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DWT Features Based Image Retrieval Using Neural Network

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Abstract

With the Advancement of data storage and image acquisition technologies have enabled the creation of large image datasets. So, it is necessary to develop exact information systems to efficiently manage these datasets. Image classification and retrieval is one of the most services that must be supported by such systems. The most common approach used is Content Based Image Retrieval (CBIR) System. Content Based Image Retrieval (CBIR) is a technique which uses visual contents (low level features) for image indexing and retrieving rather than the metadata (keywords, tags, etc.). In this paper, a CBIR system based on Discrete Wavelet Transform (DWT) and feed Forward neural network is proposed. In indexing phase, after decomposing the training images into wavelet domain, low level features (color and texture) are extracted. Standard Deviation is used to represent color feature and Entropy value is used to represent texture feature. Feed Forward Neural Network is used to index these features of the images to insert into the database. In the retrieving phase, after decomposing the test images or query images in the DWT domain, low level features (color and texture) are extracted in the same way. Finally, feed forward neural is used to find similarity between the images from the image database using these extracted features. The proposed method is computationally less complex and faster compare to existing methods.

Keywords: Discrete wavelet transform, feed forward neural network, standard deviation, entropy, low level features.

1. Introduction

With the explosive growth in image records and the rapid increase of computer, there has been an intense activity in development image retrieval technique based on image content from a large-scale image database. Content-based image retrieval supports users in accessing and searching large image collections from large scale image databases.

The word content based means that the search will analyze the actual contents of the image rather than the metadata such as keywords, tags, and/or descriptions associated with the image [3]. The term 'content' is used to refer those features, such as colors, shapes, textures…which can be derived from the image itself.

The image retrieval evolved two solutions – automatic image annotation and content based image retrieval (CBIR) [6]. The content based image retrieval techniques aim to respond to a query image (or sketch) with query-similar resultant images obtained from the image database. The database images are preprocessed for extracting and then storing – indexing corresponding image features. The query image also gets processed for extracting features which are compared with features of database images by applying appropriate similarity measures for retrieving query similar- images [6].

Different techniques have been identified and experimented to represent content of single images according to low level features, such as color, texture, shape and structure, intermediate level features of saliency and spatial relationships, or high-level traits modeling the semantics of image content [6]. CBIR systems operate in two phases: indexing and searching [10]. In the indexing phase, each image of the database is represented using a set of image attribute, such as color, shape, texture and layout. Extracted features are stored in a visual feature database. In the searching phase, when a user makes a query, a feature vector for the query is computed. Using a similarity criterion, this vector is compared to the vectors in the feature database. The images most similar to the query are returned to the user.

High retrieval efficiency and less computational complexity are the desired characteristics of CBIR system. However, designing of CBIR system with these objectives becomes difficult as the size of image database increases [1, 2]. There are several applications of CBIR - advertising, medicine, crime detection, entertainment, digital libraries etc.

There have been several researches on CBIR system. One of the most used techniques is wavelet based CBIR system.Reddy et al [1, 2], multi wavelet transform according to the characteristic of the image texture is used. They have extracted color feature using color correlogram in RGB color space and extracted texture feature by computing standard deviation. In similarity measurement they have used Euclidian distance. The experimental results show that this method is more efficient than the traditional CBIR method based on the single visual feature and other methods by combining color and texture.

Hierarchical and multilayer network which includes RBFN for retrieving image based CBIR system is proposed by P. Sankara Rao et al. [5]. Their proposed procedure is divided into two parts. At first, they have classified all the images in database image using hierarchical clustering and after that they have applied the clustered images to RBFN network, to get the desired output. Applying only color feature is not better solution for any retrieval process.

In this paper, an image retrieval system based on DWT and feed forward neural network is proposed. Color and texture features are used for feature extraction by decomposing the images into wavelet domain using DWT. For color feature representation, standard deviation and for texture feature representation entropy is used. Feed forward neural network is used to index those features to insert into the image database. Similarity measurement between the inserted images and the query images are compared using the feed forward neural network. The proposed method is computationally less complex and faster compare to existing methods and has a better retrieval rate.

