Content Based Image Retrieval for Medical Imaging Using Fuzzy FFBP Neural Network Approach

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Abstract-**Content Based Image Retrieval system based on medical images used to retrieves the similar type of medical image for a given input query image from large database. In this paper, we proposed a hybrid content based image retrieval system for medical images using fuzzy-feed forward back-propagation neural network technique. In this proposed work, Texture features such as contrast are extracted using GLCM (gray level co-occurrence matrix) Mean square energy, amplitude, standard deviation using   Gabor filter respectively. Shape   features are extracted using fuzzy edge detection. Combination of feature vectors is given as input to the   neural network. Feed Forward back propagation neural network algorithm is used in training the neural network. Feed Forward algorithm propagates in forward direction to give output and back propagation algorithm calculates error in neural network. The fuzzy-(FFBP) neural network retrieves the similar images from database corresponding to query medical image .MATLAB 2010 b has been used to implement the proposed system. The results show that proposed method retrieves 100% precision and better recall values than other existing techniques.**

Index Terms-**Content- based image retrieval (CBIR), Low-level descriptors, Fuzzy logic, Neural network, Feed –Forward, Back-propagation**

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I.INTRODUCTION

With advancement in science and technology [1], there has been increase in demand of digital data. In medical field, today we use computers of high computation and equipments make diagnosis easier by providing images live while diagnosing the patients like ultrasound images. Nowadays, other medical images such as MRI [2], CT-Scan these are used in medical research and education [3, 4]. These images help us to gather more information about different parts of human body to diagnose diseases. [5, 6]CBIR is a two-step process: Feature Extraction and Image Matching. Feature Extraction extracts the features such as texture, shape of an image called feature vectors. This process is applied on both database and query images. Image Matching is applied to compare both the images of database and query image using the feature   vectors to retrieve the most similar images from database. Since earlier CBIR systems such as MARS, QBIC [7] were based on low-level features such as color, texture etc. The drawbacks of such systems were their low efficiency and slowexecution time. To, overcome this, proposed system is developed which maps the low-level features into high –level features, using Fuzzy-FFBP neural network which makes the better classification and feature extraction. The Proposed method has higher accuracy and recall values than other existing method. The paper is organized as follows: In section II, Feature Extraction using image features descriptors and Fuzzy Feed Forward Back propagation neural network is discussed. In section III, the proposed method is presented. In section IV, the Results are given. Conclusion is drawn in section V.

II. FEATURE EXTRACTION

Feature Extraction is first process of CBIR. It is used to extract the meaningful information from images such as: texture, shape, edge. In below section each feature with their respective methods of extraction has been discussed. Then, Neural network technique has been discussed which uses these features for classification of images.

Texture Descriptor: Texture is an importantfeature for defining the high –level semantics. In this proposed work, GLCM   and Gabor filter is used to determine texture features.

GLCM (Gray Level Co-occurrence Matrix): [8] is a statistical method of extracting textural features of an image. It is tabulation of how often the different combinations of pixel brightness value occur in an image. In this proposed work, we measure contrast of images using GLCM [9, 15].

Contrast $= \sum_{i,j=0}^{N-1} P_{i,j} (i-j)^2$; // i=no of rows, j=no of columns   **(2.1)**

When i-j=0, pixels are similar to their neighbor there is no change in contrast. When i-j>0, contrast increases. When i-j<0, contrast decreases.

Gabor Filter: In this proposed work, Gabor filter has been adopted to extract texture features of an image .They are proven to be very effective. They are used to determine mean square energy, amplitude which represents homogeneous texture in regions of an image [10].Gabor filter are group of wavelets, with each wavelet carrying energy at specific orientation and specific

frequency[11]. . Let I (x, y) be the gray level distribution of an image, the convolution of the image I together with a Gabor kernel g_{mn} is defined as follows[11]:

$$G_{mn}(x, y) = \sum_s \sum_t I(x - s, y - t)g_{mn}^*(s, t) \qquad (2.2)$$

Where, s and t are the filter mask size variables, g_{mn}^* is the complex conjugate of the mother Gabor function g_{mn} and G_{mn} is the convolution result corresponding to the Gabor kernel at orientation m and scale n. After applying Gabor filters on the image with different orientation at different scale, we obtain an array of magnitudes.

$$E(m, n) = \sum_x \sum_y |G_{mn}(x, y)| \qquad (2.3)$$

$$\mu_{mn} = \frac{E(m,n)}{P \times Q} \qquad (2.4)$$

$$\sigma_{mn} = \frac{\sqrt{\sum_x \sum_y (|G_{mn}(x,y)| - \mu_{mn})^2}}{P \times Q} \qquad (2.5)$$

These magnitudes represent the energy content at different scale and orientation of the image, where mean μ_{mn}, σ_{mn} stand.deviation

