Image Classification using Neural Network for Efficient Image Retrieval

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***Abstract*— Traditional keyword based image retrieval systems has become inefficient for retrieval of images because of extensive digitalization of images and wide explosion of World Wide Web. To overcome such limitations Content Based Image Retrieval systems are used to retrieve similar images from large database for a given query image. There are various methods for CBIR are available some of which used Global image features such as Color, Texture and Shape. Some methods uses region level image features such as image segments. In our system we are using hybrid approach. We uses global image features based CBIR with feed forward back-propagation neural network. Neural network is used for classification of query image as per training database. At first neural network is trained about the color features of images in the database. The training is done by using back-propagation algorithm. This trained database is used for classification of the query image. According to retrieved image class further color based CBIR is used for retrieving similar images.**

Keywords— Content-Based Image Retrieval (CBIR), low-level descriptors, neural network, feed-forward, back-propagation.

I. INTRODUCTION

Content-based image retrieval is the application of computer vision techniques to the image retrieval problem, that is, the problem of searching for digital images in large databases.

"Content-based" means the search which analyzes the contents of an image rather than metadata such as keywords, tags, or descriptions associated with the image. The term "content" in this context might be referred to as colors, shapes, textures, or any other information that can be derived from the image itself. CBIR is desirable because the searches which rely purely on metadata are dependent on annotation quality and completeness. Having humans manually annotate images by entering keywords or metadata in a large database can be time consuming and may not capture the keywords desired to describe the image.

There are three different kinds of CBIR systems: global image properties based, region level feature based and relevance feedback based. First approach uses low-level features of an image such as color, texture and shape of an object to retrieve images. They can be easily implemented and they perform well for simple images. They are not suitable for broad content image databases. Region-based approach uses image segmentation for the retrieval of image. CBIR systems can make use of *relevance feedback*, where the user progressively refines the search results by marking images in the results as "relevant", "not relevant" to the search query, then repeating the search with the new information.

In our system we are using hybrid approach which is global image property based and neural network for effective and efficient image retrieval. As Global image property we are using color features of the image and feed forward back propagation (FFBP) neural network. FFBP precedes both in forward and backward direction. Output computation is carried out in forward direction and error computation in backward direction. We are using two unique properties for our system. 1) Global image features – HSV histogram and 2) Neural Network for classification of images by training and testing algorithms. In training we make FFBP NN to learn about the features of images in the database. We use this trained network during the testing (Retrieval of Images). Back-propagation technique, which is a supervised method for learning is used for training the neural network.

II. RELATED WORK

In digital neural network implementation, complexity of the forward phase can be reduced when the activation function is implemented through a lookup table (LUT) [1]. The LUT access time is noticeably independent from the function shape. It is well known that the network behavior, as that shown by the multilayer perceptron (MLP), greatly depends on the shape of these activation functions.

Focusing on literature survey, we find some most important CBIR systems [2], [3]. The conventional neuron model, proposed by McCulloch and Pitts in 1943 [4], is composed of a linear combiner followed by a nonlinear function (activation function) with hard-limiting characteristics. Recently, in order to develop gradient based learning algorithms, such hard-limiters are substituted with nonlinear differentiable functions [5]. Some papers overview and compare the current technique in this area [6], [7]. Earliest developed CBIR adopted various color descriptors.[8] proposed a signature-based color-spatial image retrieval system. A CBIR scheme based on global and local color

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distributions in an image is presented in [9]. [10] Proposed a CBIR method based on an efficient combination of multi-resolution of a color and texture features. The color features used in this paper are color auto-correlograms of the hue, saturation component of images in HSV color space. The texture features taken are including block difference of inverse probabilities and block variation of local correlation coefficient moments of the value component image. A survey on CBIR systems based on relevance feedback approach yields [11]. This paper introduces interactive genetic algorithm to include human computer interaction and tries to use user's subjectivity in retrieval process using a user defined fitness function. A comparison is made between two pattern recognition using statistical and neural techniques in [12]. Finally, a neural network based approach for image processing is described in [13], which reviews more than 200 applications of neural networks in image processing and discuss the present and possible future role of neural networks, in particular feed-forward neural networks.

