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## Fuzzy C-Means, ANFIS and Genetic Algorithm for Segmenting Astrocytoma –A Type of Brain Tumor

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*Abstract-Imaging plays an important role in medical field like medical diagnosis, treatment planning and patient follow up. Image segmentation is the backbone process to accomplish these tasks by dividing an image in to meaningful parts which share similar properties. Medical Resonance Imaging (MRI) is primary diagnostic technique to do image segmentation. There are several techniques proposed for image segmentation of different parts of body like Region growing, Thresholding, Clustering methods and Soft computing techniques (Fuzzy Logic, Neural Network, Genetic Algorithm).The proposed research work uses Grey level Co-occurrence Matrix(GLCM) for texture feature extraction, ANFIS(Adaptive Network Fuzzy inference System) plus Genetic Algorithm for feature selection and FCM(Fuzzy C-Means) for segmentation of Astrocytoma (Brain Tumor) with all four Grades. The comparative study between FCM, FCM plus K-mean, Genetic Algorithm, ANFIS and proposed technique shows improved Accuracy, Sensitivity and Specificity.*

**Keywords:** MRI, ANFIS, FCM, Astrocytoma, Grades I to IV, GLCM, K-means

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### 1. INTRODUCTION

Image Segmentation is a process that groups pixel which has similar attributes. The results can be used in medical field for treatment planning, tumor identification, to analyze tumor growth and computer assisted surgery. This can be done in two ways: Manual Segmentation and Automatic Segmentation. Manual segmentation is a versatile technique but can be affected by fatigue and large number of images. While automated methods provide rapid identification of tumor in comparison to manual segmentation and also results are reproducible [1]. There are various image segmentation algorithms like, Edge Based algorithms, Region based algorithms [2][3], data clustering algorithms[4], Thresholding [5][6]. But, proposed research work focus literature survey related only to the algorithms for brain tumor Segmentation. D.Jude Hemanth[7] shows superior nature of ANFIS over Fuzzy and neural network in terms of accuracy and convergence rate. Noor Elaiza Abdul Khalid [8] presents a which are used comparative study between ANFIS, FCM, and K-NN.FCM and K-NN performs better in case of light abnormalities while ANFIS in case of dark abnormalities. Hassan Khotanlou [9] proposed a technique which integrates region-based and contour based methods for improving precision of brain tumor segmentation. He uses fuzzy clustering technique, morphological operation and deformable model to implement proposed work. Logeswari [10] proposed brain tumor detection and segmentation method in which he divides proposed work in two phases-one is pre-processing and in second phase HSOM(Hierarchical self-organizing map) is applied. In last a brief comparison with other classifiers is done. Shasidhar [11] proposed a modified FCM algorithm for segmenting brain tumor. MFCM improves segmentation efficiency and computational time required for convergence. Rami J.Oweis [12] proposed pixel classification of medical image using neuro fuzzy approach, which rely on spatial properties of the image and uses multiscaled representation of image. S.Murugavalli [13] proposed a neuro fuzzy approach to detect tissues like white matter, gray matter, csf and tumor. He uses HSOM and FCM algorithm to classify images. He gave a comparative study between SOM-K-mean, SOM-Fuzzy, HSOM-K-mean and HSOM-fuzzy. M Sharma [14] proposed a technique for brain tumor augmentation using ANFIS and Genetic algorithm. She improved existing methods in terms of accuracy, sensitivity, specificity by using proposed algorithm. From previous work study it is analyzed that there are various combination of algorithms used for segmenting brain tumor. Proposed research work uses ANFIS, Genetic, FCM algorithms from them which strengthen individual weakness. The organization of the rest of this paper is as follows: Section 2 presents proposed work methodology, Section 3 discusses results. Finally, we present our conclusion and future scope in Section 4.

