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Image Retrieval Based on Tuned Color Gabor Filter Using Genetic Algorithm

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Abstract

In the past few years, there is much technical advancement in the research area of image retrieval, in particular Query by Image Content (QBIC) system. It has become indispensable to provide competent and effective method to retrieve images from the large collections of images employed in diverse applications. This paper proposes image retrieval system based on extraction of feature vectors through successive stages of color histogram, tuned color Gabor filter and shape descriptor for color, texture and shape features respectively. The proposed tuned color Gabor as intermediate stage has advantages of retrieving images based on both color and the texture. The experiment results show improved retrieval rate in terms of average precision and average recall compared to other computational methods.

Keywords: Average Precision (APR), Average Recall (ARR), Query by Image Content (QBIC) system, Shape descriptor, Tuned color Gabor filter (TCF).

INTRODUCTION

Retrieval of images is a very challenging area of research in various applications like databases related to multimedia, google retrieval and digital libraries. Content based image retrieval has proved to be an accurate and quick retrieval approach in numerous real time applications during the last decade. Query by image Content system, QBIC [4] is one of the breakthrough in the methods adopted by CBIR systems.

QBIC permits the user to specify the desired query image and extract similar images from the large collections stored in the database with better performance evaluation criteria based on precision and recall. The features used in QBIC are the color histograms, a moment based feature and a texture descriptor [5]. The image retrieval scheme proposed by Manjunath and Ma [10] using Gray Gabor features has shown better performance than using other transform features. Huang and Rui [8] proposed visual feature extraction, multidimensional indexing and retrieval system design as three fundamental bases for image retrieval. Yang et al. [17] has suggested the image retrieval method with the combination of three features color, texture and shape which leads to better retrieval.

This paper proposes a novel Query by image content system using a tuned color Gabor filter. The order for the proposed retrieval is recommended to be color, texture and shape in order to enhance the efficiency of the retrieval system [13]. The system encompasses three stages. The color feature extraction from the large database is done using color histogram during the first stage. In the second stage, tuned color Gabor filter is proposed for extraction of texture features. A polygonal fitting algorithm is employed for shape feature extraction during the third stage of the image retrieval. The proposed system shows better performance evaluation criteria in terms of average precision rate and average recall rate compared to the existing retrieval methods.

The organization of the paper is as follows: The functional block diagram of the proposed system using TCF is discussed in Section 2. The particulars of the feature extraction process are presented in Section 3. Section 4 provides experimental evaluation and results and Section 5 concludes the paper.

PROPOSED WORK

In Section 2, a novel Query by image content system using a color Gabor filter is proposed by combining color, texture and shape descriptors of an image. This feature based retrieval system has two important phases. The first phase comprises feature extraction process and the second phase consists of retrieval process. The Figure 1 shows how the features are extracted from a given query image.

QBIC method vary with respect to the feature extraction order and the methods used. For a given input image color(f_1), texture(f_2) and shape(f_3)features are extracted for the retrieval process. In few methods, all three features (f_1, f_2, f_3) are extracted from query image to form combined feature f and similarity is measured in the retrieval phase.