III. Background Study And Literature Review

This section presents a brief review of considered low-level visual features in the proposed approach and then reviews the basic concepts of the feed-forward back-propagation neural network.

A. Color Discriptor

Color is one of the important features of an image, which represent the information of the images. In our system we used HSV color model because RGB color model do not correspond to the human way of perceiving the colors. And also RGB space does not separate the luminance component from the chrominance ones. Hue is used to distinguish colors; saturation gives a measure of the percentage of white light added to a pure color. Value indicates perceived light intensity.

Information of the images can be obtained by color distribution of the pixels in the image. For this color histograms are used. A color histogram represents the number of pixels that have colors in the image's color space. For a given image, the procedure for calculation of color histogram is as follows: 1) Read images in database and extract HSV format pixel information from images. 2) Create normalized histograms for each of the HSV components of each image read from database.

B. Neural Network

In machine learning, artificial neural networks (ANNs) are a family of statistical learning algorithms inspired by biological neural networks and are used to estimate or approximate functions that can depend on a large number of inputs and are generally unknown. Artificial neural networks are generally presented as systems of interconnected "neurons" which can compute values from inputs, and are capable of machine learning as well as pattern recognition.

This neural computing technique is used in fields of classification, optimization, and control theory and for solving regression problems. NN are very effective in case of classification problems where detection and recognition of target is required. NN is preferred over other techniques due to its dynamic nature. Dynamic nature is achieved by adjusting the weights according to final output and applied input data. This adjustment of weights takes place iteratively until desired output is obtained. And this weight adjustment of network is known as "learning" of neural network.

The architecture of neural network consists of a large number of nodes and interconnection of nodes. A multiple-input neuron with multiple inputs '*R*' is shown in Figure 1. The individual inputs p_1, $p2$,… p_n are each weighted by corresponding elements $w_{1,1}$, $w_{1,2}$…$w_{1,R}$ of the weight matrix '**W**'.

The neuron also has a bias '*b*', which is summed with the weighted inputs to form the net input '*n*':

$$\mathbf{n} = w_{1,1}*p_1 + w_{1,2}*p_2 + \ldots.. + w_{1,R}*p_R + \mathbf{b} \quad (3)$$

In matrix form, this can be rewritten as

$$N = W_p + b \quad (4)$$

Now, the neuron output is given as,

$$A = f\,(Wp + b) \quad (5)$$

The transfer function used above is a log-sigmoid transfer function. This transfer function takes the input (which may have any value between plus and minus infinity) and squashes the output in between 0 to 1 range, according to the expression:

$$\mathbf{y} = \log sig(n) \quad (6)$$

$$\mathbf{y} = \frac{1}{1+e^{-n}} \quad (7)$$

Where '*y*' is output of the function for input '*n*'.

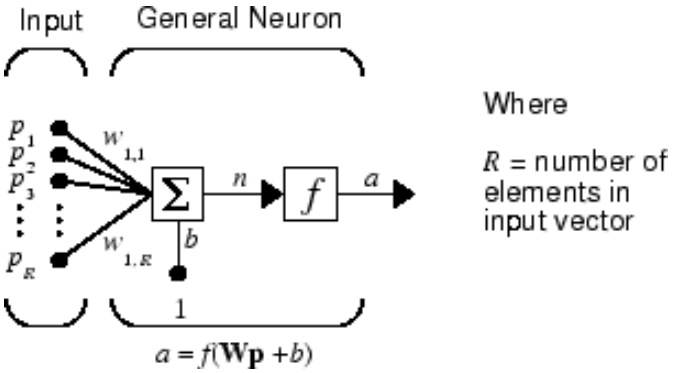


Figure-1: Multiple-Input Neuron [16]

The nodes at a particular stage constitute a "layer". The first layer is called input layer and last layer is called output layer. The layers in between output and input layer are called hidden layers. As the number of hidden layers in the network increases, the performance of network increases. Each node in a network serves the purpose of summation of all its inputs. The output of a node is further applied to the next node. The simplest of all neuron is perceptron. Perceptron is a two layer structure: input layer and output layer. The output function of perceptron may be step, linear or sigmoidal. If the output function of perceptron is step then it solves classification problems, if the output function is linear then it solves regression problems. Simple perceptron or neuron is used for resolving linearly separable data. If the data is linearly non-

separable then other technique such as back-propagation is used.