Mean: Mean(X) calculates the mean of average value of gray level intensities of an image. Mean value is directly proportional to brightness. If value is low, image will be darker or value is low, image will be bright. Mean is computed from equation (2.4).
**Standard Deviation (σ):** determines the contrast of gray level intensities. Standard deviation is directly proportional to contrast. If value is high, image will have high contrast, and vice-versa [9, 11]. It is calculated from equation (2.5).
Entropy (H): measures density level present in texture of an image. If density level is high, entropy will be large and vice-versa [12] in equation (2.6).

$$H(X) = -\sum_{i=1}^{L} P(i) \log_2 P(i) \qquad (2.6)$$

Shape descriptor: Edge contributes discontinuity, distortion leads to edge detection .In this proposed workFuzzy edge detection is used.Fuzzy system can be divided into 4 major parts [13,14] as shown in fig 2.2.
  a. **Fuzzification module** (fuzzifier) : Fuzzification module maps the input values in crisp set to values in fuzzy set
  b. **Inference engine:** The inference engine simulates the decision making capabilities of human brain. The fuzzy inference engine deduces the necessary control action in fuzzy domain based on input from fuzzifier and set of rules available in the rule base. Inference engine also aggregates the output of various rules which have fired.
  c. **Knowledge base:** The knowledge base consists of various rules which are fired according to the input given to the system.
  d. **Defuzzification module** (defuzzifier): Finally, the aggregated fuzzy output is then converted to crisp value by the defuzzification module.
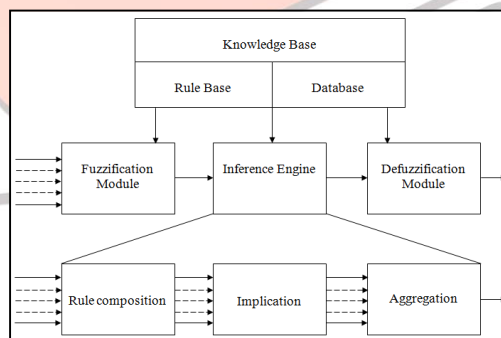
Fig 2.2 Fuzzy Inference System

In proposed algorithm, following steps are used for edge detection [16]:
  i.   Fuzzy inference system is applied to generate the output.
  ii.   Crisp inputs are fuzzified into fuzzy domains output.
  iii. Mask 3×3 window is used for scanning the input image ,shifts the one pixel to the right until it reaches the end of row to determine whether centre pixel is edge pixel or not. Slide this window for next row from beginning to end and continues until it scans the whole image and find the edge pixel value.
  iv.   Then, Defuzzify the values of fuzzy edge domain values
  v.   Apply thresholding .If pixel value>45 then pixel value=10 or 255 otherwise 0
  vi.   Apply thinning function morphological to the image being processed to remove smaller objects whose pixel value<10.
  vii. Compute region property of binary image obtained. For this we compute area, perimeter, centroid, orientation of an image using fuzzy edge detection.
Area: It is scalar quantity,determines the total no of pixels in the region.
Perimter: It is scalar quantity specifying the distance between the adjoining pixels of boundary.

Centroid: It is a vector that specifies the centre of mass of the region. The first element of centroid is the horizontal coordinate (x-coordinate) of the centre of mass and the second element is the vertical coordinate (y-coordinate). All other elements of centroid are in order of dimension.

Orientation: It is a scalar specifying the angle (in degrees ranging from -90 to 90 degrees) between the x-axis and the major axis of the ellipse that has the same second-moments as the region.

Neural Network: Neural Network is network of neurons like units called nodes. Neural network is used for classification of images as shown in fig 2.3 (a). Neural network is preferred over other techniques due to its dynamic nature. In this paper, [17] Feed forward back propagation neural network is used for classification of images.
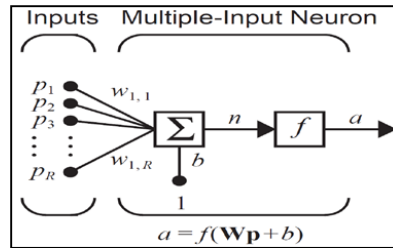

Fig 2.3(a) Simplest Neural network

Feed Forward Back Propagation Neural Network (FFBP NN):[17] in our proposed work, FFBP NN is applied in which information moves in only one direction. .FFBP NN computes both in forward and backward direction. Output is calculated in forward direction and error in backward direction. In **forward processing,** Input layer is used to input the data, it is passed on to the hidden layer, and Hidden layer processes the data. Output is derived from theoutput layer as shown in fig 2.3(b).
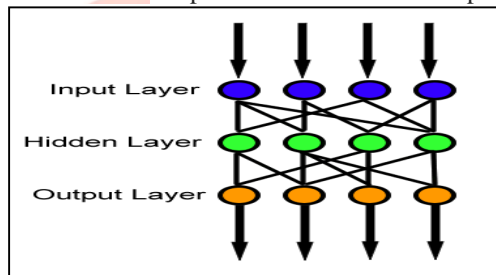

Fig. 2.3(b) FFBP NN

Back –Propagation: Error e_k is measured by comparing the output values y_k and desired d_k [17]. This is called back propagation as it computes error in backward direction as shown in fig 2.3(c).