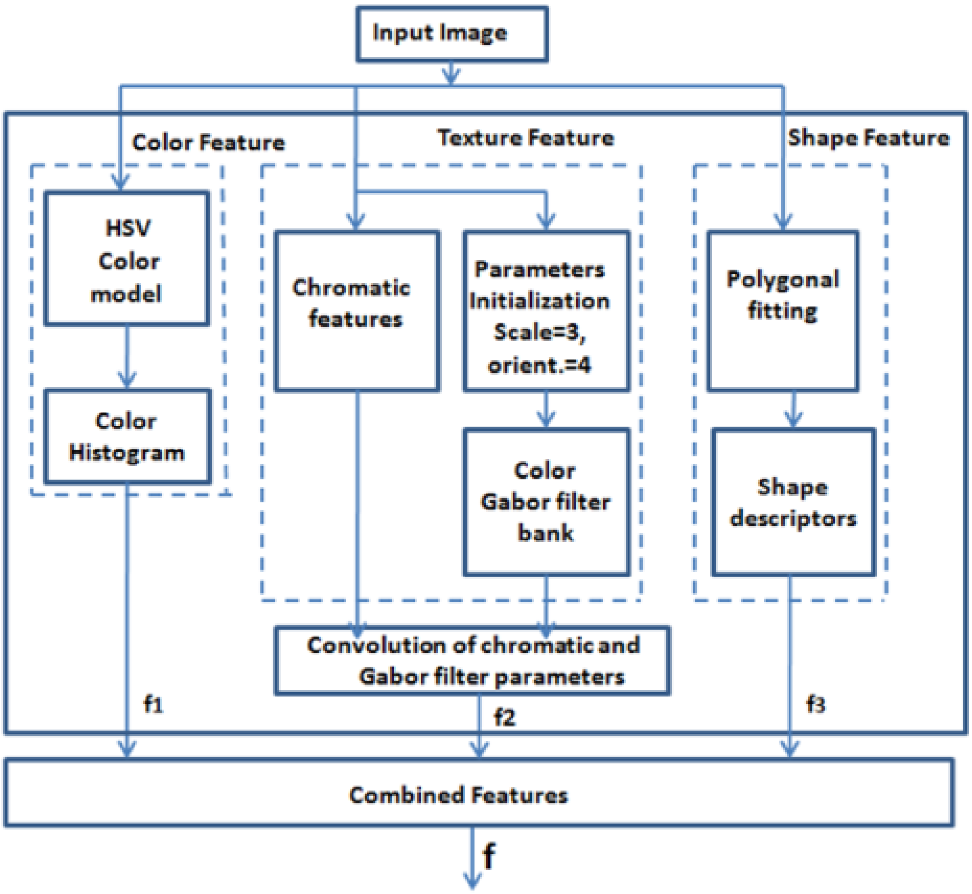

Figure 1: Feature extraction phase of given image

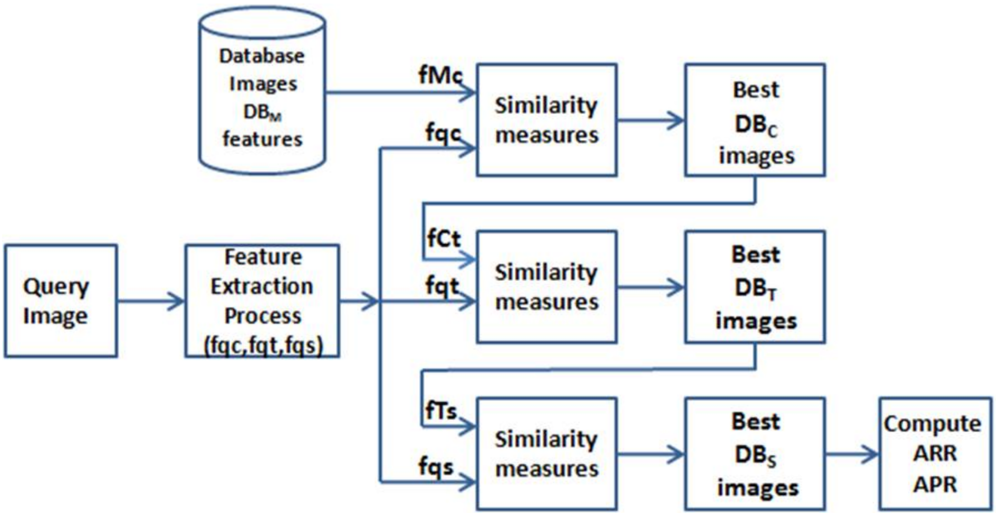

Figure 2: Retrieval process of best images from the database.

These methods are proven to have very less retrieval rate. In this paper, a successive feature extraction phases are employed in which the f_2 features are extracted for best matched f_1 feature images and f_3 features are extracted for best matched f_2 feature images. The color features(f_1), are being extracted by using HSV color model and color histogram technique. The texture features(f_2) are extracted by finding the chromatic features and then employing color Gabor filter in three scales and four orientations. The shape features(f_3) extraction is done by using polygonal fitting algorithm and shape descriptors. In this way, the features are extracted for all images of the database.

