Retrieval of Image Databases Using Supervised Learning Approach

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Abstract

Retrieval of images from large collections of image databases based on the image content has become an important issue for database and image processing communities. It is generally accepted that texture and color are the key features for the Image Retrieval Systems. Normally texture is extracted from gray scale images and the contribution of color to the perception of texture has been ignored mostly. The paper proposes a method which combines the human perception of color and texture employing supervised learning to obtain an overall impression of image. The initial results of the proposed technique found to be promising. Some of the results have been reported in the paper.

Introduction

Advances in storage and processing technologies have made possible the use of large image databases in medical imaging, geographic information systems, satellite images, and other photographic galleries. However, retrieval of images and meeting user's needs has not improved as much as a user expect and a number of issues are yet to be addressed. As a result of it the content based retrieval in image databases has recently gained much interest. Many content based image retrieval systems have been developed.[1,3,4] These systems model image data by extracting the image features such as color, shape and texture. The input images are analyzed to extract the image features these features are then used to store in the image database. Color and texture are two important cues used for image matching and retrieval. Traditionally, color images require large storage and high computational requirements. But, with advances in technology, the computing and storage costs are rapidly decreasing. As a result, color images are increasingly being used in many applications. The foremost problem with most of the content based image retrieval systems is providing the user's needs to the databases for retrieval.[8] The user can not provide the value for feature as these are either represented in the complex form such as matrices or huge numbers. As a result of it example based querying was introduced.[5,6] It supports a query by example model for retrieval. If a user has to retrieve images based on color information, the user refers to a set of colors that fall within the human perceptual range. Thus we have considered the color feature values within the human range of perception. It has been found that the user can only recognise a small set of feature values in general. Thus the system uses color feature values from approximately (256x256x256) 16 millions to twenty seven colors which are within human perceptual range. The proposed method takes care of "imprecision". The user always provides partial information while posing queries. In the proposed method efforts have been made to model the imprecision using fuzzy interpretation. The texture feature has been extracted using Gabor filter. The paper employs a neural network[7] based technique for image retrieval, which integrates color information with texture features to obtain an overall impression of image.

The rest of the paper is organized as follows. Section 2 describes the proposed system. The Reference Color Table method and Texture Feature extraction has been described in Section 3. The supervised learning method is presented in Section 4. The preliminary results have been reported in Section 5. The last section provides conclusions.

Proposed Technique

This section explains the technique of the proposed Image Retrieval System. Stage 1 deals with feature extraction from images and these feature are stored in the Image database. Images from the Kodak album have been downloaded from World Wide Web (WWW) and stored in the database. Let F_{ID} denote the set of all features used for representation of image. For example F_{ID} = {Color, Texture, Shape}. In the proposed technique we have used color and texture feature, i.e. F_{ID} = {Color, Texture}. Stage 2 gives the query to retrieve the images from database and is converted in terms of natural language such as mostly, many and few content. Fuzzy logic has been employed to define the query. Fig.1. shows a block diagram of the proposed image archival and retrieval scheme. The use of color information has been widely used for image retrieval. Histogram based color retrieval techniques suffers from important spatial knowledge.[2,9] So, a technique which uses the reference color table for color feature extraction has been used. Only twenty seven colors that fall with in human range of perception are used as input to the neural network along with the texture feature vector computed for the image. The output obtained after the training of the neural network is used to compute the similarity factor for each image for a specific query.

