A NOVEL APPROACH FOR MRI BRAIN IMAGE CLASSIFICATION AND DETECTION

Mrunal H. Suthar[1], Megha Gupta

[1]*M. Tech (Student), Dept of E.C.E, J.D.C.T., Indore, INDIA*
[2] *M.E, Asst. Prof., Dept. of E.C.E., LNCTS (RIT), Indore, INDIA*

---***---

Abstract - *Medical image processing is the most challenging and emerging field now a day's. In this field, detection of brain tumor from MRI brain scan has become one of the most challenging problems, due to complex structure of brain. The quantitative analysis of MRI brain tumor allows obtaining useful key indicators of disease progression. In this paper, a new method for MRI brain image classification & detection is to be designed using Discrete Wavelet Transform based feature extraction, Support Vector Machine based classifier and New tumor detection method is to be designed using Incremental Supervised Neural Network and Invariant moments.*

Key Words: Discrete Wavelet Transform (DWT); Support Vector Machine (SVM); Incremental Supervised Neural Network (ISNN); Invariant Moments.

1. INTRODUCTION

A Cancer is a disease, which is characterized by the uncontrolled growth and spread of abnormal cells. Cancer has become the global public health problem as it has been found that worldwide one in seven deaths occur due to cancer. According to American Cancer Society's latest statistics, in 2012 about 14.1 million peoples are diagnosed with the cancer, and 8.2 million people died of cancer. And by 2030, 21.7 million peoples are expected to be diagnose with the cancer and 13 million peoples are expected to died due to cancer. These figures show that these rates will keep increasing every year [19]. A brain tumor is mass or collection of abnormal cells in the brain. If the spreading of cancer is not stopped the it can cause the death of patient.
The cost of the diagnosis and treatment of brain tumor is very high. So, a system is needed that help the Radiologists doctors to get essential information like type of MRI Image, tumor extraction, tumor area 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. The treatment of brain tumor depends upon the both location of the tumor and size of the tumor. In this paper proposed method will not help only classify the tumorous image and detect the tumor only but it will also give you the area of tumor i.e size of tumor.

1.1 RELATED WORK

Pranita Balaji, Kanade and P.P. Gumaste [1], proposed brain tumor detection method for MRI images. In this paper, the brain tumor is detected & classified stages of the tumor by using testing & training the database. Proposed methodology consists of following main stages: image preprocessing, de noising, SWT & segmentation, feature extraction and classification. In the first step, median based filters and SWT technique are used for de-noising the image. Then spatial FCM technique is used for segmentation and Stationary wavelet transform (SWT) technique is used for feature extraction, as SWT coefficients will not change even if the signal is shifted. In the last step, using Probabilistic neural networks (PNN) images are classified with the help of extracted features.

R. Guruvasuki and A. Josephine Pushpa [3], have designed the method using multi support vector machine classifier. The image is preprocessed with median filter. The Gray Level Co-occurrence Matrix is used for feature extraction. Multi-Support Vector Machine (M-SVM) classifier is used for classification of three types of image.

Monika Jain, Shivanky Jaiswal, Sandeep Maurya, Mayank Yadav [11], have proposed strategy for detection of tumor with the help of segmentation techniques in MATLAB; which incorporates preprocessing stages of noise removal, image enhancement and edge detection. Processing stages includes segmentation. Tumor region is extracted using over global thresholding method. Post proposing stage include histogram clustering, morphological operations. In this step the shape of tumor is determine and also area is calculated.

Sandeep Chaplot, L.M. Patnaik, N.R. Jagannathan [8], propose a novel method using wavelets as input to neural network self-organizing maps and support vector machine for classification of magnetic resonance (MR) images. In this paper, they have used the wavelets as input to support vector machine and neural network.

1.2 PROPOSED METHOD

We propose new methodology for Tumor Classification and detection for MRI Brain Image based on single query system. The flow cuhart of proposed methodology is shown in **Fig. 1**. Here, user query image is given the pre-processing step for noise removal. After pre-processed 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 tier MRI image is classified in two different categories: Normal and Tumorous. In second tier if any tumorous image is detected by classifier, the system detects the tumor in image.