C. Feed Forward Back-Propagation Neural Network(FFBP)

FFBP NN is technique for pattern recognition and classification. FFBP NN is a multilayer neural network, used to implement non-linear differential functions. The architecture of FFBP NN consists of input, hidden and output layer. FFBP precedes both in forward and backward direction. It computes output in the forward procession and computes error in the backward procession.

In the forward procession, training data is applied on the neural network through the input layer. Then data is fed to the hidden layer, the hidden layer actually performs the processing. Finally the data is applied to Output Layer; Output Layer incorporates the activation function according to which output is computed. If the function at the Output Layer is step, then it performs Classification problem. If the function at the Output Layer is linear, then it performs Regression problem.

The values computed in the forward pass are compared with desired output. The difference between the desired output and the actual output gives the error. This error is computed and propagated back towards the Hidden Layer. The gradient of the error is computed and applied on a node k in this manner

$$e_k = desired\_output - actual\_output \quad (8)$$

$$e_k = d_k - y_k \quad (9)$$

Where e_k error on a single output neuron k is, d_k is desired output and y_k is calculated output of neuron k. Then gradient is calculated using question:

$$\delta k = \frac{\delta y k}{\delta x k} * e_k \quad (10)$$

Where x_k is weighted sum of input values to node *k*. This method of error reduction is called Gradient Decent. This method reduction converges to output in faster manner. All of the above processing is performed in the backward pass if FFBP algorithm.

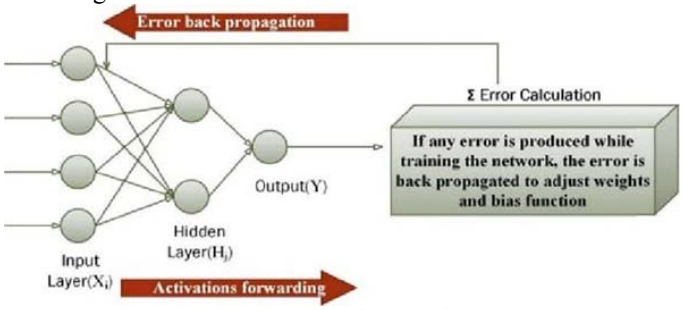


Fig 2. Simple Back propagation Neural Network [16]

The figure 2 shows a basic BPNN comprising of an input, hidden and output layer. Where inputs applied on the input layer X_i, H_j is the hidden layer and the output of the network is *Y*. Error signal that is generated when the output 'Y' is compared to the target output of the training dataset comprising of the ideal classification result. The error signal moves from the output layer to the hidden layer changing the weights to adjust to the correct result. Once this error is minimized lose to zero the weights are fixed meaning the network is trained and can be tested.

IV. Problem Defination

We have two phases in our system. First is neural network that is used for classification of the query image. After successful classification of query image further retrieval is proceed based on Image retrieval using low level image features. In our system HSV Color model is used. Color images normally are in three dimensional. HSV color components are taken from each and every image. Then the average value of H, S, and V values for both query image and target images are calculated. These three average values for each image are stored and considered as features. By using these stored features the target image from the repository is retrieved with respect to the query image. The resulted values of both the query image and target images are compared by Euclidean distance method.

A. Proposed Methods

In this, a new method for image classification is formulated in order to reduce the searching time of images from the image database. The coarse content of image is grouped under nine Categories as: Custard apple, Pineapple, Mango, Green Apple, Red Apple, Banana, Red Capsicum, Pear, and Watermelon. Thereby, we can reduce the search space by one third of what was earlier.