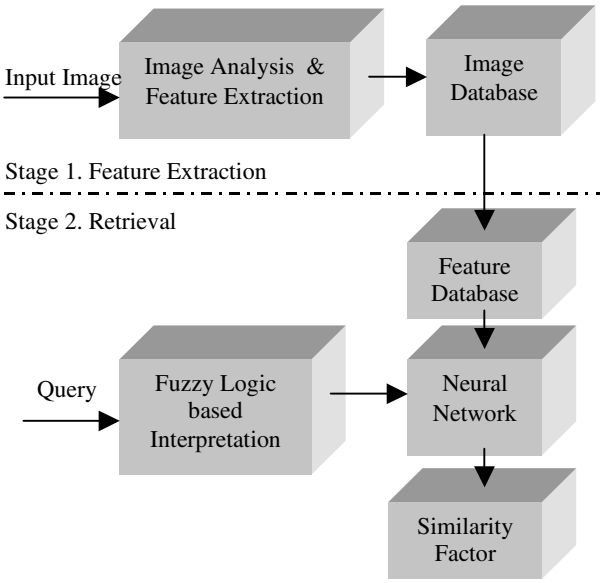


Figure 1. Block Diagram of proposed technique

Color and Texture Feature Extraction

Each image has a set of pixels. Let there are N_p numbers of pixels in each image. First we define a relationship between the pixel and F_u under the interpretation domain U as a mapping $F_p : N_p \rightarrow map(F_u, U)$ with $F_p(p,f) = \mu_p(f)$, where $p \in N_p$, $f \in F_u$, and $\mu_p(f)$ represent the membership function of p in the fuzzy set f. Each pixel in the image is mapped into RGB color space. The RGB color space is then mapped into HSV color space. The RGB and HSV values of each pixel is then passed to a filter, which finally mapped into 27 color channels: (Black, Darkblue, Blue, Darkgreen, Turquoise, Skyblue, Green, Spring-Green, Cyan, Brown, Violet, MarineBlue, OliveDrab, Grey, SlateBlue, LawnGreen, PaleGreen, LightCyan, Red, Maroon, Magenta, Orange, Pink, LightMagenta, Yellow, LightYellow, White). In this way, each pixel in the color image is mapped into the twenty seven color channels.[10] For mapping each pixel into twenty seven color the reference color table method has been used to store the color feature vector. A set (table) of reference colors are defined in the reference color table method. This set of colors is selected such that all the colors in the human perception have been covered approximately. Table 1 shows the color which has been used for the image database in the paper.

Each pixel can be mapped into more than one color channel. If the pixel maps into the color channel, it is represented as a membership value 1. There exist some color pixels that may not be mapped into any color channels. If the pixel does not map into the color channel, it is represented as a membership value 0.

Thus a relationship is obtained between the pixel and the feature representation set. Pixels that do not belong to a particular color channel, i.e., the membership value 0 does not have any significance.

Table.1 Reference Color Table

Color	R	G	B
Black	0	0	0
DarkBlue	0	0	128
Blue	0	0	255
DarkGreen	0	128	0
Turquoise	0	128	128
SkyBlue	0	128	255
Green	0	255	0
SpringGreen	0	255	128
Cyan	0	255	255
Brown	128	0	0
Violet	128	0	128
MarineBlue	128	0	255
OliveDrab	128	128	0
Grey	128	128	128
SlateBlue	128	128	255
LawnGreen	128	255	0
PaleGreen	128	255	128
LightCyan	128	255	255
Red	255	0	0
Maroon	255	0	128
Magenta	255	0	255
Orange	255	128	0
Pink	255	128	128
LightMagenta	255	128	255
Yellow	255	255	0
LightYellow	255	255	128
White	255	255	255

In the proposed technique, the color information are extracted from the image and stored in the database using the summary representation system. The summary mapping is defined as follows :

$$g : I \rightarrow map(F_u, U)$$

in which F_u is a set of twenty seven colors, and I be the set of images in the databases. The summary information of an image has shown in Fig. 2. is given below :

S(i) = {(Black,0.02), (Darkblue,0.00), (Blue,0.00), (Darkgreen,0.14), (Turquoise,0.00), (Skyblue,0.00), (Green, 0.02), (SpringGreen,0.00), (Cyan,0.00), (Brown,0.00), (Violet,0.00), (MarineBlue,0.00), (OliveDrab,0.00), (Grey,0.00), (SlateBlue,0.00), (LawnGreen, 0.00), (PaleGreen,0.00), (LightCyan,0.00), (Red,0.81), (Maroon,0.00), (Magenta,0.00), (Orange,0.02), (Pink,0.23), (LightMagenta,0.00), (Yellow,0.00), (LightYellow,0.00), (White,0.00) }

Figure 2. Example Image

This summary information can be interpreted as the image I belongs to a fuzzy set red with the membership value 0.81. The membership value 0.81 represents the

ratio of total number of pixels that fall in the red channel to the numbers of pixels in the image. Fuzzy logic is used to define the query. Generally user prefer to provide the queries in terms of natural language such as mostly, many and few. So we have assumed the content for each image as to be "mostly", "many" and "few". In the proposed model the interpretation domain is a fuzzy set [0,1]. The ranges of the values used are [0.9,1] for "mostly", [0.4, 0.5] for "many" and [0.1, 0.2] for "few".

For extraction of texture features, the images are converted to gray scale images and the Gabor filter technique has been used.

The color information for the image along with the texture feature has been stored in the image database. The feature vectors are supplied as input to the neural network and the network is trained for the output.

The Supervised Learning algorithm is as follows:

Supervised Learning Algorithm

Step 1: Given a image extract the color and texture features for the image and store it in the image database.

Step 2: Given a query image q, extract its features $\{f_1^q, f_2^q, \ldots, f_r^q\}$.

Step 3: Train the neural network for Image features.

Step 4: Compare each query feature vector f_i^q with the features of the images in the image database and return

Step 5: Receive the user feedback.

Step 6 : Train the network incrementally according to user feedback.

Step 7: Go to step 3 with adjusted network.