2. Proposed Method

Proposed method is to improve the performance of image retrieving technique. In our proposed method, discrete wavelet transform is used to extract low level features from images**.** Standard deviation is used to extract color feature and entropy is used to extract texture feature**.** Then feed forward neural network is applied to cluster the images according to their extracted features**.**

The proposed method can be divided into two phases – indexing and retrieving**.**

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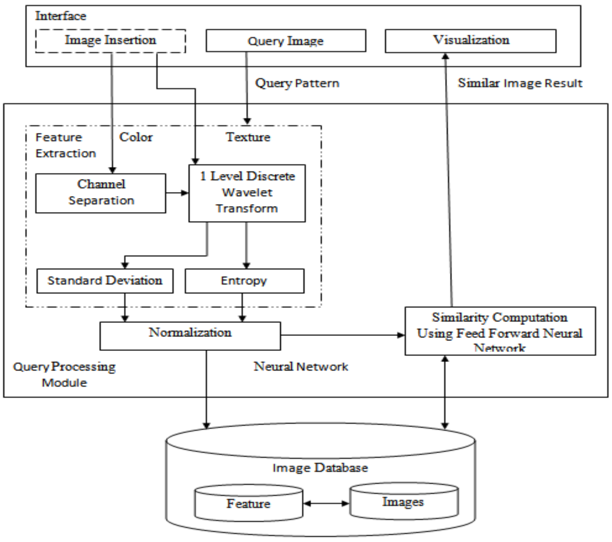

Figure 1: Our Proposed System Architecture.

A. Image Indexing

Input Training Images

At first to train images and insert them into database, images are read through a graphical user interface (GUI).

A1. Color Feature Extraction

Channel Separation

At first the RGB images are separated into three channels – R, G and B. Channel separation is used for getting the true color intensities.Each pixels of color can be determined by combining of the red, green and blue intensities which are stored in each color plane at the pixels location.

DWT Transform

Discrete wavelet transform is used to get the low-level color features. Here, one level discrete wavelet transform is used and LL sub band of the transformed images are used for low level color feature extraction. 1 level DWT is used for less complexity and most features of the images can be obtained from the LL sub band.

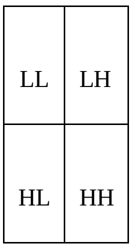

Figure 2: 1 Level DWT

Standard Deviation

Finally, the standard deviation is used to get the low-level image features of the images. Standard deviation is used to determine the mean value of the color intensity of the pixels of an image.

By calculating the variance for all three components obtained –

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(X_i - X)^2 \quad (1)$$

Where σ^2 is the variance, N is the number of pixels; x_i is the value of each pixels and $\bar{x}$mean of the matrix. And σ is the standard deviation.

Where x is the mean and can be expressed as -

$$\frac{1}{N}\sum_{1}^{N} X_i \quad (2)$$

Here, three elements of the feature vector are obtained which can be expressed as follows –

$C = [C_1, C_2, C_3]$

A2. Texture Feature Extraction

DWT Transform

DWT transform is used for texture feature extraction. Here one level DWT transform is used to get the low-level texture features.The wavelet transform method converts image data to the frequency domain by the translation and dilation of the basis function [12], called a wavelet. Analyzing the sub-bands created by transformation, the images information can be acquired.

Convert HL, LH and HH subbands into Gray Level Image

DWT subbands are converted into gray level images subbands and then entropy is applied to get low level texture features. Here, HL, LH and HH subbands are converted into gray level image subbands.These sub bands represent the high frequency of the images. The sub bands represent texture values of the images more clearly. So, in our proposed method these high-level frequencies are used texture feature extraction.

Entropy

Finally, the entropy is used to extract the texture feature of the training images. Here, three values of each of the images are obtained.

Entropy is used to determine the texture values of the images. The equation that we have used can be expressed as follows –

$$H(X) = -\sum_{i=1}^{n} P_{i} \log_2 P_i \quad (3)$$

Where X is a random variable which can be one of the values X_1, X_2,..., X_n with probability P_1 ,P_2 ,..., P_n. H(X) can be interpreted as representing the amount of uncertainty that exists in the value of X.