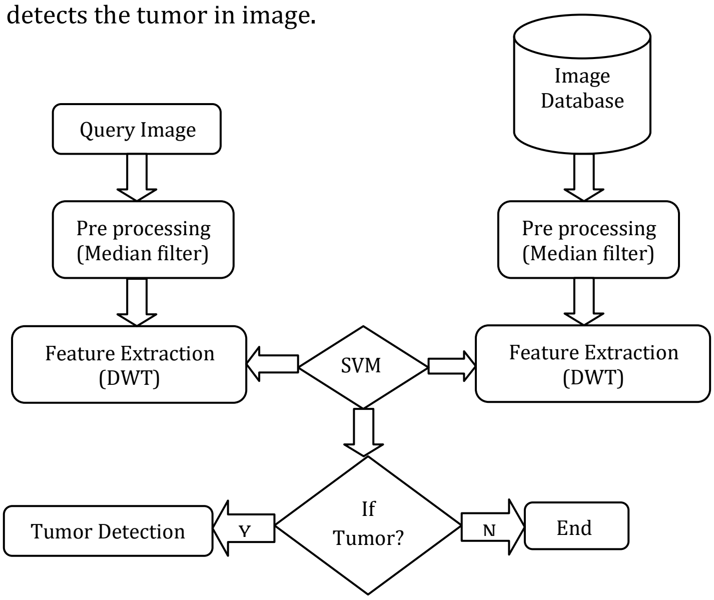

Fig -1: Proposed Method

[A] Classification

Classification part consists of three steps: Preprocessing, Feature Extraction and Classification.

Preprocessing: The preprocessing step is nothing but noise removal step. Median filter is used for noise removing from the images. The advantage of this method is that it does not blur the edge information of image.

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]. We have used the wavelet transform for the same. The main reason 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. Haar basis filters are used for decomposition. **Fig. 2** shows the process of a two-level 2D DWT. In this figure, HP and LP denote the high-pass and low-pass basis 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 sub band represents vertical, horizontal, and diagonal edge detail of image.

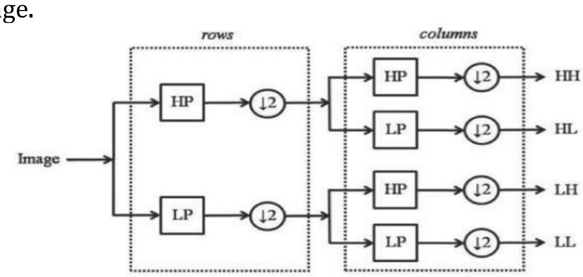

Fig -2: Diagram of wavelet decomposition

Classification using SVM: 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. Here Radial Basis Function (RBF) kernel is used for classification because it gives better result than other kernel. The optimization parameter of RBF kernel is less than other kernals. RBF kernel function can be defined as; exp $(-\gamma ||X_i - X_j||^2)$, where γ is the variance. For increasing the performance the optimum value of γ can be found using 10 fold cross validation method.

Table 1 shows the classification result of the proposed method. As shown in Table total thirty images of normal and tumorous both category is given for training set and thirty images of both category images are tested. The classification accuracy of our method is 98.33 percent. **Table 2** shows the comparison table in which the accuracy of proposed method is compared with SVM with other kernals. Result shows that RBF kernel gives better result than the polynomial and linear kernel. **Table 3** shows the comparison of classification result of proposed method with other authors' method.

[B] Tumor Detection

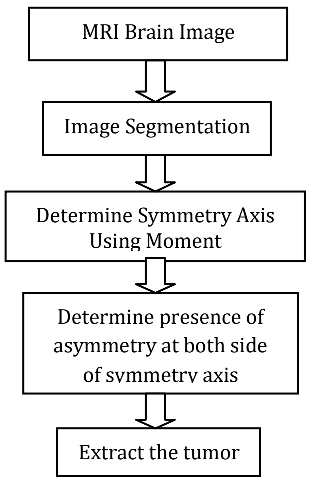

Fig -3: Block Diagram of Tumor Detection

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%

TABLE 2
Classification Accuracy comparison with other kernals

Sr. 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 authors' method

Sr. 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

The second part is tumor detection part. In proposed method, if any tumorous image is detected by classifier, the tumor is detected from this tumorous image. Tumor detection methods are divided in two staps [9]:
(i) Mid Sagittal Plane Extraction
(ii) Segmentation

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

As shown in Fig. 3 tumor detection part consists of four steps.