$$e_k = desiredoutput - actualoutput$$
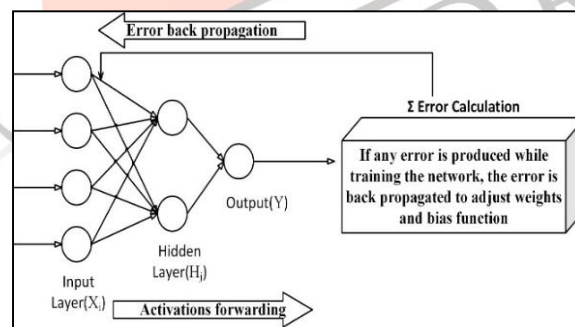
$$e_k = d_k - y_k \qquad (2.7)$$

Fig 2.3(c) Basic Back Propagation Neural Network

In this paper, input given to neural network is feature vectors: contrast, area, entropy etc,hidden layer consists of 56 neurons and output layer gives one resultant value which is class value to which the query image belongs

III. PROPOSED METHOD

This section discusses the proposed method of Content Based Image Retrieval System as shown in fig 3.1 follows :

Query Image: : It is first step in Content based image retrieval system in which user inputs its problem i.e. which type of image is required by user. This results input in CBIR system in form of query is called query formation.

Preprocessing: In this phase, image is processed for removal of noise by using median filter, resizing the images to the same size, changing the colored image to gray scale image.

Feature Extraction: Texture features such as contrast, mean square energy, mean, amplitude, standard deviation using GLCM using equation(2.1-2.6), Gabor filter and shape features such as area, perimeter, centroid, orientation using fuzzy edge detection.

Image Database: The image database includes various gray scale images of size 160×160. The image collection that we have used in this work contains 1400 medical images like chest, brain, etc. The image database generally consists of huge collection of different images

Image Features Database: A feature vector is extracted from each image in the database and the set of all feature vectors is organized as a database index is called feature database.

Neural network classification: The feature vector of query image and image features database are input to neural network . FFBP NN is used for classification of images. It classifies images into different classes and gives single resultant output value of class to which query image belongs.

Similarity Measurement: In similarity measurement, the distance between the feature vectors of query image is compared with the feature vector of images in a class of database (output from neural network). The images are retrieved according to shortest distance basis [18].For similarity measurement, Manhattan distance (City block distance) is used for similarity measurement. . It represents the distance between two points in an image. Images will be more similar when distance will be less. . The Manhattan distance (d) between two vector a and b is given by equation [19,20]

$$d(a, b) = \sum_{i=1}^{n} |a_i - b_i| \qquad (3.1)$$

Similarity comparison between query image and database images is calculated using their distance value.

Ranking and Indexing: In this, it categorizes the images of a class according to most similar image at top rank accordingly. It is done with aid of indexing scheme.

Relevant medical image: After this, most similar medical images are retrieved as output.

In the proposed method shown in fig 3.1,Preprocessing of images are done to remove noise if any present using median filter .Feature extraction is done :texture features such as contrast is measured using GLCM; mean square energy and amplitude are measured using Gabor filter. Few other texture features such as mean, standard deviation, entropy are also extracted of medical images. Shape features are derived using fuzzy edge detection technique. Combination of Feature vectors from both texture and shape are input to neural network .In FFBP NN, Training is done using feed forward back propagation neural network for image database. The input to neural network is features vectors extracted from images both texture and shape. The hidden layer consists of 56 neurons. It learns about all features of images in database. In this phase, labeling is provided to images, images are categorized and target value is set. After training, testing is done on query image. It simulates the network using query pattern.
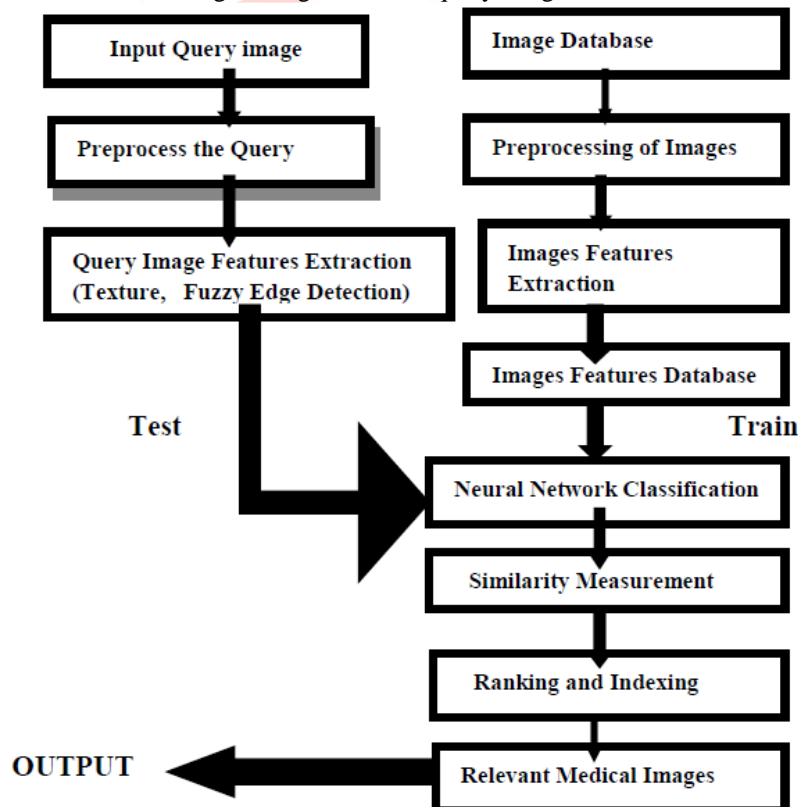
Fig.3.1 Block diagram of proposed work

