A Novel CBIR System Using Adaptive K-Means Clustering and Multi Class SVM Classification

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Abstract- *In this paper, a Novel CBIR system with adaptive K-means using Hue, Saturation and Intensity color space and multi kernel SVM method with an efficient combination of contrast enhancement, color moment, DWT features is proposed. We extended the previous work which used binary SVM classifier and color features. First of all take a query image, then the appearance of the image is improved by using contrast adjustment. Using adaptive K-means, segment the object edges. For its color feature, apply color moment method, convert RGB into HSI color space and make feature vector. Extract texture features using DWT and inverse difference moment (IDM). Skewness and Kurtosis are extracted for shape feature. Variance, root mean square (RMS) is extracted for color feature. After extracting the image features, we used a supervised learning technique which is known as Multi kernel SVM to determine the optimal outcomes. After combining the features, classification of data is performed. And finally comparison is made between the proposed method and the previous method. The proposed method gives better accuracy and precision value. This work is simulated on MATLAB 2013R simulator.*

Keywords- DWT, SVM, K-means, Color Moment, HSI.

I. INTRODUCTION

The progress in digital photography, storage limit and speed of network made possible in storing a high quality large amount of images. Applications of digital images include military, medical, virtual museums and individual photograph Collections [1]. CBIR is used to retrieve the most similar images as related to the given query image. Assume there are a huge number of color pictures in the database. For an image submitted by user, we would like to obtain those images from the database which are most similar to the input query image. To find a solution for this problem, two concepts are needed to be developed, first the feature which gives the color information of picture and the second one is a similarity measure to find the similarity between two images. As image retrieval is having so many applications in various domains such as digital library, remote sensing and so on, so Research on image retrieval is having lot of importance [2].

Content Based Image Retrieval

With the increased use of digital images, CBIR has emerged as a popular research topic in the past decades as limitations are associated with metadata-based systems. A CBIR is desired to retrieve valuable information from databases. In CBIR, features like color, shapes, and textures are extracted, then analyzed rather than performing annotation. It aims to retrieve relevant pictures using visual and semantic contents of the images. Currently, CBIR techniques are working on a combination of low level features, i.e. color feature, texture feature and shape features. CBIR is also referred as query by image content and it is an application of computer vision. In CBIR, a user submits an image called input image and wants to obtain the similar images from a database. Features are then extracted from query image and then compared with the pre-calculated features of images, which are available in the separate database known as feature descriptor. Some similarity metrics are used to perform comparisons and accordingly pictures are retrieved from the database [3].

In [4] has designed a RBIR system which uses the HSV color space, the DWT and clustering algorithm k- means to perform segmentation on image so that image will be segmented into regions. A set of optical characteristics is employed to present each and every region of image and Bhattacharyya metric is used to find a likeness between regions. The proposed system has developed over 180 general images categorized into 9 groups and the systems is evaluated through many examples of retrieval of images.

II. LITERATURE SURVEY

He Zhang et. al. (2015) [5] A CBIR system is introduced which is a combination of color and texture feature. According to texture characteristics of the image, Fusion algorithm combines Gabor transform and edge histogram can be utilized to represent information of texture. The color histogram in Hue, Saturation and Value color space is used as a color feature, and the blocking color histogram as well as a fuzzy color histogram are introduced in this paper.

Yuber Velazco-Paredes, et. al. (2015) [6] Due to vast applications of CBIR system in various domains, CBIR is a hot research topic nowadays, a lot of research has been carried out on techniques which are region based and in these techniques the user is free to specify a particular region of the picture and the system will return images with similar regions to the query. A method to retrieve images based on irregular regions of interest where the user can select one region, is proposed.

Nooby Mariam, et. al. (2015) [7] Contents of the images are used by retrieval systems of images based on image contents to represent and search the images. Color, Texture and Shape are considered as the contents of an image. Among the different image features, edges are the important one as edges represent mainly the local intensity variations.