(1) Image Segmentation using ISNN:

Segmentation is the process of dividing an image into a region [18]. Here MRI Brain Image is segmented using Incremental Supervised Neural network (ISNN). The ISNN is the supervised learning method with incremental structure. By choosing vectors from the training set, the input layer nodes of ISNN are formed. All the vectors are in the training set have their own class labels. The learning algorithm of ISNN calculate 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. Counter has given to the every node of first layer. The classes of both the input vector and winner node (the node nearest to the input vector) are compared. If the classes are same then weight is updated according to equation (24). If the classes are not equal then new node is included in the first layer and the input vector is given as weight vector of that node. Thus the node in first layer is incremented by this way. **Fig. 4** shows the Structure of ISNN.

$$Wji(k+1) = Wji(k) + \mu\,(Xi(k) - Wji(k)) \quad (1)$$

k = iteration number
Wji =ith weight of the jth winner node
μ = learning rate = 0.05

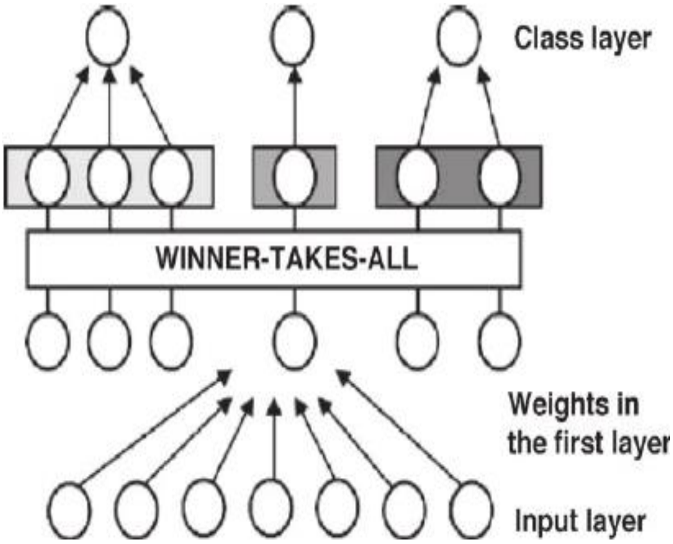

Fig -4: Structure of ISNN

Algorithm for ISNN:

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

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

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

4) Compare the classes of the input vector and winner node. If the classes are the same, modify the weights of the winner node according to equ. (24), increases the counter value and then go to step 2. Otherwise go to step 5.

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

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 using ISNN algorithm and **Fig. 7 to 13** shows the segmented image of class one to seven respectively.

