table of proposed method with other authors' method is shown in Table 3. Result shows that our method gives good result.

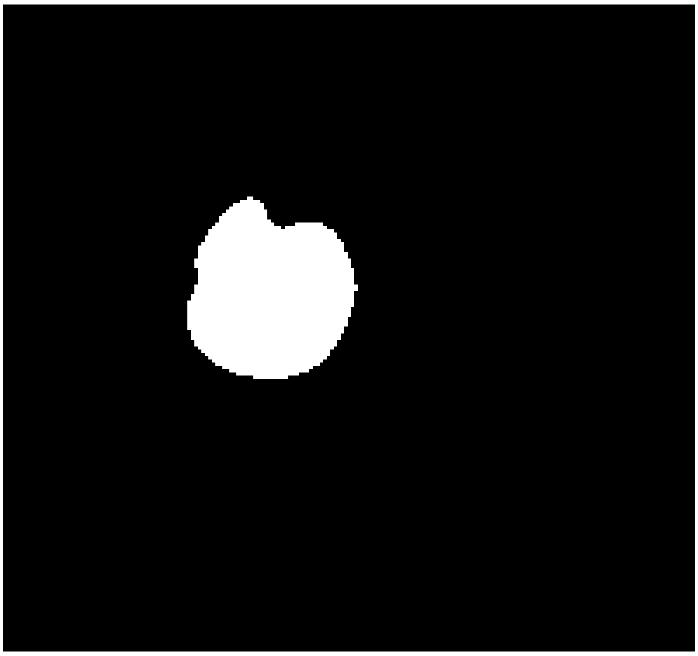

Fig. 15 MRI Image Contain Tumor

Area of Tumor = 1899

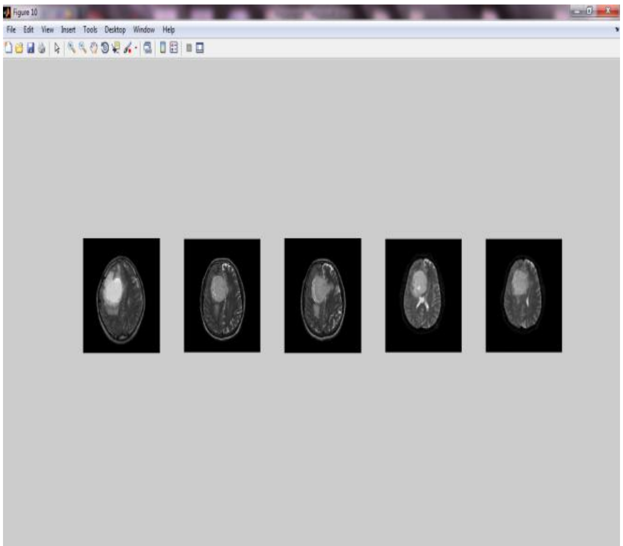

Fig. 16 Retrival Images

C. Result of Tumor Detection

In this study sixty original MRI Brain images have different size tumor and at different location are used for checking the result. **Table 4** shows the tumor detection result which shows that sixty images are tested using this method and in forty eight images it is correctly detected. **Table 5** shows the some tumorous images which are tested and the tumor area after tumor detection.

Table 2

Classification Accuracy comparison with other Kernals

No	Approach	Classification Accuracy (%)
1	DWT + SVM with linear kernel	86.54
2	DWT + SVM with polynomial kernel	90.38
3	Proposed method	98.33

Table 3

Classification Accuracy comparison with other Methods

No	Approach	Classification Accuracy (%)
1	DWT + PCA + ANN (EI-Dahshan, Hosny, & Salem, 2010)	98.33
2	DWT + PCA + k-NN (EI-Dahshan et al., 2010)	96.66
3	Proposed method	98.33

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Table 4

Tumor Detection Result

No of Image Tested	Correctly Detected Tumor
60	48

Table 5

Tumor Area Calculation

No	Image	Area
1	1.jpg	896
2	2.jpg	800
3	3.jpg	1673
4	5.jpg	999
5	6.jpg	1474
6	8.jpg	988
7	9.jpg	1786
8	11.jpg	2001
9	12.jpg	1116
10	13.jpg	913
11	14.jpg	259
12	15.jpg	1279
13	16.jpg	510
14	18.jpg	3849
15	20.jpg	1139
16	22.jpg	2086
17	23.jpg	1062
18	24.jpg	1367

V CONCLUSION

In this paper New Content Based MRI Brain Image Retrieval method is designed along with MRI brain classification and tumor detection. Two different scenarios are considered in this method. In the First scenario, Images are classified in normal and tumorous category using SVM with RBF kernel. The parameter of RBF kernel is found using 10 fold cross validation method. The accuracy achieved is 98.33% in this method. The proposed method is also compared by using different kernals of SVM and different authors' method. Result shows that RBF kernel gives better result in image classification and gives good accuracy. In second scenario, Tumor is detected using ISNN and invariant moment. The method is tested on Sixty MRI Brain tumor images those have tumor with different size and at different location. In forty eight MRI images the tumor is correctly detected. The accuracy achieved is 80.00% in tumor detection. The proposed method gives robust result for both classification and tumor detection.

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