Categorize the image by comparing the feature vectors of query image with that of database.When pattern is recognized, the class label to which the query image belongs is retrieved as output from neural network.After this, Similarity measure is done by comparing the query image with images present in that class label returned by neural network. It is done using Manhattan distance shown equation(3.1). The most similar top 50 ranked images are retrieved as output and shown to user as output.

IV.SIMULATION RESULTS

The present method has been implemented using MATLAB 2010b. A GUIDE tool has been used to develop the front end of GUI. Image processing toolbox and Neural network toolbox of MATLAB has been used to perform image processing and neural network tasks. Image Database used in the proposed work contains about 1400 biomedical images of knee, chest, brain, and leg. Texture and shape features are used for feature extraction .About 30 query images are used for CBIR system evaluation. The configuration of neural network includes setting the learning rate to 80%, setting the permissible error to 0.003 and selecting the "Gradient Descent" (back propagation) as training algorithm. The performance of training plot can be determined using performance plot as shown in fig 4.2 below and equation (4.1).

Performance plot=no of epochs/Mean Square Error (MSE)   **(4.1)**
Best training performance is at epochs 34 is 4.1027e-06 as shown in performance plot in fig 4.3.
Gradient are individual error for each of the weights in neural network is 0.0055743 at epochs 34.Mu indicates how much weight change on each iteration. Mu range from 10^{-6} to 10^{-4} at epoch 34 as shown fig 4.4 below.
Validation set is used to determine the performance of a neural network on patterns that are not trained during learning. Validation fail is 0 as shown in fig 4.4.
Also, the Regression plot [16] determines the relationship between input and output parameters is given by in equation (4.2):

$$Output = learning - rate \times Target + bias \qquad (4.2)$$

In the proposed work, regression plot is shown in fig 4.5
Output=1×target+0.00081 at epochs 34   **(4.3)**
Performance of system can be measured using precision and recall values as follows [19, 20],

$$\textbf{Precision=}\frac{T_P}{T_P+F_P} \qquad (4.4)$$

$$\textbf{Recall=}\frac{T_P}{T_P+F_N} \qquad (4.5)$$

Where T_P : No. of relevant images retrieved is,F_P is no. of irrelevant images retrieved. F_N: No of relevant images that are not retrieved.
  Table I represents the average precision and average recall values for input query images. Average precision values shows 100% results for various query images which shows good results.

Table - I Precision and Recall values

Test image	Average precision Values	AverageRecallValues
1. Knee	1	0.14
2. Brain	1	0.26
3. Chest	1	0.11
4. Leg	1	0.12