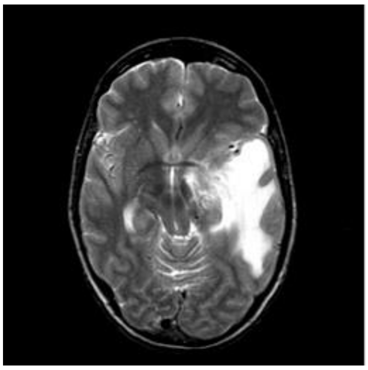

Fig -5: Tumorous Image

segmented image

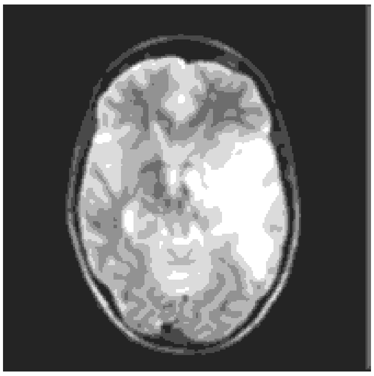

Fig -6: Segmented MRI Brain Image

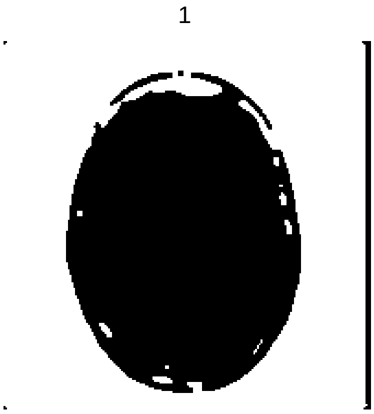

Fig -7: Segmented First tissue

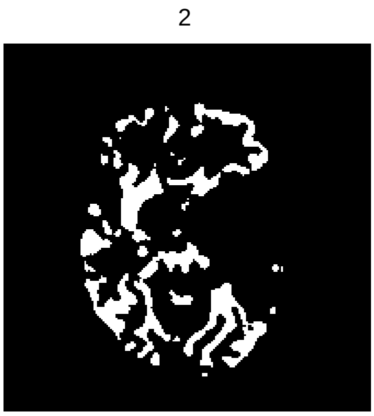

Fig -8: Segmented Second tissue

Fig -9: Segmented Third tissue

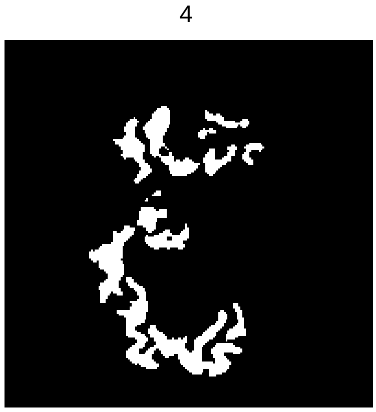

Fig -10: Segmented Forth tissue

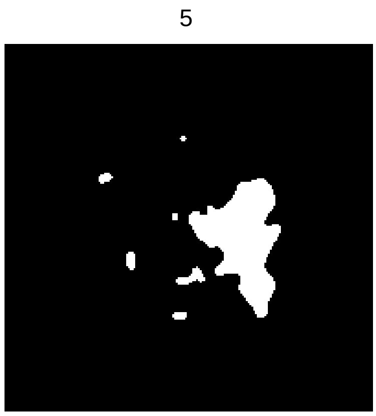

Fig -11: Segmented Fifth tissue

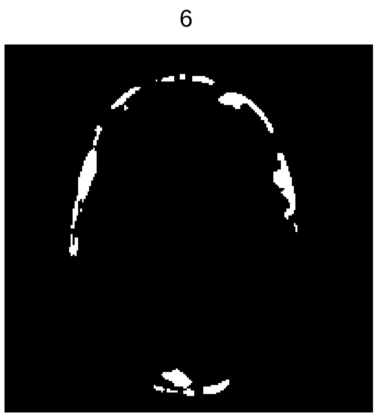

Fig -12: Segmented Sixth tissue

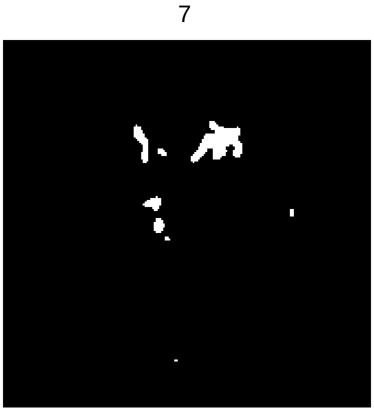

Fig -13: Segmented Seventh tissue

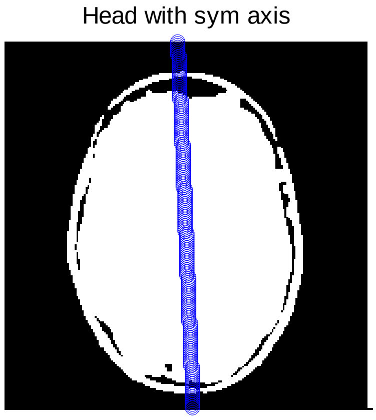

Fig -14: Head with Symmetric Axis

(2) Determine Symmetry Axis Using Moment:

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

Algorithm:

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

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

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

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

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

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

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

(3) Determine Presence of Asymmetry at Both Side of Symmetry Axis;

After getting symmetry axis, presence of asymmetry on both the side can be check for detection of tumor. So in this step matching on both the side of symmetry axis is found. Give the label to left symmetry axis as L and right side of symmetry axis as L.