B. Image Retrieval

Image Retrieval from the image collections involved with the following two phases:

1) Phase-1

During Phase-1 classification of query image is performed. This result is then passing on to phase-2. Steps for phase-1 are Pre-processing, Feature Extraction and Image Classification.

a) Pre-Processing

The aim of the pre-processing is an improvement of the image that suppresses unwilling distortions or enhances some image features, in preprocessing for image classification we are following two steps

- Resizing of image into 256 * 256 pixels
- Convert each image into gray image

b) Feature Extraction

Feature Extraction is processes of knowing the color distribution information of any image. For this histograms are used. Process for creating histogram is given below:

- Read images in database and extract gray format pixel information from images.
- Create normalized histograms for each components of each image read from database.

In our system we are using 54 Images as test images that are to be used during training phase of the neural network.

c) Image Classification

Image Classification is processes of determining the class of the image according to database. For example in our system we have total nine classes. For each class we have six test images. Architecture for the phase-1 is shown in fig. 3.

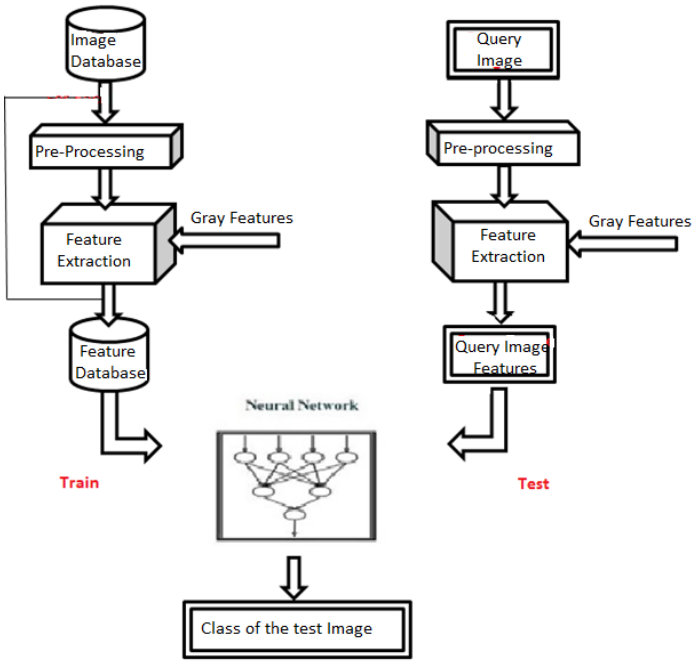


Fig 3. Architecture of phase-1

The training process includes creation, configuring a three-layered neural network and making it learn about the extracted features of training images. Training set includes all the images from image database (6 Images for each 9 classes). The learning process is carried out using back-propagation algorithm, which include computing error, updating weights In order to minimize the error.

The training makes the network store the learnt knowledge in its knowledge base. This knowledge base is used in later phase in comparison and decision making tasks by network. The comparing the features between query and training set images. And decision making task includes making decision about which two images features are most matched with respect to each other.

The testing phase includes the querying and retrieving class of the query image. The query image is first preprocessed and also its features are extracted. The trained network is presented with query image features. The network, acting as a classifier, selectively retrieves top matched, relevant, similar images as that of query image from the training database and gives the class of the query image.

2) Phase-2

Phase 2 is process of retrieving similar image from the database using global image properties (Color Features) as per result of phase-1. Result of phase-1 gives class of the query image. During Phase-2 retrieval of similar image is performed according to query image and its class. Steps for phase-2 are Pre-processing, Feature Extraction, similarity comparison and displaying n most similar images.

a) Pre-Processing

Pre-processing of this phase is same as first phase but in this phase processing and enhancement is perform on RGB image rather than gray image. In preprocessing for image retrieval phase we are following two steps; 1) Resizing of image into 256 * 256 pixels and 2) Convert each RGB color space into HSV color space

b) Color Feature Extraction

Feature extraction is carried out in the same way as we did in phase-1.