### 2. PROPOSED WORK

The proposed work is divided in to five steps: Adaptive Histogram Equalization, Morphological Erosion, Edge Detection (Canny edge detection),Feature Extraction using GLCM, feature selection using genetic algorithm and for Extracting tumor area(Fuzzy c-means segmentation) is used as shown in fig 2.1.

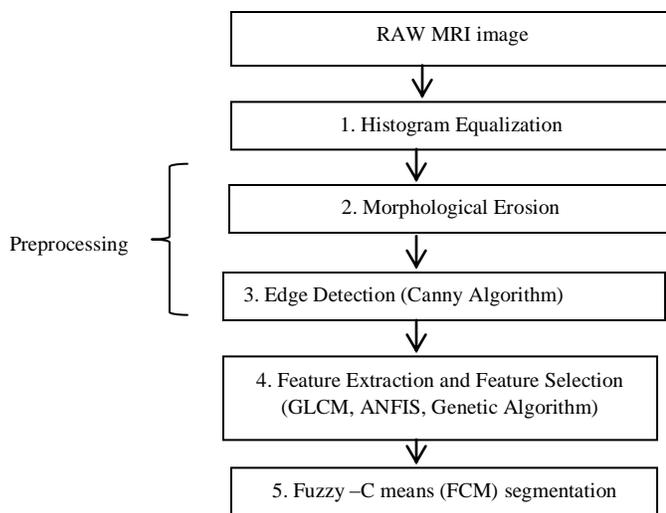


Fig. 2.1 Steps involved in Proposed Methodology

### 2.1 Raw MRI image Database

Proposed research work uses Astrocytoma type of brain tumor images. Astrocytoma has four GRADES -Pilocytic Brain Tumor (GRADE-1), Low Grade Brain Tumor (GRADE-2), Anaplastic Brain Tumor(GRADE-3),Giloblastoma Brain Tumor (GRADE 4). Pilocytic and Low Grade brain tumor came under the category of Benign Brain Tumor while Anaplastic and Giloblastoma Brain Tumor are Malignant type of Brain Tumor.

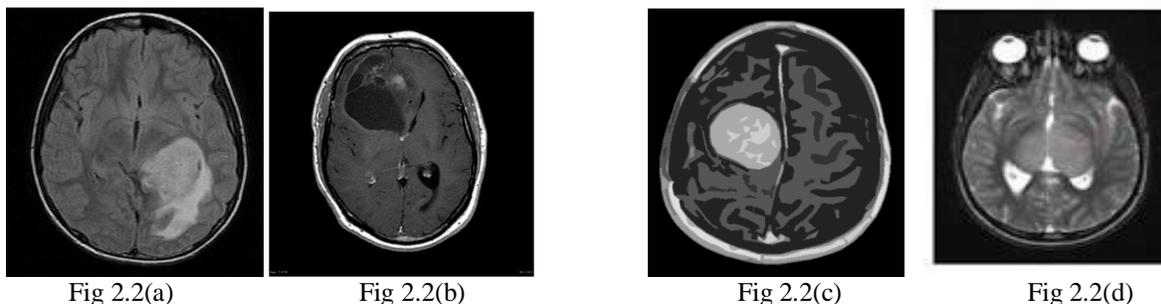


Fig 2.2(a)

Fig 2.2(b)

Fig 2.2(c)

Fig 2.2(d)

Fig 2.2 (a) Pilocytic Brain Tumor (GRADE-1)

(b) Low Grade Brain Tumor (GRADE-2)

(c) Anaplastic Brain Tumor (GRADE-3)

(d) Giloblastoma Brain Tumor(GRADE 4).

Primary focus of proposed work is to classify these four grade to know severity of tumor. Generally Grade 1 and 2 (Close to normal) is less harmful than Grade 3 and 4 (Worst). A database is prepared to classify these all four grades.

