A Novel Approach for Image Retrieval using Back Propagation Neural Network

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Abstract— This technique uses visual contents to search images from large scale image databases according to the user's interest. The features refers to color, shape, texture that can be derived from the image. In this paper an image retrieval system using artificial neural network (ANN) in MATLAB with the help of wavelet transforms is contemplated. In the proposed system, mean and standard deviation of the images are calculated later to the filtering process of the images using wavelet transforms. Using the neural network classifier the system is trained and tested and classifies the images from a vast database relevant to the requirement. A database having 1000 images spread across ten categories is taken for the implementation purpose. Net average precision and recall values are computed for the database query. The obtained results show the performance improvement with higher precision and recall values.

Key words: Image Retrieval, Back Propagation, Neural Network

I. INTRODUCTION

Multimedia data comprising of images, audio, and video is becoming increasingly common. The decreasing costs of consumer electronic devices such as digital cameras and digital camcorders, along with the ease of transportation facilitated by the Internet, has led to a phenomenal rise in the amount of multimedia data. Given that this trend of increased use of Multi media data is likely to accelerate, there is an urgent need for providing a clear means of capturing, storing, indexing, retrieving, analyzing, and summarizing such data. Image data is a very commonly used multimedia data type.

The early image retrieval systems are based on manually annotated descriptions, called text-based image retrieval (TBIR). TBIR is a great leap forward, but has several inherent drawbacks. First, textual description is not capable of capturing the visual contents of an image accurately, and in many circumstances, the textual annotations are not available. Second, different people may describe the content of an image in different ways, which limits the recall performance of textual-based image retrieval systems. Third, for some images there is something that no words can convey. To resolve these problems, content-based image retrieval (CBIR) became an active and fast developing research area from the early 1990s, and has attracted significant research attention. CBIR aims to search images that are perceptually similar to the query based on visual content of the images without help of annotations.

II. NEED AND IMPORTANCE OF RESEARCH PROBLEM

In today's scenario image classification and retrieval has become the most challenging and important research work for a wide range of applications like geographical information and remote sensing systems, crime prevention, intellectual property, medical diagnosis, military applications architectural and engineering design, art collections, etc. Locating a desired image in a large and varied collection of database is a considerable impediment for the researchers. Early work on image retrieval can be dated back to the 1970's but they were not based on visual features but textual annotation. Hence it couldn't support task dependent queries. Traditional methods posed such problems which have led to the image retrieving techniques based on content or features such as texture, color and shape.

It has been shown that artificial intelligence (AI) plays an important role in the feature extraction, similarity measures, and relevance feedback of CBIR. CBIR using AI technology is emerging as a new discipline, which provides the mechanisms for retrieving image data efficiently and naturally by means of AI technology. Many researchers have been concentrating on CBIR using AI technology. The research and development of CBIR using AI technology are receiving increasing attention. By means of AI technology, large volumes of image data can be retrieved effectively and naturally from image databases. Intelligent CBIR systems are hereby built based on AI and databases to support various problem solving and decision making. Intelligent CBIR systems is a field that must be investigated by academic researchers and developers together, both from the CBIR and AI fields.

III. OBJECTIVES

The primary objective of the proposed work is to study the architecture of neural network and understand the efficiency of these neural networks in the categorization and efficient retrieval of the images.

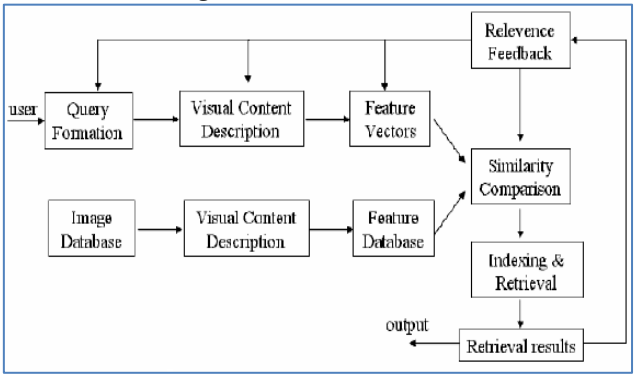

Fig. 1: Research Methodology

The main objective of this research intends to undertake the work with the following sub objectives:-

1) To reduce the semantic gap by using relevance feedback mechanism.
2) To develop an improved approach to compare and analyze the neural network architecture.
3) To develop novel approaches to discover image patterns on image data set.