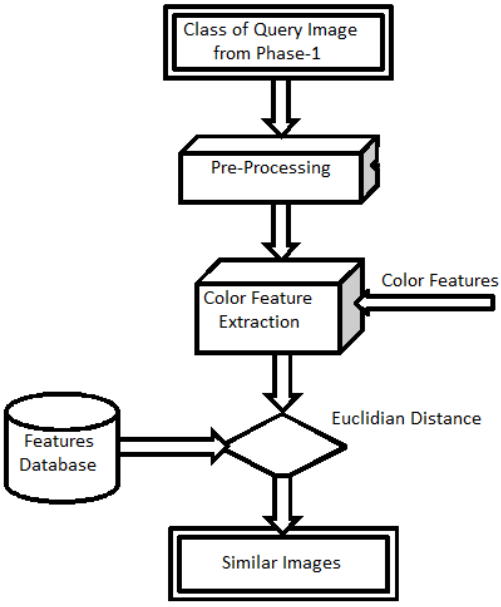


Fig 4. Architecture of Phase-2

c) Similarity Comparision

Similarity comparison means finding images from the database which are near (Similar) to query image according to its color features. Euclidian Distance is used to find similarities between query image and dataset images.

d) Display

Most similar images according to Euclidian Distance are displayed as per its priority.

V. Implemetation And Result

The experimental work is carried out using the database of the fruit images for experiment. The database is partitioned into nine categories of fruits, including, Sitafal, Guava, Banana, Pineapple, apple, pear, green apple, mango, watermelon, red capsicum etc., and each category contain six images. Images from each category are shown in fig 5.

To realize the proposed system MATLAB is used. The GUI design environment tool is used to develop the required front end GUI. The Image Processing toolbox and the neural network toolbox of MATLAB are used to implement the required image processing and network tasks.

A three layered neural network which is used as classifier, is setup and configured with parameters that are best suitable for image retrieval task. The configuration includes setting the permissible error to 0.001, and selecting the Back-Propagation as training algorithm, then, network is trained

about the extracted features of all images from the training database.

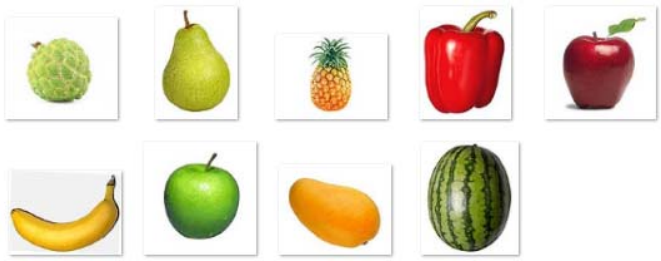


Fig 5. Images from each Category

The performance plot is a graph of epochs versus the mean square Error (MSE). The number of epochs we have taken is 500 and MSE measure the average of the squares of the errors. A given query image features are extracted and searched for similar images. For query image relevant images are considered to be those which are belong to same class. Fig 6 shows the graph for best training performance:

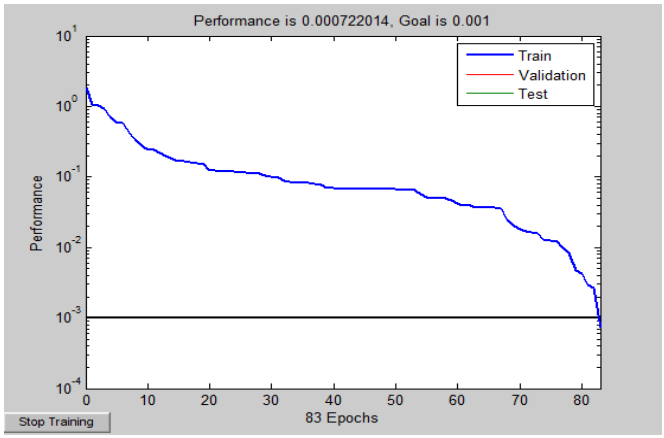


Fig 6. Best Training Epochs

Fig 7 (a) describes the query image and output for query image of custard apple without neural network is shown in fig 7 (b).