### 2.2 Adaptive Histogram Equalization

First step of proposed work is to preprocess raw MRI images. Preprocessing is the basic step to remove noise. Performance of further steps relies on preprocessing. Proposed work uses CLAHE (Contrast limited adaptive histogram equalization) for improving contrast of MRI images. CLAHE is a contrast enhancement algorithm proposed by Karel Zuiderveld [14]. CLAHE does not work on entire image. Instead it works on small portion of image. Finally output of small areas are combined using bilinear interpolation method. CLAHE is applied using function `adapthisteq` which is built-in function in MATLAB 7.0 where  $I$  represent input image and  $A$  is resulting image.

MATLAB:  $A = \text{adapthisteq}(I)$

### 2.3 Morphological Erosion

This is used as an image preprocessing tool to sharpen regions and to fill gaps of binarized image. There are four basic morphological operations defined like dilation, erosion, opening and closing [15]. Here, proposed research work uses morphological erosion. In erosion every pixel which touches background pixel is converted into background pixel. Objects become smaller after applying erosion. Mathematically erosion can be represented as,

$$(A \ominus B)(x) = \{x \in X, x = a + b : a \in A, b \in B\} \quad (1)$$

Where A is matrix of binary image and B is mask

MATLAB: BW2 = imerode (BW1,SE);

Where SE is structuring element

#### 2.4 Edge Detection

Edge detection algorithms are used to find sudden changes in an image and also reduces amount of data by filtering useless information. There are various edge detection algorithm like sobel, prewit, LoG, Canny. This proposed research work uses Canny edge detection algorithm [16] because it performs better under all conditions [17][18].

MATLAB: EDGE (IMAGE, 'Canny');

#### 2.5 Feature Extraction

For an image, features are the characteristics of the objects. Texture is the main feature of an image. Feature extraction is the process of extracting some features from the pre-processed image. These features are used for segmenting image. Image segmentation can be done in two ways: stastical approach and structured approach. Proposed research work uses stastical approach. There are several stastical techniques for measuring texture such as co-occurrence matrix, Fractals, Gabor filters, wavelet transform [19]. Proposed research work uses Gray Level Co- occurrence Matrix (GLCM) .GLCM captures numerical feature values using spatial relationship among neighborhood pixels features. These numerical feature values are used for further comparing and classifying features [19].GLCM extract 20 texture features (Autocorrelation, Contrast, Correlation, Cluster Prominence, Cluster Shade, Dissimilarity, Energy, Entropy, Homogeneity, Maximum probability , Sum of squares, Variance, Sum average,, Sum variance , Sum entropy, Difference variance , Difference entropy ,information measure of Correlation, Information measure of correlation2 Inverse difference (INV), Inverse difference normalized (INN) Inverse difference moment normalized )which are calculated using function available in MATLAB 7.0 for a given image:

GLCM2 = graycomatrix(image,'Offset',[2 0;0 2]) Where, image is used for grey scale image. Table 2.5.1 shows feature extracted for an image using function available in MATLAB

Table 2.5.1 20 GLCM Features

Feature No	Feature Name	Feature Values
1	autocd	43.1530
2	contrd	1.8692
3	corrpd	0.1392
4	cpromd	34.6933
5	cshad1	5.2662
6	energd	0.1233
7	Dissid	0.6877
8	entrod	2.6980
9	homopd	0.65645
10	maxprd	0.6411
11	sosvhd	0.1973
12	savghd	44.9329
13	svarhd	13.2626
14	senthd	133.5676
15	dvarhd	1.8188
16	denthd	1.8927
17	inf1hd	1.2145
18	inf2hd	-0.0322
19	indnkd	0.2863
20	idmnkd	0.9107

#### 2.6 Feature Selection using Genetic Algorithm and ANFIS (adaptive network fuzzy inference System)

Feature selection helps to reduce the features which improve the prediction accuracy and also computation time is reduced. The main aim of feature selection is to select those features which are relevant and informative. Mostly search procedures are used for feature sub set selection. Popularly used feature selection algorithms are Sequential forward Selection, Sequential