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4) To utilize neural network algorithms to train the neural networks with image data sets and study the efficiency of the retrieval.
5) To compare and analyze the efficiency of retrieval based on precision and recall parameters with respect to computational time.

IV. METHODOLOGY

A. Back Propagation Neural-Network based categorization and retrieval.

1) Feature extraction and representation:
Features are properties of images such as color, texture, shape, edge information extracted with image processing algorithms. A single feature does not give accurate results, but a combination of features is minimally needed to get accurate retrieval results.

2) Color:
The most widely used visual feature in image retrieval is color feature. Color feature is relatively robust to background complications. Each pixel can be represented as a point in 3D color space. Commonly used color space include RGB. In the RGB color space, a color is represented by a triplet (R, G, B), where R gives the intensity of the red component, G gives the intensity of the green component and B gives the intensity of the blue component.

A number of important color features have been proposed in the literatures, including color moments (CM), color histogram, color correlogram etc. The Color moment can be used as remedies of user's queries which are semantic in nature. Color histogram is a popular color feature that has been widely used in many image retrieval systems. Color histogram is robust with respect to viewpoint axis and size, occlusion, slow change in angle of vision and rotation. The color correlogram was proposed to characterize not only the color distributions of pixels, but also the spatial correlation of pairs of colors. Compared to the color histogram the color correlogram provides the best retrieval results, but is also the most computational expensive due to its high dimensionality.

3) Color moments:
To differentiate objects based on color, Color moments have been successfully used in many retrieval systems, especially when the image contains just the object. The basis of color moments is that the distribution of color in an image can be considered as a probability distribution which can be characterized by various moments. ie. If the color in an image follows a certain probability distribution, the image can be identified by that distribution using moments. The first order (mean), the second order (variance) and the third order (skewness) color moments have been proved to be efficient and effective in representing color distributions of images.

4) Texture:
Texture is another property of image which is used in pattern recognition and computer vision. Texture is defined as structure of surfaces formed by repeating a particular element or several elements in different relative spatial positions. The repetition involves local variations of scale, orientation, or other geometric and optical features of the elements.

5) Haar wavelet Transforms:
Wavelet transforms provide a multi-resolution approach to texture analysis and classification. The wavelet transform represents a function as a superposition of a family of basic functions called wavelets.

For a 1D Haar transform of an array of N elements, find the average of each pair of elements, find the difference between each pair of elements and divide it by 2, fill the first half of the array with averages, fill the second half of the array with coefficients and Repeat the process on an average part of the array until a single average and a single coefficient are calculated. For a 2D Haar transform, Compute 1D Haar wavelet decomposition of each row of the original pixel values and then compute1D Haar wavelet decomposition of each column of the row-transformed pixels. Red, green and blue values are extracted from the images. Then we apply the 2D Haar transform to each color matrix. We apply Haar wavelet decomposition of an image in the RGB color space. We continue decomposition up to level 4, and with F-norm theory we decrease the dimensions of image features and perform highly efficient image matching.

The similarity between two images is computed by calculating the distance between feature representation of the query image and feature representation of the image in the dataset. We use Canberra distance for distance calculation of the feature vectors.

A feature vector is extracted from each image in the database and the set of all feature vectors is organized as a database index. When similar images are searched with a query image, a feature vector is extracted from the query image and is matched against the feature vectors in the index. If the distance between feature representation of the query image and feature representation of the database image is small, then it is considered similar. Thus we can use Haar wavelet for matching images from the database.

6) Daubechies wavelet:
The Daubechies wavelets, based on the work of Ingrid Daubechies, are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some given support. With each wavelet type of this class, there is a scaling function (called the *father wavelet*) which generates an orthogonal multiresolution analysis.

In general the Daubechies wavelets are chosen to have the highest number *A* of vanishing moments, (this does not imply the best smoothness) for given support width *2A - 1*. There are two naming schemes in use, D*N* using the length or number of taps, and db*A* referring to the number of vanishing moments. So D4 and db2 are the same wavelet transform.

Among the 2^{A-1} possible solutions of the algebraic equations for the moment and orthogonality conditions, the one is chosen whose scaling filter has extremal phase. The wavelet transform is also easy to put into practice using the fast wavelet transform. Daubechies wavelets are widely used in solving a broad range of problems, e.g. self-similarity properties of a signal or fractal problems, signal discontinuities, etc.