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In the retrieval process phase, the similarity measures are used to get the 'S' best matched images from 'M' database images. The similarity measures used at each stage of the retrieval process is mentioned in Section 3. Firstly, similar 'C' images are being extracted based on $f_1$features from M database images. Then, similar 'T' images and 'S' images are extracted successively based on $f_2\, and f_3$features. The performance metric of the system is evaluated. The symbols C, T and S in the figure are used as subscript of DB indicating the number of images from the database.

FEATURE EXTRACTION PROCESS

In Section3, we describe the extraction of f_1, f_2 and $f_3$features employed in this paper in detail.

A. Color Feature Extraction (f_1)

An important and dominant feature recognized by humans is color. The QBIC system uses color to extract features during the first stage. An appropriate color space and an efficient color descriptor must be determined to extract the color features. Even though there are various color spaces like RGB, HSV and CIE L*a*b [6], there is no unique solution that confirms the best for QBIC. A number of color descriptors such as color moments [18], color histograms [12] and color correlograms [11] can be used to retrieve color. In this paper, HSV color space is used to retrieve color information to ensure perceptual uniformity from a large database. As an efficient color descriptor, color histogram is used to represent the color of the global areas. This results in more number of color components leading to processing overhead which can be minimized by quantizing the HSV values [13]. In this paper, quantized color histogram is employed.

Algorithm for color histogram matching process:

Step1: Pre compute the color histogram of all the 'M' database images (dB_{Ci}) in HSV model. [13]

Step2: For a given query image compute the color histogram features (Q_C)

Step3: Find the similar 'C' images out of 'M' database images(C<M) and the retrieved 'C' images are passed as input images to the next stage.

The similarity between the images is measured using the equation given below.

$$\text{Similarity of } i^{th} \text{image} = f_1 = \frac{\sum min(Q_C, dB_{Ci})}{\sqrt{\sum Q_C^2}\sqrt{\sum dB_{Ci}^2}} \qquad (1)$$

B. Texture Feature Extraction (f_2)

Gray Gabor is a type of wavelet widely used in texture analysis and their classification. It is used for extracting texture information in given orientation and scale [7]. In this paper, a color Gabor is employed in designing tuned color texture filter TCF, which is used for extracting minimum texture energy in given scale and orientations. The minimum energy is obtained using evolutionary algorithm (GA). Advantage of proposed TCF is that it is uniquely tuned to the query image and it has two-fold property i.e. the filter is tuned with respect to both color and texture description of the given image which is a main source in implementing this human visual system. Firstly, a regular color Gabor filter in specified orientation and scale is considered and then TCF is proposed. In this paper, the result of the proposed TCF is compared with the traditional methods of image retrieval employing Gray Gabor filter in specific orientation and scale [13] , optimized gray Gabor [9] and a color Gabor filter. The results show that the TCF out performs regular color Gabor filter in terms of APR and ARR.

C. Regular Color Gabor Filtering

In this system, the parameters of regular color Gabor filter such as scale, frequency and orientation are varied to extract different texture features. Here, three scales and four orientations are considered and then the obtained twelve regular color Gabor filters are convolved with the query image to extract 12 features. The algorithm for regular color Gabor filter is described below.

Algorithm for Regular Color Gabor Filtering operation

```
Initialize maxscale=3, maxteta =4
for i= 1:C
    for scale= 1:maxscale
        for teta=1:maxteta
            Read the i^th image
            Convert the i^th image to Lab colorspace
            Represent the image asI = Hue + j Chroma (Eq.2)
            Generate the Gabor function for the given scale and
             orientation
            Convolve the Gabor and the represented image I
            Find the energy E_Db(s,teta)(Eq.3)
        end
    end
end
```

The two chromatic features Hue (H) and Chroma (C) are computed from the equations [15].

$$Hue\ H = \tan^{-1}\frac{b}{a} and\ \ Chroma\ C = (a^2+b^2)^{\frac{1}{2}} \qquad (2)$$

Where a and b are color stimulus computed from the L*a*b Color space.

$F_o = G(s, teta)|_f$*I and

$E_{Db}(s, teta)|_f = (Real\{F_o\})$^2 $+ (Img\{F_o\})$^2 (3)

Where * represents convolution, F_o is the Regular color Gabor output and $E_{dB}$is the Energy of the filter, f is the frequency considered as constant in this paper (f=10).