Here, three elements of the feature vector are obtained which can be expressed as follows –

$T = [T_1, T_2, T_3]$

A3. Normalization

Normalize the Extracted Features and Combine Feature Vector

After extracting the color and texture features of the images, the values are normalized using the following equations –

$$A_i = \frac{a_i}{|Ai|}$$

$$|A_i| = \sqrt{\sum_{i=1}^{n} (a_i)^2} \qquad (4)$$

Here, a_i is the feature values of each feature vector.$\widehat{A_1}$ is the normalize value of each element.

To minimize the extracted values normalization is used. By normalizing the extracted features, a feature vector is formed. Here, normalized color and texture features are used to form the features vector.

$V= [V_1\ V_2\ V_3\ V_4\ V_5\ V_6]$

The above feature vector is used as an input of the neural network.

A4. Create Feature & Image Database

In our proposed method, to perform the analysis for image classification, the back-propagation algorithm has been implemented using MATLAB 's Neural Network Pattern Recognition Tool (NPRT). The classifier uses two-layer feed-forward back propagation network. Two-layer feed forward network can be best defined as a network with sigmoid hidden and output neurons, which can classify vectors arbitrarily well. The network is trained with scaled conjugate gradient back propagation.

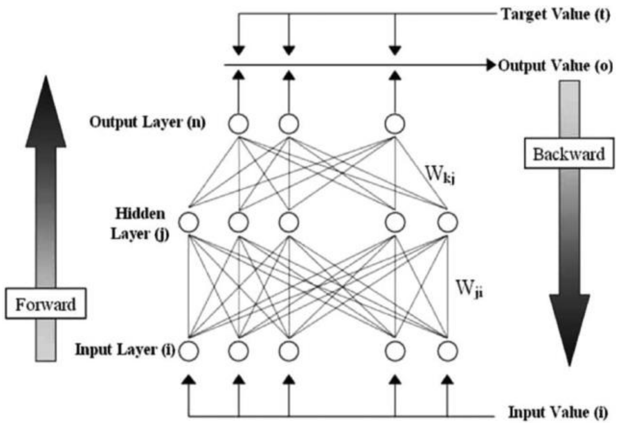

Figure 3: The structure of a neural network.

To train the network, the input data and target data need to be fed into the network. The extracted color and texture features give the input data and the class label of images gives the target data. The network then divides the input sample data into three different samples which are training, validation and testing samples. The training samples are used to train the network, and the network is adjusted according to its error. The validation samples are used to measure network generalization, and to halt training when generalization stops improving. Testing samples are then used to provide an independent measure of the network performance during and after training. From the training window, the network's performance can be observed and if the error of the network is still large, the network can be retrained back as to get more accurate and efficient result.

Finally, the indexed images and images features are inserted into the database followed by each images and the image groups.

B. Image Retrieval

Similarity measurement between the training images and the query image will be found using the trained Neural Network.

Image feature extraction and normalization steps are similar to A1 to A3.

For image retrieval neural network is used in the proposed system. After trained the normalized feature vectors in the neural network tool the classified vector is obtained. In classificationphase some fixed weights are obtained which are used for similarity measurement. To retrieve images, the six feature elements of the query images are calculated in the neural network. After calculating the feature elements three outputs are obtained with respect to the output classes of the neural network. Finally, the retrieved images are obtained using the error calculation.The images of the lowest error class are shown as outputs of the retrieval system.The error calculation equation can be expressed as follows –

Error = | target – output |

3. Experimental Results

The proposed system is implemented using a database of 500 images with different classes. These images are arranged in 5 semantic groups: tiger, bird, apple, lion and butterfly.It includes 100 images from each semantic group.There are two methods for evaluation of an image indexing method [10]. One is evaluation of it in an image retrieval system and other is use of it in an automatic image classification. Formats of all the images that used in the proposed method are jpg.

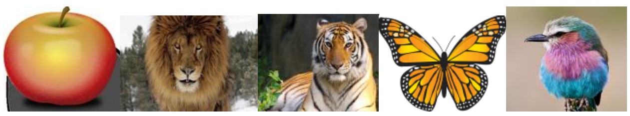

Figure 4: The classes of images for training and testing.