The Daubechies wavelets are not defined in terms of the resulting scaling and wavelet functions; in fact, they

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are not possible to write down in closed form. The graphs below are generated using the cascade algorithm, a numeric technique consisting of simply inverse-transforming [1 0 0 0 0 ...] an appropriate number of times.

B. Neural Network architecture:

An artificial neural network, often just named a neural network, is a mathematical model inspired by biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases a neural network is an adaptive system changing its structure during a learning phase. Neural networks are used for modeling complex relationships between inputs and outputs or to find patterns in data. The inspiration for neural networks came from examination of central nervous systems. In an artificial neural network, simple artificial nodes, called "neurons", "neurodes", "processing elements" or "units", are connected together to form a network which mimics a biological neural network.

The cost function is an important concept in learning, as it is a measure of how far away a particular solution is from an optimal solution to the problem to be solved.

Learning algorithms search through the solution space to find a function that has the smallest possible cost.

For applications where the solution is dependent on some data, the cost must necessarily be a function of the observations; otherwise we would not be modeling anything related to the data. It is frequently defined as a statistic to which only approximations can be made.

Choice of model will depend on the data representation and the application. Overly complex models tend to lead to problems with learning.

Learning algorithm: There are numerous trade-offs between learning algorithms. Almost any algorithm will work well with the correct hyper parameters for training on a particular fixed data set. However selecting and tuning an algorithm for training on unseen data requires a significant amount of experimentation.

The neural network classifier consists of three layers with an input layer, a hidden layer, and an output layer. The input layer has input nodes, the hidden layer has hidden nodes, and the output layer has output nodes. The neural network is trained and changed weights until the minimum error reduces to 0.1.

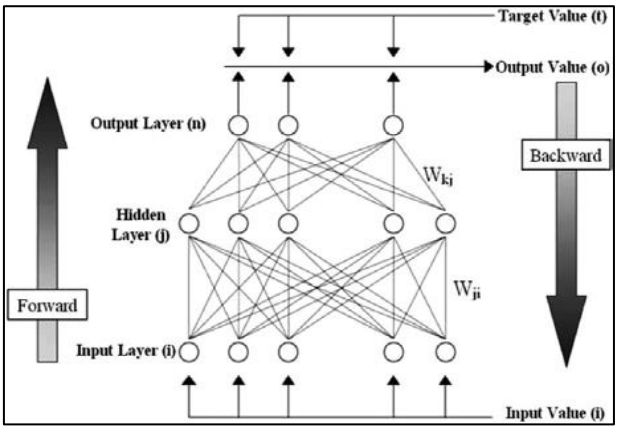

Fig 2: Various layers of neural network

C. Combining the features:

The image retrieval using only single feature such as color moment or color histogram may be inefficient. It may either retrieve images not similar to query image or may fail to retrieve images similar to query image. To produce efficient results, we use combination of color and texture features. The similarity between query and target image is measured from two types of characteristic features which includes color and texture features. Two types of characteristics of images represent different aspects of property. While calculating similarity measure, appropriate weights are considered to combine the features.

The distance ‘d ‘ is calculated for each query image with all images in the database. The image that has a lower distance value is considered the similar image and the results are ranked in the ascending order of d. From the studies, It is seen that the value of the average precisions based on single features i.e. only Gabor texture features or only Color moments are less than the average precisions of combined features of color moments and Gabor texture features. This shows that there is considerable increase in retrieval efficiency when both color and texture features are combined for CBIR. Also it is found that the texture and color features are extracted through wavelet transformation and color histogram and the combination of these features is a faster retrieval method which is robust to scaling and translation of objects in an image.

D. Classification of images:

The nearest images obtained using feature extraction techniques are routed to Neural Network classification [13]. Neural Networks are very effective in case of classification problems where detection and recognition of target is required. It is preferred over other techniques due to its dynamic nature of 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 2. The individual inputs P1, P2…., P_R are weighted by corresponding elements W „ W „ … , W ,• of the weight matrix W.

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 retrieved images are classified using three layer neural network. The first layer has input neurons which send data via synapses to the second layer of neurons, and then via more synapses to the third layer of output neurons. The synapses store parameters are actually weights that manipulate the data in the calculations. In each iteration, the weights of interconnections are updated for efficient retrieval. The next process is the clustering of the accumulated images into positive and negative feedback.