Below shows the following figures representing the implementation of proposed work: Fig 4.1 represents the training of neural network; Fig 4.2 represents the performance goal achieved by neural network at epochs 34 iterations. Fig 4.3 shows the performance plot; Fig 4.4 shows the gradient, validation and mu plot; Fig 4.5 represents the regression plot; Fig 4.6 represents the output of CBIR system when brain as query image is input to the system; Fig 4.7 shows the output when Chest as query image; Fig 4.8 shows the output when leg as query image; fig 4.8 shows the output when knee as query image is input to the system.
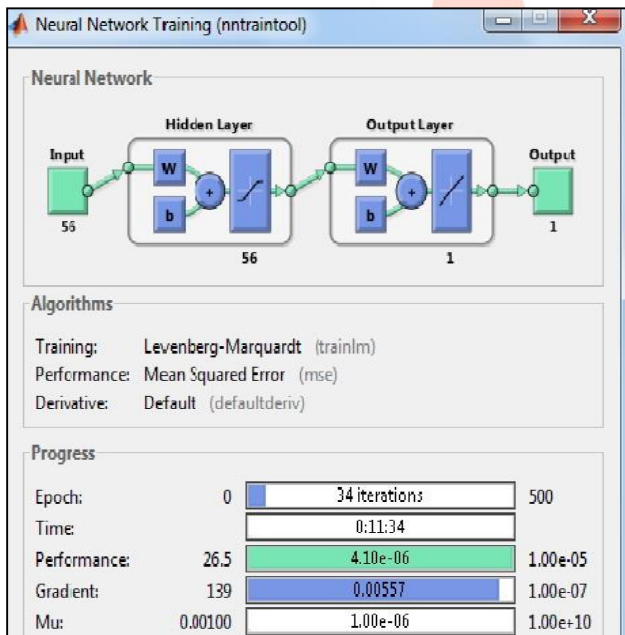
4.1 Training   Neural Network
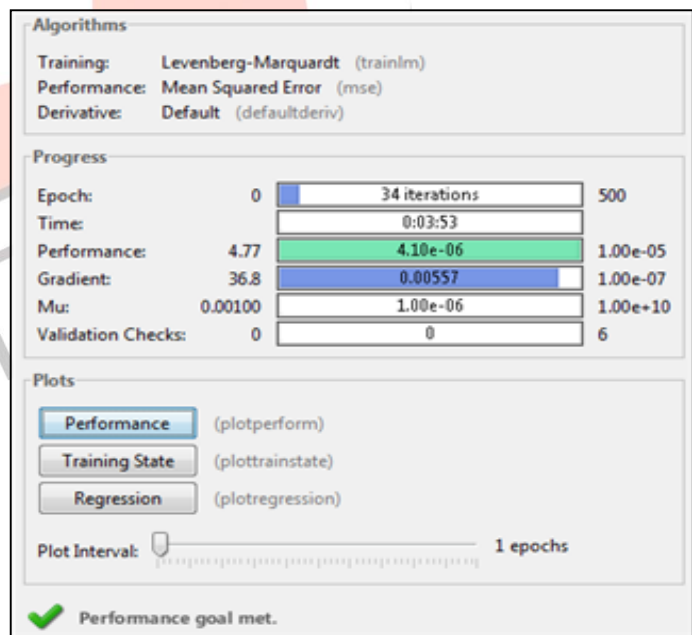
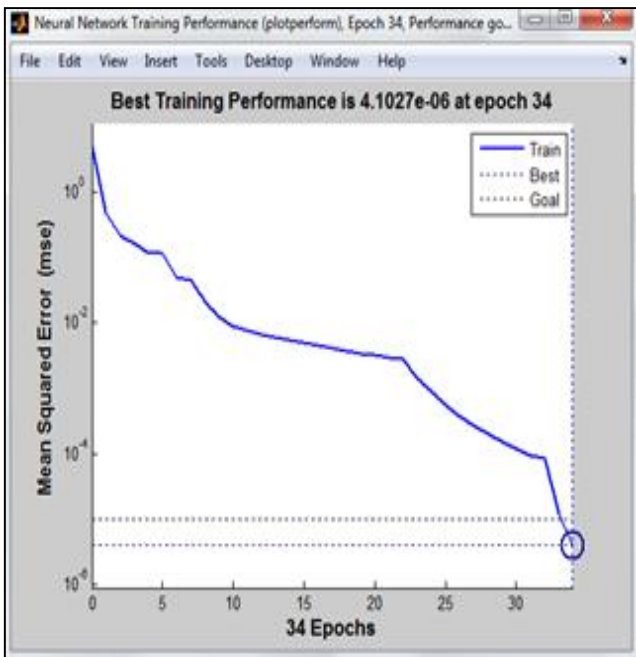**Fig 4.2** Performance goal met Epochs at 34 iteration
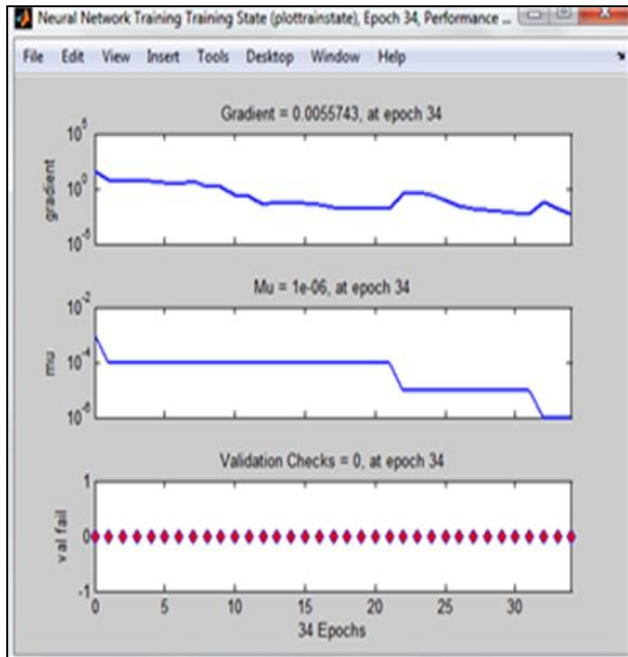
Fig 4.3 Performance Plot