Swati Agarwal et. al (2015) [8] This method is different from the existing methods which are based on histogram approach. The proposed algorithm uses the database of features, that combines both color feature as well as edge feature. In this paper wavelet transform is used to reduce the size of the feature vector and simultaneously preserving the content details. The test is performed to check the system robustness against alterations of query image such as geometric deformations and the addition of noise, etc. Image database of wang is used for experimental analysis and results are shown in terms of precision and recall.

Kavita Chauhan et. al. (2015) [9] CBIR is a kind of search engine, It is used to perform indexing of images using their contents as well as features. Existing CBIR systems and techniques for their feature extraction are discussed. Apart from this performance analysis and limitations of these systems have discussed.

Maheshwari et al. [10] Have proposed a method in which moment of color and Gabor filter are introduced for feature extraction for image dataset. K-means and hierarchical clustering algorithm are used to group the image dataset into various clusters.

III. PROPOSED WORK

In this algorithm, we have proposed a combination of color, shape and texture features. In this approach, the previous work is enhanced to achieve better accuracy. This process consists of the following steps: (i) Pre Processing (ii) Feature Extraction (iii) Classification

A. Pre Processing: In this process, take a query image which is resized with 384*256 size. After that enhance the query image using contrast adjustment and stretching. Using Adaptive K-means algorithm, find the connected component and discard less than threshold value edges. Find the segmented object of an image.

B. Feature Extraction: Calculate the segmented image feature value on Mean (M), STD, RMS, Variance (V), Smoothness (S), Kurtosis (K), Skewness, IDM. Color moment is used to extract the feature of color. Convert Red, Green and Blue color space into HSI (Hue, Saturation and Intensity). Texture feature is extracted by using DWT. Finally merged all features. This process is also executed for database images. Store all features into matrix file.

C. Classification: After the feature extraction process, read the stored database of features and query image features. The database is divided into 10 classes: Africa, Beach, Monuments, Elephant, Horses, Building, Food, Flower, Mountain, Dinosaur. Then randomly select the training dataset and test dataset for classification.

Proposed Algorithm

1. Consider the RGB image with the size of M*N.
2. Apply contrast stretching for returning lower and upper bound values of an image.
3. Take lower and upper bound value then enhance the image using contrast adjustment.
4. After this, segment the image using Adaptive K-means algorithm.
   i) Find the mean of pixels of each channel.
   ii) This mean will be the Centroid of the first cluster.
   iii) Now find out the maximum distance and multiply it by 0.25. The resultant value will be considered as distance threshold.
   iv) Pixels having distance more than the distance threshold will be member of first cluster. Remaining pixels will be qualified for the next round.
   v) Now calculate mean of remaining qualified pixels and repeat steps from (iii) to (v).
   vi) Clusters are formed, now take square root of sum of square of red, green and blue values of each center and in this way we will get single value for each center.
   vii) Sort the centers.
   viii) Find difference between two consecutive centers.
   ix) Now intercluster threshold value is set to 25.
   x) If the difference between two consecutive centers is less than the intercluster threshold value, then centers will be discarded.

5. Convert input RGB color space image into HSI color space image for color feature and store feature vector of mean value using the formula:

$$\text{Mean(M)} = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{Q(i,j)}{M\times N}$$

Where $Q(i,j)$ is enhanced image, M×N is the total number of pixels.

6. Extract the color moment feature with the help of thefirst moment (mean) from segmented image.

$$\mu = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{K(i,j)}{M\times N}$$

7. Apply 2-DWT to get estimated coefficient and vertical, horizontal and diagonal detail coefficients for components.

coeff = dwt2(Q)
meancoeff = mean2(coeff)
stdcoeff = std2(coeff)

Where coeff is the first level coefficient of DWT on enhanced image, and meancoeff is a feature vector of the mean value of coefficient and Stdcoeff is a feature vector of standard deviation value of coefficient.