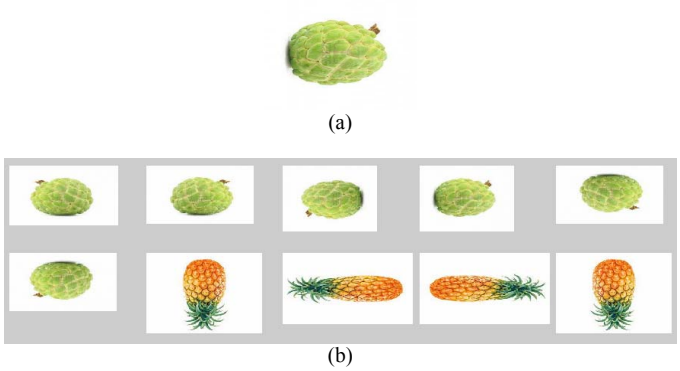
Fig 8 (a) describes the query image and output for query image of custard apple with neural network is shown in fig 8 (b).

The performance of the system is measured and compared by calculating precision and recall for the cases of retrieval using classification and without classification. Precision and recall is defined as,

$$\text{Precision} = N_{A(q)}/N_{R(q)} \quad (11)$$

$$\text{Recall} = N_{A(q)}/N_t \quad (12)$$

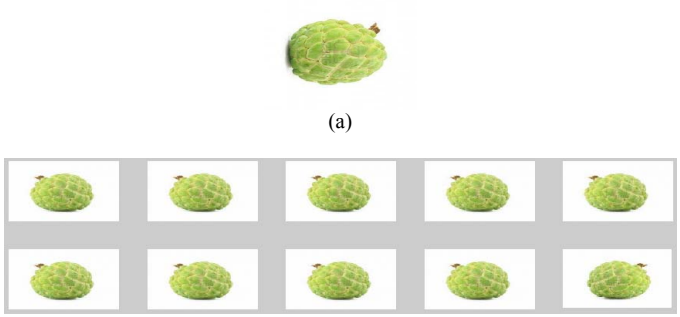
Where $NA(q)$ is the number of relevant images similar to the query, $NR(q)$ is the number of images retrieved by the system in response to the query, and Nt represents the total number of relevant images available in the database.



(a)

(b)

Fig 7. (a) Query Image (b) Output without classification



(a)

(b)

Fig 8. (a) Query Image (b) Output with classification

The table given below shows the details of retrieval precision and recalls values for each class of image. The TABLE I give the precision values along with the average precision and similarly gives recall values along with their average. Values for $N_{R(q)}$ and N_t are 10 and 54 respectively.

		CBIR with Neural Network		CBIR without Neural Network	
Class	***Category***	***Precision***	***Recall***	***Precision***	***Recall***
1	Sitafal	100	90	60	60
2	Pineapple	100	90	60	60
3	Green Apple	100	90	60	60
4	Red Apple	100	90	60	60
5	Banana	100	90	60	60
6	Red Capsicum	100	90	60	60
7	Mango	100	90	60	60
8	Watermelon	100	90	60	60
9	Pear	100	90	60	60
	Average	**100**	**90**	**60**	**60**

Table 1: Precision and Recall value

VI. CONCLUSION

This paper has presented a CBIR system using feed-forward neural network. The color histograms are used as color information of an image. The experiments are done on limited classes of fruit images. The use of feed-forward neural network has considerably improved the recall rate and also retrieval time, due to its highly efficient and accurate classification capability. Also, the back-propagation algorithm has increased the retrieval precision due to its capability of minimizing the error during training process itself. The result may be affected if the images of same fruit, taken for training, are having less global similarity.

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