The training images are trained using the neural network tool for classification. After the classification, we have got the confusion matrix of the image classes. A confusion matrix is a specific table layout that allows visualization of the performance of an algorithm. Each column of the matrix represents the instances in a predicted class, while each row represents the instances in an actual class [6].

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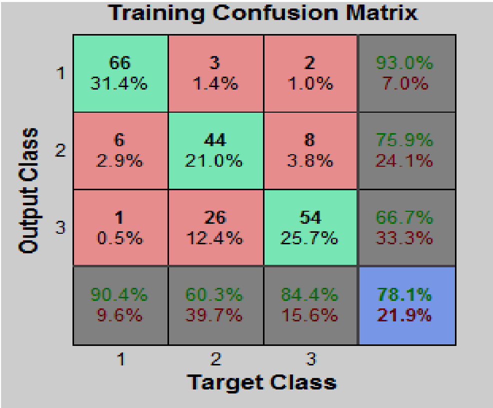

Figure 5: Confusion Matrix

The performance graph describes the performance of the system proposed system. It shows the classification rate of the image classes. The performance graph of our proposed system is following –

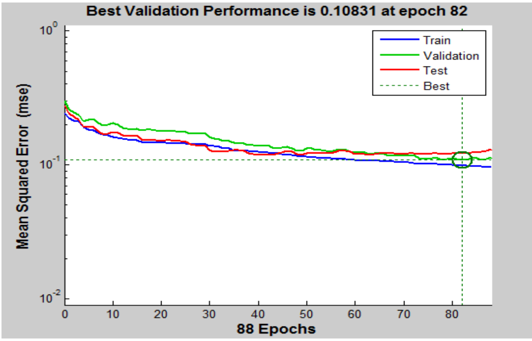

Figure 6: Performance Graph

Table I shows the classifier performance of the image classes after performing the neural network. Here, the success rate of the each of the classes and their error rates with respect to success rate are shown.

TABLE I
Classifier Performance for Image Indexing

Class Name	Success Rate	Error Rate
Apple	91.7%	8.3%
Tiger	86.4%	13.6%
Bird	83.2%	16.8%
Lion	87.6%	12.4%
Butterfly	90.1%	9.9%

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The error histogram graph is shown following –

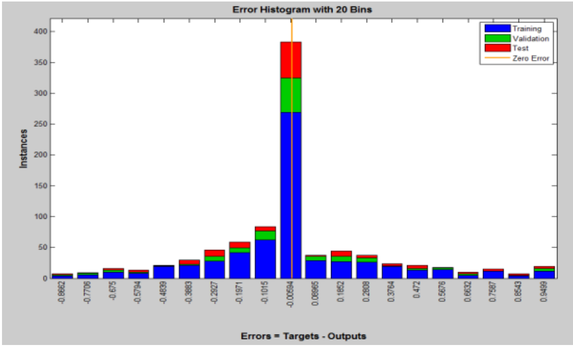

Figure 7: Error histogram graph.

The error histogram describes the error rate of the image classes after the neural network training. Retrieving rate of the proposed system is similar to the image indexing performance rate.

(a)

(b)

Figure8:(a) Query image. (b) Retrieved images.

4. Conclusion

The performance of the CBIR system is dependent as the features vector that represents the image in the database. In this paper, a CBIR approach is proposed using DWT and feed forward neural network. DWT is used to extract the features of images by decomposing into wavelet domains and neural network is used for image classification and similarity measurement. The proposed system is applicable to improving the performance of content-based image indexing or retrieval systems.

Future work will focus on developing the better features extraction which classify more effectively images and improving our system to acquire higher classification results for more various.

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A Brief Author Biography

Raj Kumar Sah currently studying in M.Tech. Research Scholar in Computer Science and Engineering from A P Goyal Shimla Universit, Shimla (H.P.) India (2016-2018). He received B.Sc. degree in Computer Science and Engineering from Khulna University, Khulna, Bangladesh, in 2014. His research interet area includes Image Processing, Artificial Intelligence, Machine Learning At present; He is engaged in image segmentation application.

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