The above algorithm is repeated for all the 'C' images and for the query image. Consequently, the energies of the query image in three scales and four orientations are used for the similarity measure. The most similar 'T' images out of 'C' images (T<C) are being selected for the next stage using the equation (4).

Similarity of i^{th} image $f_2 = \sum_{teta}\sum_{s}\{E_q(s, teta) - E_{Dbi}(s, teta)\}^2$ (4)

Retrieval system performance metric are measured and shown in the results section where regular color Gabor filter outperforms the conventional Gray Gabor filter and tuned Gray Gabor filter in terms of APR and ARR. But this method turned to be a drawback as it resulted in more computational complexity in terms of number of convolutions. For a retrieval system with 1000 images, it requires 12*1000=12000 convolutions.

A tuned color Gabor filter (TCF) is proposed in this paper to reduce the computation complexity of this method. The detailed description of the evolution algorithm used for tuning the color Gabor filter is presented in next sub section.

D. Genetic Algorithm

The computer simulation models of evolution that permits us to learn the nature of complex biological and social systems are Genetic algorithms. It also enhances interdisciplinary area of research by integrating with neural networks. Calabretta [2] suggested genetic algorithms as a tool for scientific modeling and industrial optimization. Tsai et al. [15] proposed the Gabor filter energy minimization through exhaustive search method. This method leads to complexity with more efficient defect detection rate. Chisti et al. [3] proposed an optimized Gabor filter using PSO and GA for minimizing the Gabor energy by varying scale, frequency and orientation parameters. In this paper the Gabor filter energy is minimized in four different orientations by maintaining the remaining two parameters scale and frequency constant. In GA each iteration of the three operators namely selection, crossover and mutation can be considered as a generation. The preliminary population is processed with the aid of these three operators iteratively until the termination state is encountered.

Selection: It is a stochastic operator that selects probably the best strings from existing population to form a mating pool with all proper quality strings.

Crossover: It is a stochastic operator that swaps some of the genes in one parent by the equivalent genes of the other and produce an offspring with desirable features.

Mutation: It is unary variation operator that is used to perform random selection of any bit position in a string and complement it.

Termination: This condition is commonly based on specified threshold energy or number of iterations. The termination in this proposed method is done depending on number of iterations (50).

E. Tuned Color Gabor Filtering (TCF)

A tuned color Gabor filter is employed for feature extraction to overcome the inefficiency of retrieval system using regular color Gabor filter as discussed above. In the proposed retrieval system, a color Gabor filter is tuned to the query image with the aid of genetic algorithm to produce minimum energy by varying the filter orientation parameter and the filter that produces minimum energy after convolution with the query image is said to be tuned filter. Four different tuned color Gabor filters forming four channel tuned color Gabor filter is employed in the retrieval system to increase the retrieval rate. The number of tuned filters can be increased at the cost of computational complexity. The four orientations (namely $0< \theta <45$, $46< \theta <90$, $91< \theta <135$, $136<\theta<180$) are considered to obtain four tuned color Gabor filters.

The four features from each database image are extracted using four tuned color Gabor filter. As a result, each database image extract four features and with a database of 1000 images account to a total of 4*1000 =4000 convolutions for the database with 4000 features being extracted. It is now evident that the computations have been drastically reduced when compared to regular color Gabor filter (12,000 convolution) thereby reducing the complexity of image retrieval. And also the retrieval efficiency of the proposed system is increased as discussed in the results section.