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

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

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

$m_{Ti,00} = m_{Li,00} + m_{Ri,00}$ (7)

$WA_{Li} = m_{Li,00} / m_{Ti,00}$ (8)

$WA_{Ri} = m_{Ri,00} / m_{Ti,00}$ (9)

$WA_i = |WA_{Li} - WA_{Ri}|$ (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 for determining the tissue with the tumor. Based on the moment computed for left hand sides and right hand sides of the symmetry axis, $C1_{-6R,i}$ and $C_{1-6L,i}$ component are computed.

$m_{Ri,pq} = m_{Ri,pq} / m_{Ri,00}$ (11)

$m_{Li,pq} = m_{Li,pq} / m_{Li,00}$ (12)

$C_{1R,i} = m_{Ri,20} + m_{Ri,02}$ (13)

$C_{1L,i} = m_{Li,20} + m_{Li,02}$ (14)

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

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

$C_{3R,i} = (m_{Ri,30} - 3m_{Ri,12})^2 + (m_{Ri,21} - 3m_{Ri,03})^2$

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

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

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

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

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

(18)

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

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

(19)

$V_{Li} = [C_{1L,i}\ \ C_{2L,i}\ C_{3L,i}\ C_{4L,i}\ C_{5L,i}\ C_{6L,i}\ ]$

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

$|V_{Li}| = \sqrt{(C1L,i\,)^2 + (C2L,i\,)^2 + \cdots. + (C6L,i\,)^2}$ (21)

$|V_{Ri}| = \sqrt{(C1R,i\,)^2 + (C2R,i\,)^2 + \cdots. + (C6R,i\,)^2}$ (22)

$D_i = \sqrt{(C1L,i - C1R,i)^2 + (C2L,i - C2R,i)^2 + \cdots + (C6L,i - C6R,i)^2}$ (23)

D_i distance is weighted by,

$WD_i = D_i x |WA_{R,i} - WA_{L,i}|$ (24)

(4) Tumor Extraction:

Algorithm for tumor extraction:

1) The Tth tissue that have the longest weight distance is accepted to contained the tumor. So location of tumor is search with in this tissue.

2) Tth tissue is smoothed by using median filter. So that the pixels which do not belong to the tumor in the Tth tissue are removed.

3) The highest pixel intensity in image is searched. The coordinates of the highest pixel intensity is taken as seed pixel for the region growing process.

Fig. 15 shows the extracted tumor part in Image. After tumor portion is extracted, the area of tumor has calculated by calculating the pixel which contained 255 value in the image. There are of give image is 1786.

Fig -15: MRI image showing tumor part

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 4
Tumor Detection Result

No of Image Tested	Correctly Detected Tumor
60	48

3. CONCLUSIONS

In this paper new method is designed for 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.

REFERENCES

[1] Parveen and Amritpalsingh, "Detection of Brain Tumor in MRI Images, using Combination of Fuzzy C-Means and SVM," 2nd International Conference on Signal Processing and Integrated Networks (SPIN),pp. 98-102, 2015.

[2] Hatice CinarAkakin and Metin N. Gurcan,"Content-based microscopic image retrieval system for multi-image queries", IEEE Transaction on Information Technology in Biomedicine, Vol. 16, No. 4, pp 758-768, 2012.

[3] Guruvasuki, A. Josephine Pushpa Arasi, "MRI brain image retrieval using multisupport vector machine classifier", International Journal of Advanced Information Science and Technology, Vol. 10, No 10, pp 29-36, 2013

[4] Mohanpriya S., Vadivel M, "Automatic Retrieval of MRI Brain Image using Multiqueries System", ***IEEE Conference***, pp 1099-1103, 2013.