Backward selection, Genetic Algorithm and Particle Swarm Optimization. Proposed research work uses Genetic algorithm for selecting features obtained from GLCM (Grey Level Co-Occurrence Matrix). Genetic algorithm is a popular soft computing technique which is used for feature subset selection. There are several approaches which follow Genetic algorithm to solve feature subset selection problem[20]. Genetic Algorithm is a very robust technique but computational time taken by it is high when no. of features are large. So, a filter approach is used with Genetic Algorithm. Proposed research work uses ANFIS (Adaptive neural network fuzzy inference System) as filtering tool for Genetic Algorithm. Genetic Algorithm based feature subset selection algorithm which uses ANFIS for fitness function follows following step:

1. GLCM extracts 20 texture features. Mark them as Feature1, Feature 2 and so on.
2. Following Parameters For Genetic Algorithm are set:  
Population Size: 10  
Maximum Chromosome Length: 7
3. Initial Subset of 7 features is selected randomly from all possible solution sub space. These 7 features are represented by binary string (11010110101000000000), where 1 shows presence of feature and 0 absence of feature i.e. Feature no1, 2, 4, 5,6,7,9 are selected initially

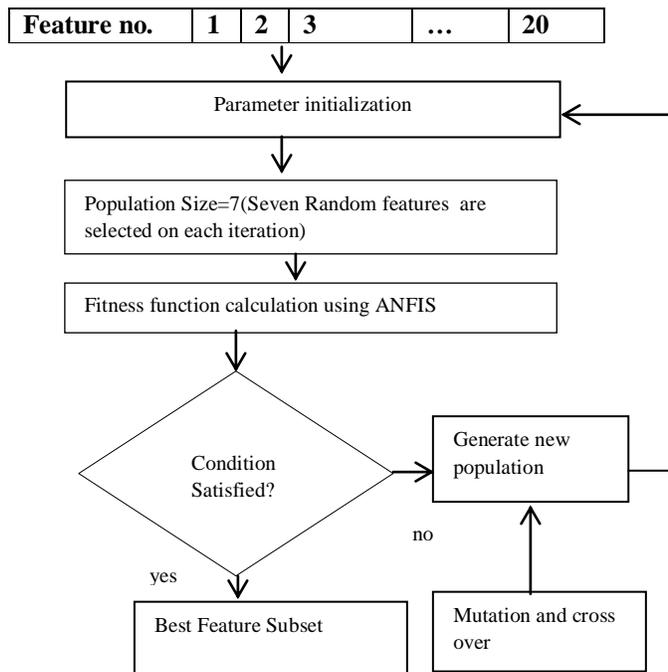


Fig 2.6.1 Steps involved in Feature extraction and Feature Selection

4. Fitness Function: Fitness function decides the success of Genetic Algorithm. For proposed research work Fitness function is determined by ANFIS

$$\text{Fitness (f)} = \sum_{i=1}^{20} \frac{TP}{TP+FN} + \frac{TN}{TN+FP} + \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

Where Fitness (f) means fitness value for a subset, True Positive (TP) means Both training algorithm and testing algorithm results are positive, True Negative (TN) is Both training algorithm and testing algorithm results are negative, False Positive (FP) is training algorithm result is positive and testing algorithm are negative and False Negative (FN) is Training algorithm result is negative and Testing algorithm results are positive.

5. Fitness<sub>max</sub> represents maximum threshold value for a feature subset.

$$\text{Best\_Feature\_Subset} = \text{Fitness(f)} - \text{Fitness}_{\max} \quad (2)$$

If the difference between two is 0 to 15 then that particular feature subset is considered as best feature subset. Otherwise mutation and crossover is done to generate new population. Go to step 4 again

### 2.5 Fuzzy C-Means Segmentation

Clustering is a mathematical tool that groups the data with similar feature vector in to one group and dissimilar data in to different group. In hard clustering, a feature vector can be a part of only one cluster. Whereas, in Fuzzy clustering feature vector can belong to more than one cluster but have different membership degrees (between 0 and 1).