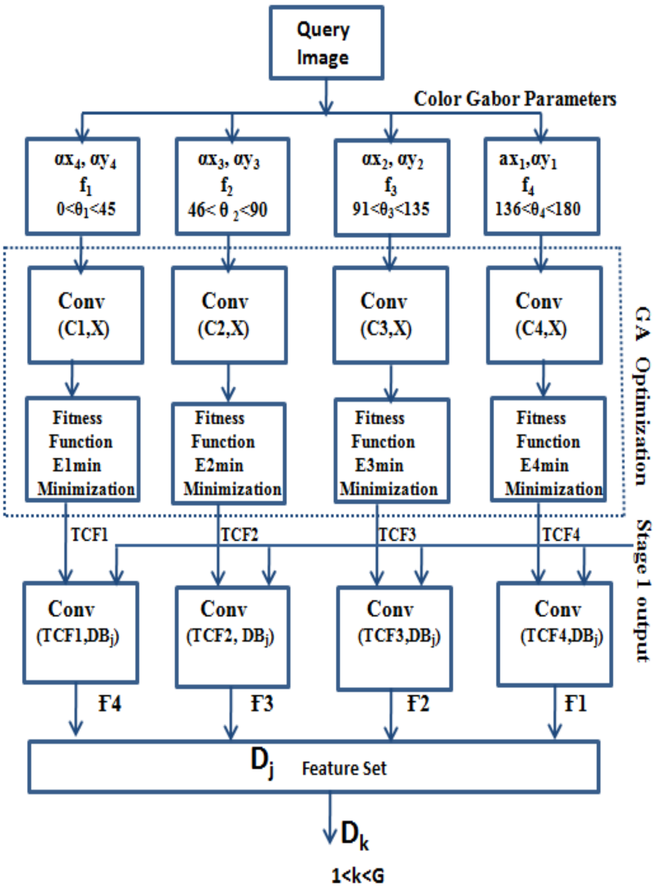

Figure 3: Proposed four channel optimized tuned color Gabor filter (TCF)

A four channel optimized tuned color Gabor filter (TCF) proposed for the retrieval system is shown in Figure 3. This is employed in the second stage of texture feature extraction process. Each of the four channels is optimized in the designated orientation in the TCF filter keeping scale and frequency constant (f=10, scale σ_x =5, σ_y=5) that results in four set of parameters particular to query image. The energy for each image in the database is calculated with respect to the four tuned Color Gabor filters. The images with similar energies are considered as the best match images.

The similarity is computed with between the Feature set of Four energies E_{ij} with i= 1 to C where j=1, 2, 3, 4 and the C best match images from the stage one and four energies of query image E_{Qj}. In this way, the 'T' best match images are retrieved by selecting the first 'T' minimum distances vector $d_{min}(i)$ as specified in the equation (5). The energy computation of the tuned Gabor filter is similar to the energy computation of the regular color Gabor filter which is given in equation (3).

$$d_{\min}(i) = \sqrt{\sum_{j=1}^{4}(E_{Qj} - E_{ij})^2} \quad (5)$$

Where E_{ij} represent the j^{th} energy of the feature set of the i^{th} image in 'C' images

E_{Qj} represent the j^{th} energy for the query image feature set.

The $d_{min}(i)$ vector is sorted and first 'T' minimum distance images are being selected as input to the shape feature extraction stage.

Algorithm for Tuned Color Gabor Filtering

Initial parameters

Generate initial population

Compute C and H for the input image

C=sqrt(double(a).*double(a) + double(b).*double(b));

H=atan(double(b./a)); where a and b are from Lab color space

Using Eq. (2)

Compute the fitness function (Energy E) of the initial population (Eq. 3)

Ittr: Sort the population depending on the fitness values

Perform single point crossover

Perform mutation

Compute the fitness of the new population

Go to Ittr, until termination condition is true

Parameters selection:

After conducting many experiments, the optimal value of the σ_x, σ_y and frequency of the Gabor filter have been identified as σ_x =5, σ_y=5, f=10 where the accuracy of the retrieval rate is more. A binary GA is proposed in this work with No. of Parameters =1, pop size=50, selection probability =0.5, mutation probability=0.15, no. of bits=6. The optimization of Color Gabor is performed in the four different directions (theta) with respect to the input image and algorithm is terminated based on the maximum number of iterations taken as 50.

F. *Shape Feature Extraction (f_3)*

The efficiency of shape feature extraction plays a vital role in the retrieval process. The contour of the image denotes the pattern of shape of an image. The precision of QBIC primarily rely on the technique used for shape feature extraction. The different techniques adopted for shape feature extraction include region based like moment descriptors [14], boundary based like simple contour shape descriptors and fuzzy logic [1]. In this paper, the shape feature extraction is done using polygonal fitting algorithm and Fourier descriptors for image retrieval [15].

Algorithm for shape feature

Step1: Pre compute the Fourier descriptors of all the 'T' images retrieved from the second stage (T_i)

Step2: For a given query image compute the Fourier descriptor value (Q_s)

Step3: Find the similar 'S' images(S<T) out of 'T' database images. These 'S' images are considered as the best matched images.