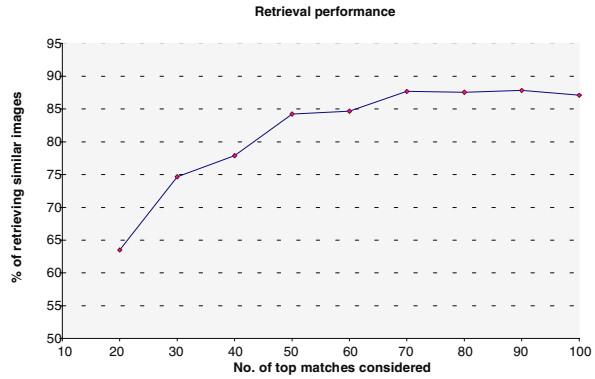


Figure 3 (i). Retrieval Performance

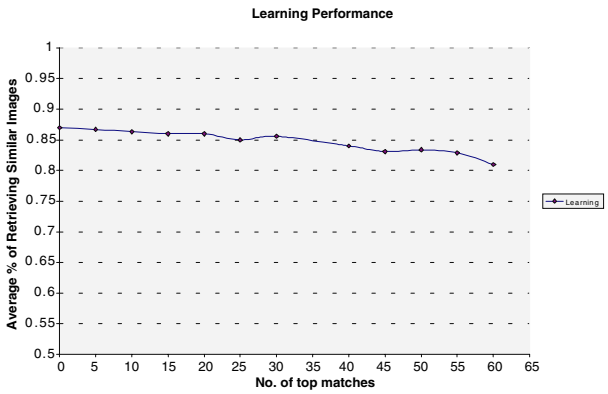


Figure 3 (ii). Learning Performance

Experimental Results

The algorithms have been implemented in C/C++. The routines of KUIM software have been used for calculating the average difference of images for retrieval The experiments are carried out on a Pentium III 800 MHz machine with 256-MB memory. For testing the effectiveness of the algorithm collection of images from Kodak album the World Wide Web has been used as Image Database. The training file of neural network is developed by considering the Learning rate (η) as 0.3 and momentum (α) as 0.7. Initially we have performed the experiments by taking 100 iterations.

Figure 3(i) and Fig.3(ii) illustrates the retrieval performance and learning performance respectively.

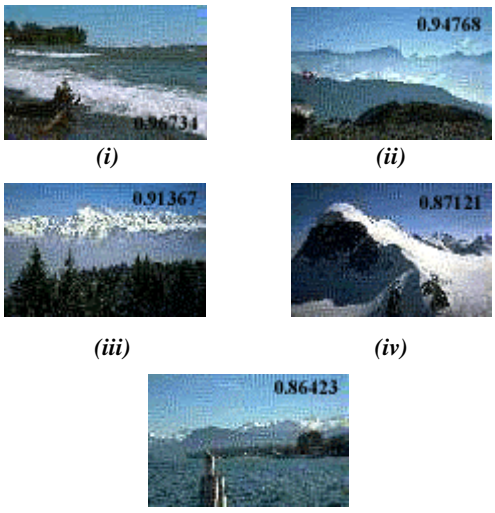
Some of the results obtained for Color queries are presented below:

Figure 4. Query Image

Similar images based on color query are given as under with the similarity factor as mentioned.

Conclusions

We have tested and implemented the algorithm for color queries. The complexity for feature computation for color is $O(M^2)$. For texture based queries independently the algorithm is under testing phase. The preliminary results of the approach for color based queries appears to be quite satisfactory. Our future work will incorporate the other features of image such as shape. We intend to use the image retrieval method for medical diagnosis, we are in a process of acquiring the medical images from National Technical Information Services Springfield U.S.A.



(i) *(ii)* *(iii)* *(iv)* *(v)*

Figure 5. First Five Similar Images in color based on Query Image given in Fig. 4.

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Biography

R.C. Joshi received the B.E degree in Electrical Engineering from University of Allahabad in 1967. M.E and Ph.D degree from University of Roorkee in 1970 and 1980 respectively. He joined the faculty in the year 1970 and currently he is Professor in Electronics and Computer Engineering Department, Head, Computer Centre, Indian Institute of Technology, Roorkee. He has guided more than 10 Ph.D's and more than 100 M. Tech Dissertations. He was awarded Gold Medal by Institution of Engineers for best research paper in the year 1974. His current research interest includes Parallel and Distributed Computing, Mobile Computing, Computer networks, Multimedia and Image databases.

Shashikala Tapaswi received her B.E degree in Electronics Engineering in 1986 from Jiwaji University, Gwalior. M.Tech Computer Science from University of Delhi in 1993. She joined as a faculty in M.I.T.S Gwalior in 1987. She is presently Reader and Head of Computer Applications Department. Currently she is pursuing her Ph.D in Computer Engineering from Indian Institute of Technology, Roorkee. Her research interests are Image Databases and System Software.