Steps of Fuzzy C-means Algorithm:

Let  $X = \{x_1, x_2, x_3, \dots, x_n\}$  represents feature vector and  $V = \{v_1, v_2, v_3, \dots, v_c\}$  represents set of centers of cluster.

- 1) Randomly select 'c' cluster centers.
- 2) Fuzzy membership  $\mu_{ij}$  is calculated using:

$$\mu_{ij} = \frac{1}{\sum_{k=1}^c \left( \frac{d_{ik}}{d_{ij}} \right)^{\frac{2}{m-1}}} \quad (3)$$

- 3) Then, fuzzy centers  $v_j$  are calculated using:

$$V_j = \left( \sum_{i=1}^n (\mu_{ij}^m x_i) / \left( \sum_{i=1}^n \mu_{ij}^m \right) \right) \forall j = 1, 2, \dots, c \quad (4)$$

4) Step 2) and 3) are repeated either minimum 'J' value of 'J' is achieved or  $\|U^{(k+1)} - U^{(k)}\| < \beta$ . Where 'k' represents iteration step and  $\beta$  is the termination criterion having value between [0, 1]. 'U' =  $(\mu_{ij})_{n \times c}$  represents fuzzy membership matrix. 'J' represents objective function. Four clusters are formed against each Grade of Astrocytoma (I to IV). Proposed research work segment MRI brain image with all of its four GRADES. When a new test image is tested to know type of tumor. Firstly, image is pre-processed, then feature are extracted and compare with the trained images. Best match is the solution of proposed system.

### 3. Results



Fig.3.1 Main GUI

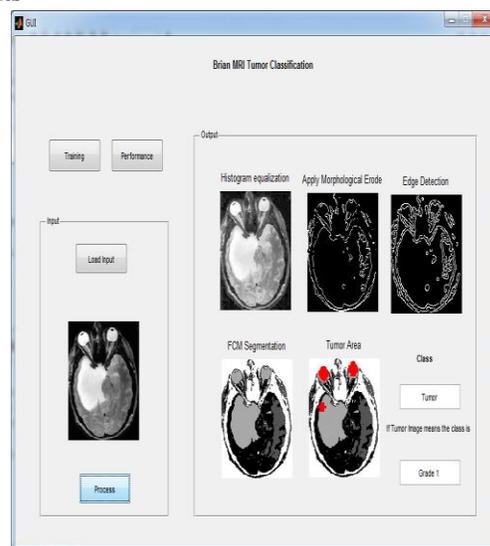


Fig.3.2 Process of image segmentation

Fig.3.1 shows the main graphical interface of proposed work. To test a image press load input then browse image which is to be test and then press process to segment image.

Fig.3.2 shows process followed by proposed work. Tumor part is highlighted by red. Fig.3.3; Fig.3.4 shows the result for different image.

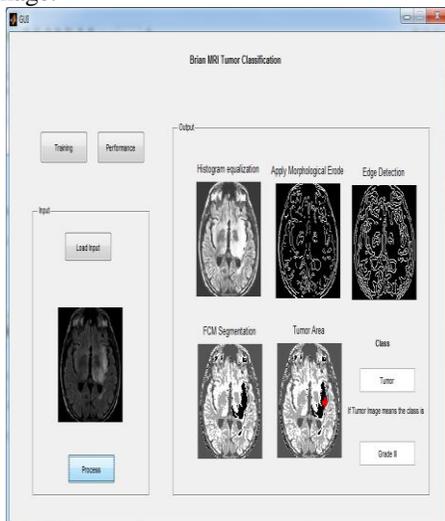


Fig.3.3 Process of image segmentation (GRADE1)