8. Extract color features of segmented image with the help of RMS:

$$\text{RMS} = \sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{K(i,j)^2}{M\times N}}$$

9. Calculate variance of segmented image.

$$\text{Variance} = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{(|K(i,j)|-\mu)^2}{M\times N}$$

10. Calculate the second moment (standard deviation) for color feature using below formula:

$$\text{STD} = \sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{(|K(i,j)|-\mu)^2}{M\times N}}$$

11. Find smoothness of the segmented image for texture feature.

$$\text{Smoothness} = 1-\frac{1}{1+a}$$

Where a= sum of pixels of segmented image K (i, j)

12. Find the degree of asymmetry of an image and is known as third moment (Skewness).

$$\text{Skewness} = \sqrt[3]{\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{(|K(i,j)|-\mu)^3}{M\times N}}$$

13. Kurtosis is a measured for a fourth moment of an image.

$$\text{Kurtosis} = \sqrt[4]{\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{(|K(i,j)|-\mu)^4}{M\times N}}$$

14. Calculate inverse difference moment (IDM) for texture feature.

$$\text{IDM} = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{K(i,j)}{1+(i-j)^2}$$

.

15. Repeat Step 1 to Step 14 until all images in the database are processed.
16. Determine the similarity matrix of enhanced image and image database using L1 distance, L2 distance, Correlation, Canberra and relative distance.
17. We have used L1, L2, Correlation, Canberra and Relative Deviation. Methods used to arrange images, moreover, compute the distinction or comparison between two vectors. Given two vectors Q and D, where

$$Q = \begin{bmatrix} q_1 \\ q_2 \\ \vdots \\ q_n \end{bmatrix} \text{ and } D = \begin{bmatrix} d_1 \\ d_2 \\ \vdots \\ d_n \end{bmatrix}$$

$$\text{Where distance} = \sum_{i=1}^{N}\frac{|Q_i-D_i|}{|Q_i|+|D_i|}$$

18. Classify the images using multi linear kernel SVM classifier and combine low level features.
19. Calculate accuracy, precision, and recall of retrieved images.

$$P = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}}$$

$$R = \frac{\text{Number of relevant image retrieved}}{\text{Number of relevant images in the database}}$$