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The images obtained are routed to fuzzy c-means clustering algorithm. The positive and negative relevance of every image with the query image is analyzed. Accordingly, relevant and irrelevant image subsets are created, which will be progressively populated across iterations, based on the change in weights of individual features, thus changing the distance between the query image and the database images. This will help in retrieving the exact query image from the database. The Relevance Feedback based similarity technique is used where in each iteration the feature weights are updated. The number of output images required can be controlled by the user.

V. SIZE OF SAMPLES

The proposed research work is implemented on different groups of image data sets, each of them comprising various kinds of images. The data set characteristics differ in terms of samples and attributes.

1	African People & Villages
2	Beach
3	Buildings
4	Buses
5	Dinosaurs
6	Elephants
7	Flowers
8	Horses
9	Mountains & Glaciers
10	Food

Table 1: Image categories in Corel-1000

Machine learning and other artificial intelligence (AI) approaches have attracted increasing interests in the content-based image retrieval (CBIR) area. Many research works have been conducted, which led to quite a few encouraging achievements. However, there remain a number of emerging challenges and open issues to be addressed:

1) Better interaction scheme to alleviate the manual efforts.
2) Faster converging process to speed up the retrieval task.
3) Noise-tolerate mechanism.

Recent retrieval systems have incorporated users' relevance feedback to modify the retrieval process in order to generate perceptually and semantically more meaningful retrieval results. Recent works on color image coding using vector quantization has established that color and pattern information can be used as image indices for classification and retrieval purposes. The diagram indicating the process is shown below.

VI. RESULT

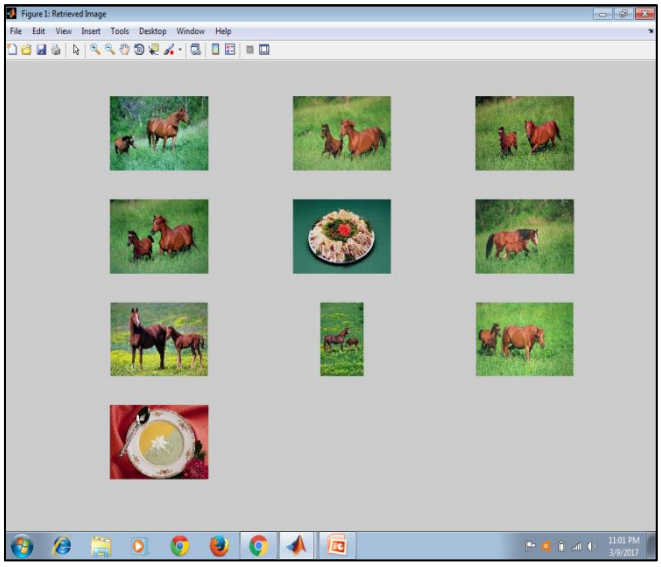

Fig. 3: Result

VII. CONCLUSION

This paper investigated various feature extraction algorithms in CBIR. A study of different color and texture features for image retrieval in CBIR is performed. Numerous methods are available for feature extraction in CBIR. They are identified and studied to understand the image retrieval process in the CBIR systems. Studies made on experiment results show that:

The method based on hybrid combination of color and texture features has higher retrieval accuracy than the other methods based on single feature extraction. Color moments, color histograms, color correlogram and gabor texture are considered for retrieval. It is difficult to claim that one feature is superior to others. The performance depends on the color distribution of images.

The combination of color descriptors produces better retrieval rate compared to individual color descriptors. Color moments and color histogram features can be combined to get better results. Color histograms and correlograms can be combined retaining advantages of histograms with spatial layout. Similarly, Texture feature can be combined with color moments or color histogram to get accurate results for image retrieval.

From the studies, it is found that only one color feature or texture feature is not sufficient to describe an image. There is considerable increase in retrieval efficiency when both color and texture features are combined.

Also we have reviewed various papers related to different classification methods for the improvement of image retrieval in CBIR. Among different classification methods, Neural Network classification is an efficient method for image retrieval. It takes into account the characteristics of relevant and irrelevant images.

Neural Network classification has considerably improved the recall rate and also retrieval time, due to its highly efficient and accurate classification capability.

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