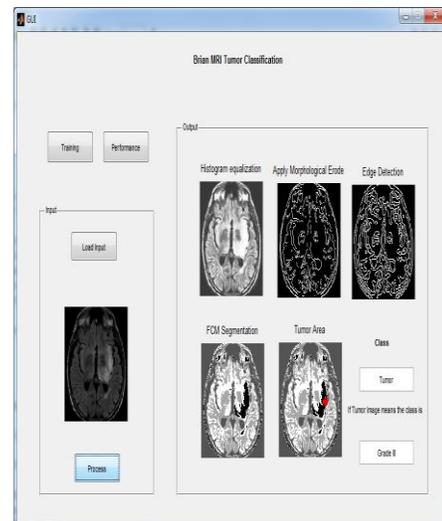


Fig.3.4 Process of image segmentation (GRADE4)

#### 4. Conclusion and Future work

Performance of different image segmentation algorithm can be compared with following parameters:

True Positive (TP): Both Proposed Segmentation algorithm and manual segmentation by doctor's results are positive

True Negative (TN): Both Proposed Segmentation algorithm and manual segmentation by doctors results are negative

False Positive (FP): Proposed Segmentation algorithm result is positive and manual segmentation results by doctors are negative.

False Negative (FN): Proposed Segmentation algorithm result is negative and manual segmentation by doctor's results is positive.

$$\text{Sensitivity} = \text{TP} / (\text{TP} + \text{FN}) * 100\%$$

$$\text{Specificity} = \text{TN} / (\text{TN} + \text{FP}) * 100\%$$

$$\text{Accuracy} = (\text{TP} + \text{TN}) / (\text{TP} + \text{TN} + \text{FP} + \text{FN}) * 100\%$$

Table 4.1: Comparison of classification performance for the proposed technique and recently other work

Algorithms	Sensitivity	Specificity	Accuracy
FCM	96%	93.3%	86.6%
ANFIS+ Genetic	95%	93%	90%
K-Mean+ FCM	80%	93.12%	83.3%
Proposed (ANFIS+ Genetic+ FCM)	96.6%	95.3%	98.67%

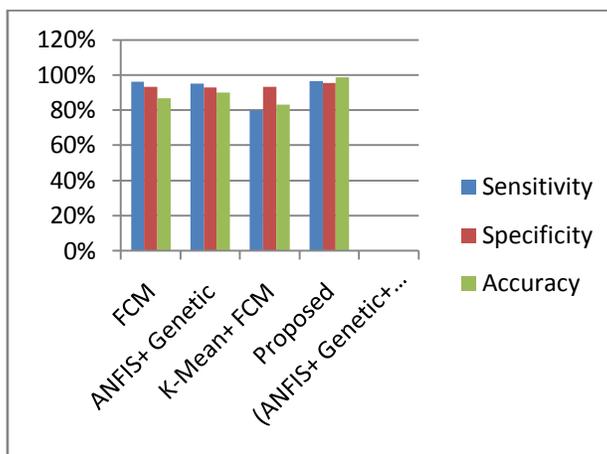


Fig.4.1 Comparison graph of classification performance for the proposed technique and recently other work A comparative study is shown in Table 4.1and Fig.4.1.There are three performance measure to compare these algorithm i.e. Sensitivity, Accuracy, Specificity. Proposed algorithm shows improved accuracy, sensitivity, specificity from FCM, ANFIS plus Genetic, K-mean plus FCM. This proposed algorithm can be extended to segment other tumor types(Giloma, Metastases) also.

#### References

- [1] Michael R. Kaus, Simon K. Warfield, Arya Nabavi, Peter M. Black, Ferenc A. Jolesz, Ron Kikini, "Automated Segmentation of MR Images of Brain Tumors", Radiology, pp.586-591,2001
- [2] R. Adams, and L. Bischof, "Seeded region growing," *IEEE Trans. Pattern Anal. Machine Intell.*, vol. 16, no. 6, pp. 641-647, June, 1994.
- [3] Z. Lin, J. Jin and H. Talbot, "Unseeded region growing for 3D image segmentation," *ACM International Conference Proceeding Series*, vol. 9, pp. 31-37, 2000.
- [4] A. K. Jain, M. N. Murty, and P. J. Flynn, "Data clustering: a review," *ACM Computing Surveys*, vol. 31, issue 3, pp. 264-323, Sep. 1999.
- [5] Fabijanska, A., "A survey of thresholding algorithms on yarn images," MEMSTECH, International Conference pp.23-26,2000