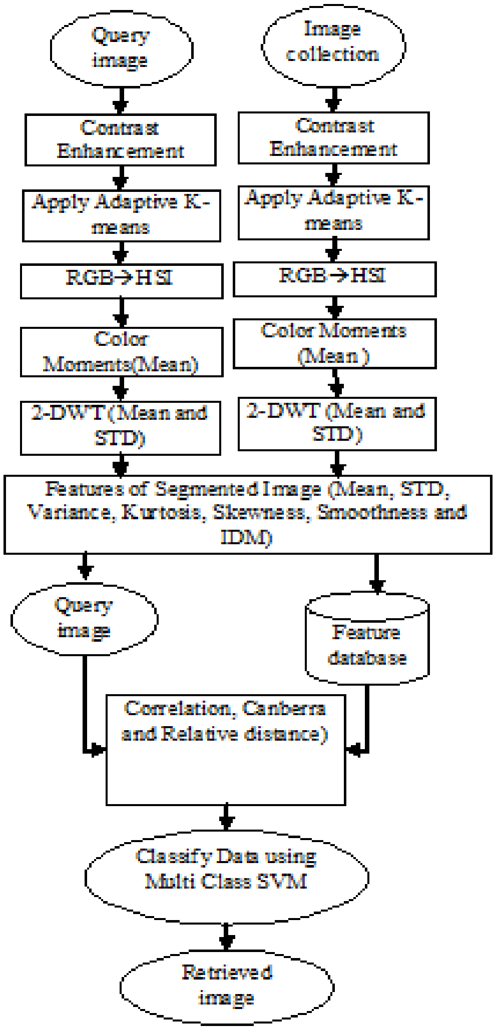


Fig1. Flow chart of Proposed System

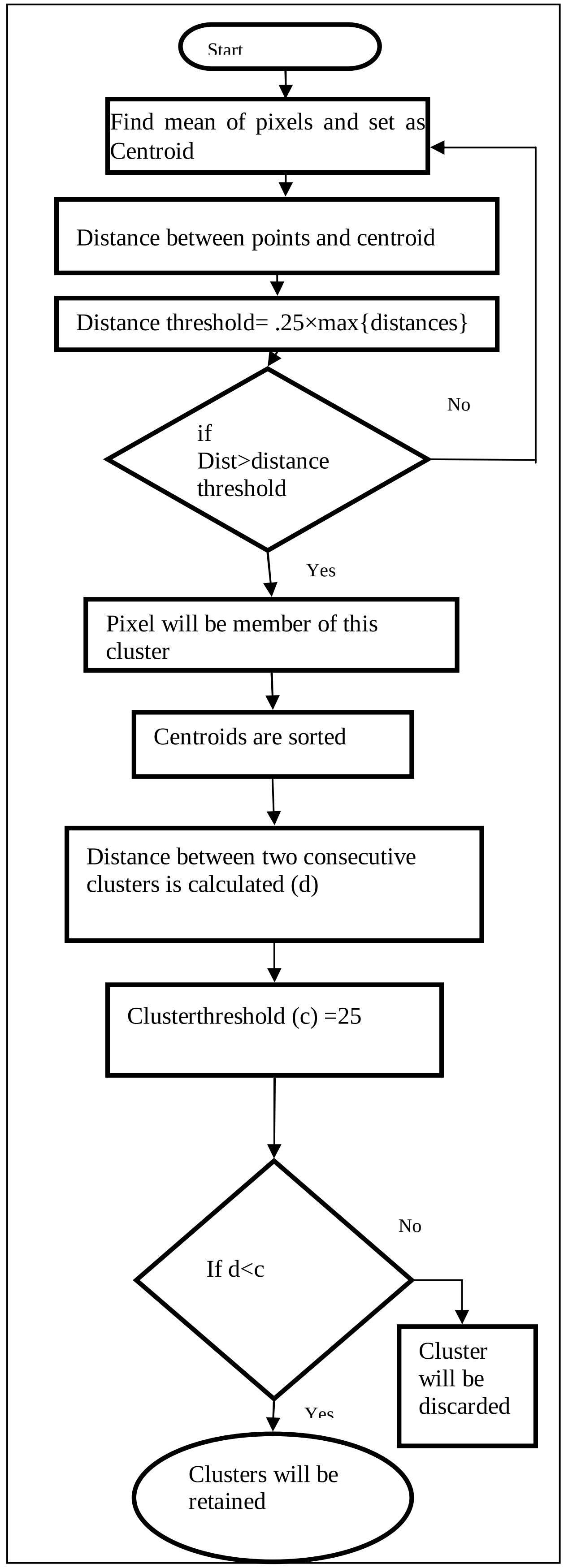


Fig2. Flow chart of Adaptive K-means Algorithm

IV. RESULT ANALYSIS

The experimental result based on Corel database which contain 1000 images of 10 different categories. Each category contains 100 images. The similarity measure is computed using L1, L2, Correlation, Canberra and Relative Deviation distance. The performance is measured on precision, recall and accuracy of the system.

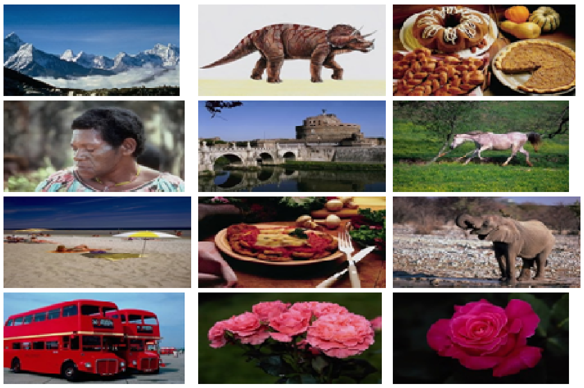


Fig3. Image Dataset

Fig4. Shows Result of Flower Image

Table 1. Shows Shape Feature using Skewness and Kurtosis

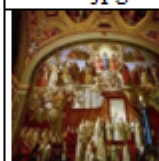
Image	Shape Feature	
	Kurtosis	Skewness
 13.jpg	4.894	1.711
 125.jpg	1.823	0.695
 249.jpg	2.907	1.181
 366.jpg	5.642	1.775

Table 2. Shows Color Feature

Image	Color Feature					
	Mean	STD	RMS	Variance	Color moment	HSI
13.jpg	1.930	1.453	2.395	2.044	77.661	0.336
125.jpg	2.584	1.576	3.023	2.464	92.463	0.396
249.jpg	1.830	1.266	2.123	1.295	72.998	0.331
366.jpg	1.853	1.227	2.153	1.318	69.916	0.314