[5] B.Ramasubramanian, G. Praphakar, S. Murugeswari, " A Novel Approach for Content Based Microscopic Image Retrieval system Using Decision Tee Algorithm", International journal of scientific& engineering research, Vol. 4, No 6, pp 584-588, 2013.

[6] Yudong Zhang, Zhengchao Dong, LenanWua, ShuihuaWanga, "A hybrid method for MRI brain image classification", Elsevier journal Expert system and Application, Vol. 20, No 2, pp 10049-10053 ,2011.

[7] Hashem Kalbkhani, Mahrokh G Shayesteh, Behrooz Zali-vargahan "Robust algorithm for Brain Magnetic Resonance Image Classification based on GARCH variances Series", ELSEVIER Biomedical Signal Processing and Control 8(2013) 909-919

[8] Sandeep Chaplot , L.M. Patnaik , N.R. Jagannathan ,"Classification of magnetic resonance brain images using wavelets as input to support vector machine and neural network", ***Elsevier Journal on Biomedical Signal Processing and Control, Vo.1, No 1***,pp 86 -92 ,2006.

[9] Z. Iscan, Z. DokurandT. Olmez, "Tumor detection by using Zernike moments on segmented magnetic resonance brain images", Elsevier Journal of Expert system and Application, Vol. 37, No 3, pp 2540-2549, 2010.

[10] ShenFurao, Tomotaka Ogura, Osamu Hasegawa, "An Enhanced Self Organizing Incremental Neural network For Online Unsupervised learning", ***Elsevier Journal on Neural Network, Vol. 20, No 8***, pp 893-903, 2007.

[11] Monika Jain, Shivanky Jaiswal, Sandeep Maurya, Mayank Yadav " A Novel Approach for the Detection & Analysis of Brain Tumor," International Journal of Emerging Technology and Advanced Engineering, vol. 5, Issue 4, pp. 54–59, 2015.

[12] R. S. RajKumar and G. Niranjana, "Image Segmentation and Classification of MRI Brain Tumor Based on Cellular Automata and Neural Networks," IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 1, Issue 1, March 2013.

[13] KetanMachhale, HariBabuNandpuru , VivekKapur and LaxmiKosta, "MRI Brain Cancer Classification Using Hybrid Classifier (SVM-KNN)," International Conference on Industrial Instrumentation and Control (ICIC), pp.60-65, 2015.

[14] Padma Nanda Gopal & R.Sukanesh," wavelet stat ist ical feature based segmentat ion and classificat ion of brain computed tomography images"IET Image P rosess Vol7 pp 25 -32 2013

[15] KailashSinha and G. R. Sinha, "Efficient Segmentation Methods for Tumor Detection in MRI Images," IEEE Student's Conference on Electrical, Electronics and Computer Science, pp.1-6, 2014.

[16] Pranita Balaji Kanade, Prof. P.P. Gumaste, "Brain tumor detection using mri images," International journal of innovative research in electrical, electronics, instrumentation and control engineering, vol. 3, issue 2, pp.146-150, february 2015.

[17] Amir Ehsan Lashkari, "A Neural network based Method for Brain Abnormality Detection in MR Images using Zernike Moments and Geometric moments", International Journal of Computer Appliction, Vol. 4, No 7,pp 1-8, 2010.

[18] El- Shayed A El Dahshan, Tamel Hosny, Abdel- badech M. Salem, "Hybrid intelligent techniques for MRI brain images classification", Elsevier Journal of Digital Signal Processing, Vol.20 , No 2 ,pp 433-441,2010

[19] Brain Tumor Facts & Statistics: http://www.sdbtf.org/facts-boutbt.html

[20] R.C. Gonzalez, R.E. Woods, "Digital Image Processing, second edition, Pearson Education, Ch. Wavelet and Multi resolution Processing", pp. 349–408 , 2004.

BIOGRAPHIES

Mr. Mrunal Suthar has received his B.E. degree in Electronics and Communication Engineering from Veer Narmad South Gujarat University, Surat, India in 2011. He is currently pursuing his M.Tech degree in Electronics and Communication Engineering from RGPV, Madhya Pradesh, India. His research interests include Medical Image Processing and optical communication.