- [6] Tranos Zuva, Oludayo O. Olugbara, Sunday O. Ojo and Seleman M. Ngwira, "Image Segmentation, Available Techniques, Developments and Open Issues", Canadian Journal on Image Processing and Computer Vision Vol. 2, No. 3, March 2011, pp. 20-29
- [7] D. Jude Hemanth, C.Kezi Selva Vijila and J.Anitha , "Application of Neuro-Fuzzy Model for MR Brain Tumor Image Classification", Biomedical Soft Computing and Human Sciences, Vol.16, No.1, pp.95-102
- [8] Noor Elaiza Abdul Khalid, Shafaf Ibrahim, Mazani Manaf , "Comparative Study of Adaptive Network-Based Fuzzy Inference System (ANFIS), k-Nearest Neighbors (k-NN) and Fuzzy c-Means (FCM) for Brain Abnormalities Segmentation", International journal of computers Issue 4, Vol 5, pp.513-524,2011
- [9] Hassan Khotanlou, Jamal Atif, Olivier Colliot ,Isabelle Bloch," 3D brain tumor segmentation using fuzzy classification and deformable models", WILF, pp. 312-318,2005
- [10] T. Logeswaria, M. Karnan, " An Improved Implementation of Brain Tumor Detection using Segmentation based on Soft Computing", Journal of Cancer Research and Experimental Oncology Vol. 2(1) pp. 6-14, March, 2010
- [11] Shasidhar, M.Raja, V.S.Kumar, B.V., "MRI Brain Image Segmentation Using Modified Fuzzy C-Means Clustering Algorithm", CSNT pp 473 – 478, 2011
- [12] Rami J. Oweis and Muna J. Sunna, "A Combined Neuro Fuzzy Approach for Classifying Image Pixels in Medical Applications". Journal of Electrical Engineering, Vol.56, pp 146-150, 2005
- [13] S.Murugavalli and V.Rajamani, "An Improved Implementation of Brain Tumor Detection Using Segmentation Based on Neuro Fuzzy Technique", Journal of Computer Science, pp. 841-846, 2007
- [14] Minakshi Sharma, Sourabh Mukharjee, " Brain Tumor Segmentation Using Genetic Algorithm and Artificial Neural Network Fuzzy Inference System (ANFIS)", Advances in Intelligent Systems and Computing, Vol.177, pp.329-339, 2012
- [15] Zuiderveld, Karel. "Contrast Limited Adaptive Histogram Equalization." *Graphic Gems IV*. San Diego: Academic Press Professional, 474–485, 1994
- [16] Rafel C.Gonzalez, Richard E. Woods, Steven L.Eddins, "Digital image processing using MATLAB", pp.338-339
- [17] J. Canny, "A Computational Approach To Edge Detection", IEEE Trans. Pattern Analysis and Machine Intelligence, pp.679-714, 1986
- [18] Ehsan Nadernejad, Sara Sharifzadeh, Hamid Hassanpour, ' Edge Detection Techniques: Evaluations and Comparisons, Applied Mathematical Sciences, Vol. 2, 2008, pp.1507 – 1520, 2008
- [19] Ehsan Nadernejad, Sara Sharifzadeh, Hamid Hassanpour, " Edge Detection Techniques: Evaluations and Comparisons, Applied Mathematical Sciences", Vol. 2, pp. 1507 – 1520, 2008
- [20] Harlick, "R.M. Statistical and structural approaches to texture", Proceedings of the IEEE, vol.67, pp.786-804, 1979
- [21] I.Gath and A. B. Geva, "Genetic Algorithm with Fuzzy Fitness Function for Feature Selection", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, pp. 773-781, 1989