Fig 4.4 Gradient, Mu, Validation plot

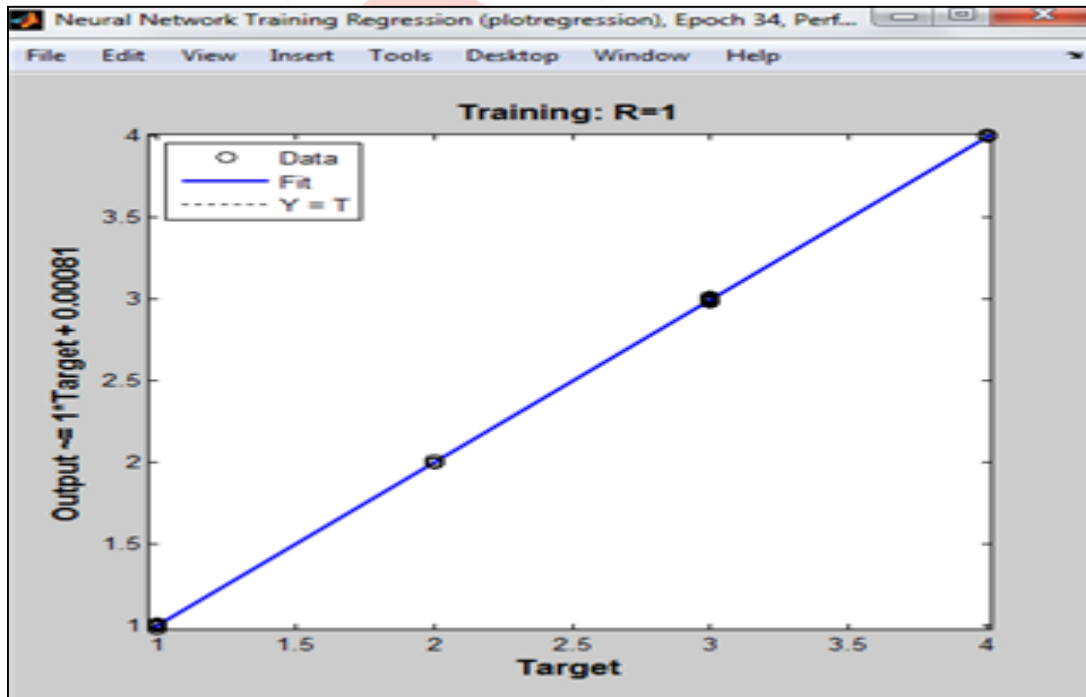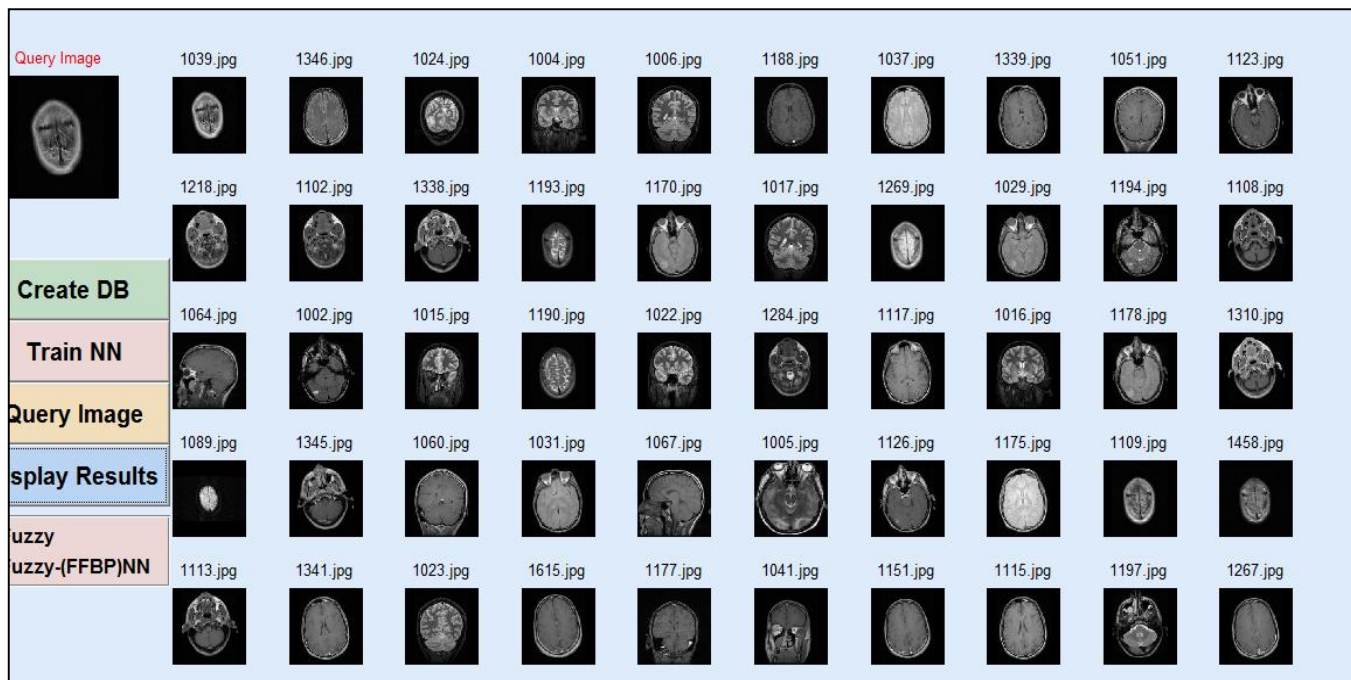Fig 4.5 Regression Plot at R=1