Table 3. Shows Texture Feature

Image	Texture Feature		
	Smoothness	Wavelet Moment	IDM
13.jpg	0.999	4.359	1614.93
125.jpg	0.999	4.538	1263.29
249.jpg	0.999	3.580	1527.62
366.jpg	0.999	3.265	1244.57

Table 4. Shows Previous Approach Accuracy on Different Similarity Measures

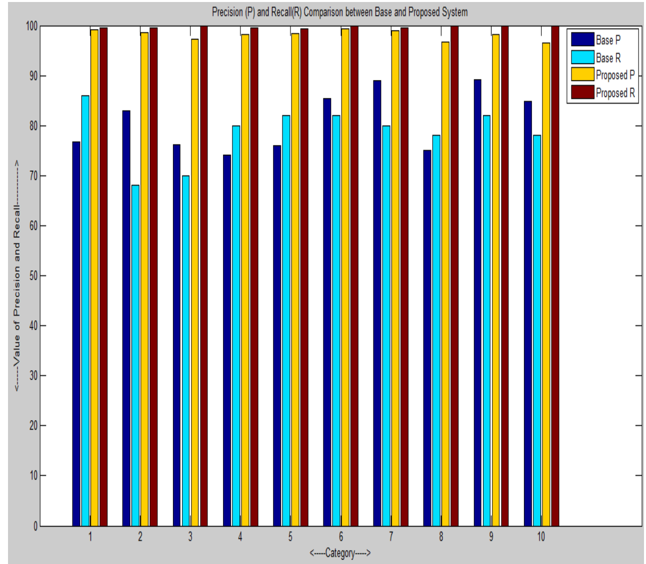
Query Image	Base Accuracy of Similarity Metrics (%)			
	L1	L2	Relative Deviation	Correlation
Africa	83.26	81.90	81.45	78.28
Beach	86.88	81.00	84.62	81.90
Monuments	76.47	86.88	79.64	86.88
Buses	82.35	81.00	82.81	82.35
Dinosaurs	81.45	85.07	80.09	78.28

Table 5. Shows Proposed Approach Accuracy on Different Similarity Measures

Query Image	Proposed Accuracy of Similarity Metrics (%)				
	L1	L2	Relative Deviation	Correlation	Canberra
Africa	97.2	99.6	97.6	99.6	99.4
Beach	99.8	99.6	97.4	99.8	98.8
Monuments	98	98.2	97.2	99.6	99.6
Buses	99.8	99.6	99.6	99.8	99.6
Dinosaurs	98	99.4	99.8	99.6	99.8

Table 6. Comparison between Previous and Proposed Method

Category	Base Results		Proposed Results	
	Precision (%)	Recall (%)	Precision (%)	Recall (%)
African	76.78	86	99.11	99.55
Beach	82.92	68	98.66	99.55
Monuments	76.087	70	97.33	100
Buses	74.0741	80	98.22	99.54
Dinosaurs	75.9259	82	98.44	99.32
Elephants	85.4167	82	99.33	100
Flowers	88.889	80	98.88	99.55
Horses	75	78	96.66	100
Mountains	89.1304	82	98.22	100
Food	84.7826	78	96.44	100



Graph1. Comparison between Previous and Proposed Method

V. CONCLUSION

After comparing the proposed method with the previous method, it is found that Multi class SVM gives an optimal result as compared to the first method. In the proposed system, the image classes used by us give very good images retrieval accuracy. Our system performance is good in terms of precision value and recall value and it is shown in the graph. At the same time the accuracy is uniform for all the classes, making SVM a better choice. Here we use different types of distances like Canberra, L1, L2, Correlation and Relative standard derivation to calculate similarity between two images. In this system, the overall accuracy has reached up to 99%. This approach focuses only on retrieval of image files, but in future this work can be enhanced to retrieve the audio and video file by using same features or modifying them. For classification of more features at a time, multi kernel SVM can be utilized.

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