Fig 4.6 Brain as query image

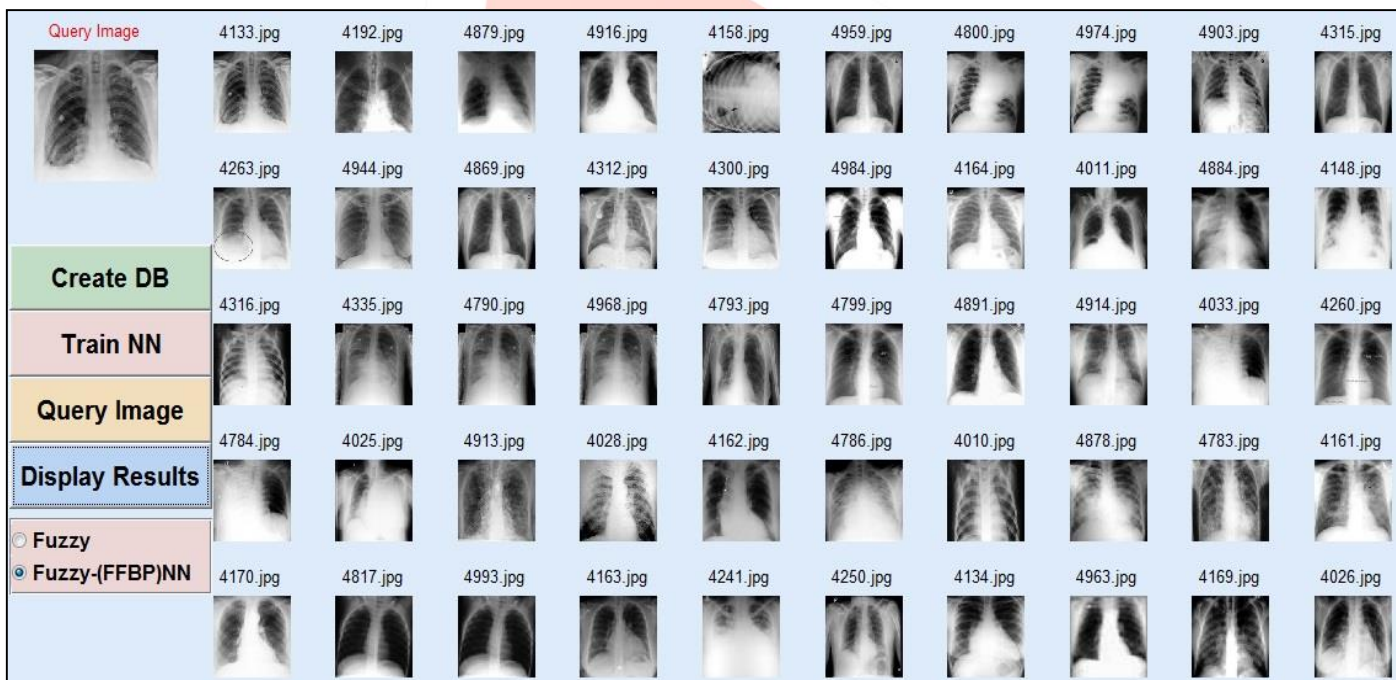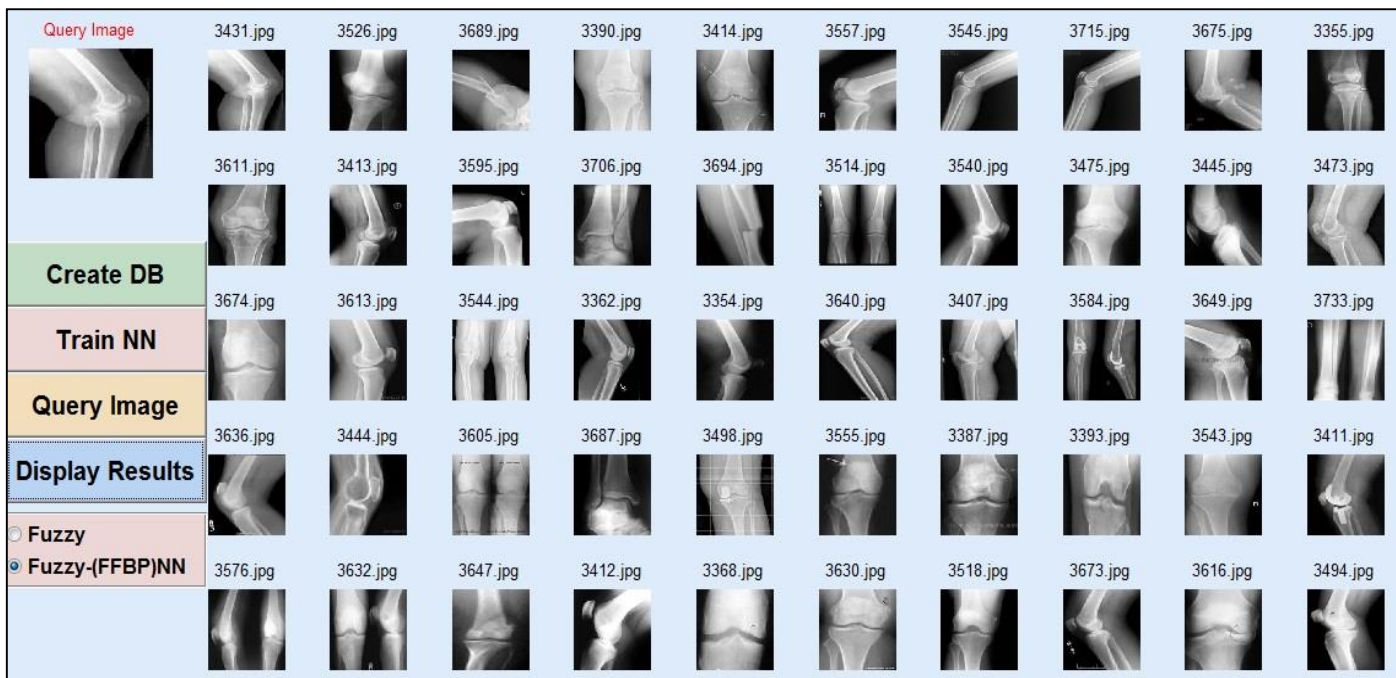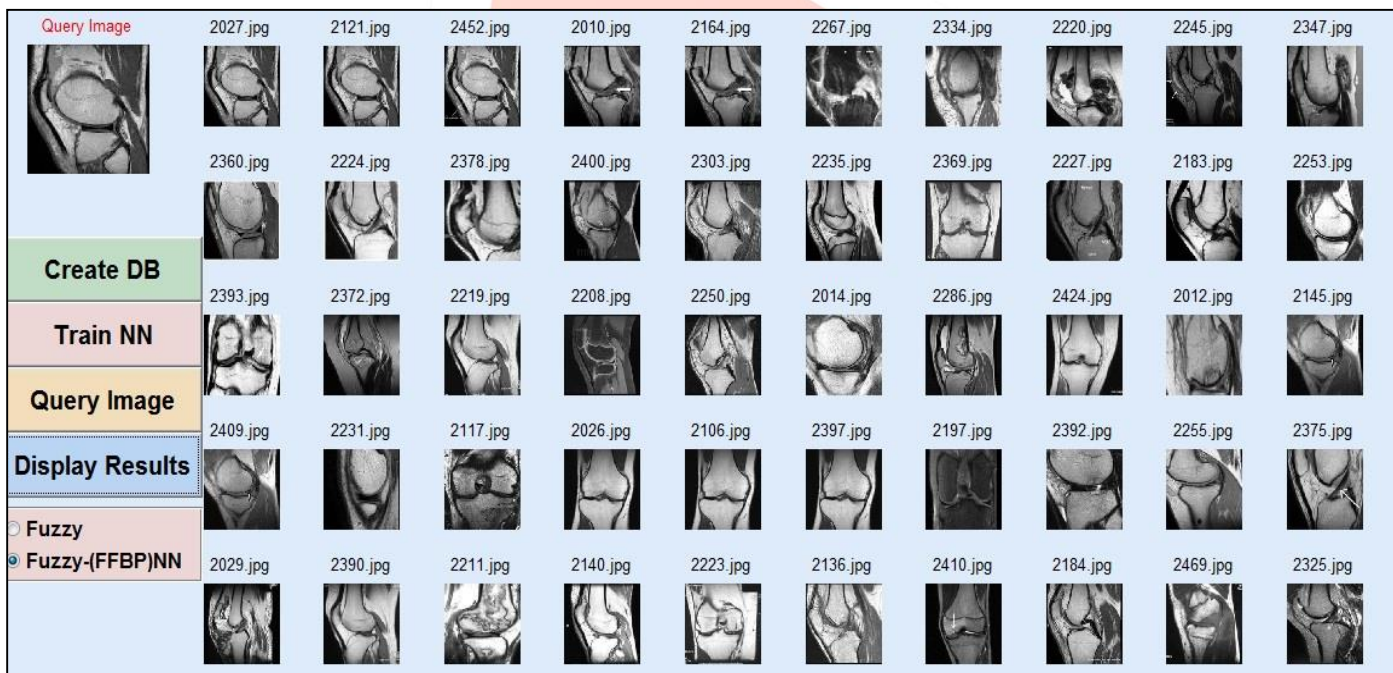Fig 4.7Chest   as query image

Fig 4.8 Leg as query image

Fig 4.9Knee as query image

V.CONCLUSION AND FUTURE SCOPE

In this study, Content based image Retrieval using texture features and shape features for medical imaging using FFBP NN has been successfully implemented. The images in database are trained using feed forward algorithm and error is computed using back propagation algorithm. Testing is done on query image to retrieve the most similar images from database. Fuzzy neural approach makes the system more efficient and provides more accuracy in results than existing systems. As in some cases, it was drawback that the retrieval result contains the irrelevant images but this system is 100% accurate.

The future scope is the use of more efficient technique to reduce the query execution time of this CBIR system so that it can be applied in medical field more efficiently.

VI.ACKNOWLEDGMENT

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