The similarity based on the shape feature is measured using the below equation.

Similarity of i^{th} image $f_3 = \sqrt{\sum_{i=0}^{T-1}(Q_s - T_i)^2}$ (6)

A successive feature is extracted at each stage and similarity is measured based on the equations (1), (4) and (6) for the retrieval of best matched images. In the results section, it has been shown that the proposed TCF has resulted in increased APR and ARR values.

EXPERIMENTAL EVALUATION AND RESULTS

In Section 4, the results of proposed system after experimental estimation are reported. The proposed system is executed in MATLAB using COREL database [16]. The COREL database is a stock photo database consisting of 1000 natural images which form 10 sets each having 100 regular images. The various sets contain Beaches, Foods, African people, Dinosaurs, Flowers, Mountains, Buildings, Horses, Buses and Elephants respectively. One image from each set is depicted in Figure 4.

Figure 4: Sample images depicting each category of COREL database

The illustration of query image is done in Figure 5.

Figure 5: Query Image

Let M be the set of total database images exemplified by color, texture and shape features. The correctness of the proposed system is governed by parameters C, T and S and therefore more care is to be given in assigning values to them. The proposed system has selected parameters to be 12, 8 and 4 correspondingly. The parameters C and T can be set manually to enhance the performance of the proposed system. The proposed system is assessed by scheming results of APR and ARR.

The proposed QBIC system results are portrayed in Figure 6, by assigning 12, 8 and 4 values to parameters C, T and S respectively. The range of exploration is tapered by filtering the irrelevant images at every stage of retrieval. By doing so, the performance metrics are improved for the proposed QBIC using color, texture and shape features for retrieval.

(i)

(ii)

(iii)

Figure 6: The transitional computation results for each stage (i) Result of first stage with C = 12, (ii)Result of second stage with T = 8 and (iii) Final result of system with S = 4.

The proposed QBIC system make use of retrieval metric based on average precision rate and average recall rate. The numerical equivalent of relevant retrieved images divided by the numerical equivalent of total retrieved images is defined as Precision, P.

$$P = \frac{Number\ of\ relevant\ images\ retrieved(r)}{Total\ number\ of\ images\ retrieved} \quad (7)$$

The ratio of numerical equivalent of relevant retrieved images to the numerical equivalent of total relevant images in the entire database is defined as Recall, R.

$$R = \frac{Number\ of\ relevant\ images\ retrieved(r)}{Number\ of\ relevant\ images\ in\ the\ database(M)} \quad (8)$$

The proposed QBIC system is measured by treating every image in each set as query image and thereby the extracted results of every query image can be used to measure the retrieval outcomes. The performance metrics of the system is assessed for every set in the database by considering 20 as the numerical value of output images.

Experimental results obtained using proposed TCF method and color Gabor filter in specified orientation and scale and other models employing Gray Gabor filter [8] and Gray Gabor filter in specific orientation and scale [13] and Optimized gray Gabor filter [9] are displayed in Table1.

It is witnessed that the retrieval model employing color Gabor filter have improved average precision than existing models in each set except for 'Flowers' set. However, it is evident that the proposed TCF method has shown better average precision than existing models for all sets.

Table 1: Evaluation of Average Precision Rate of the Proposed and other models

Category ID	Class	Proposed Method	Color Gabor	Madhavi & Patnaik, [9]	Shrivastava & Tyagi, [13]	Huang & Rui,[8]
1	Beaches	0.607	0.592	0.586	0.581	0.456
2	Food	0.912	0.894	0.881	0.747	0.426
3	African people	0.806	0.762	0.753	0.736	0.424
4	Dinosaurs	1.000	1.000	1.000	1.000	0.581
5	Flowers	0.905	0.886	0.875	0.903	0.895
6	Mountains	0.864	0.749	0.681	0.538	0.267
7	Buildings	0.671	0.639	0.627	0.617	0.401
8	Horses	0.915	0.904	0.898	0.813	0.585
9	Buses	0.868	0.839	0.813	0.789	0.846
10	Elephants	0.812	0.785	0.756	0.726	0.429
Average		0.836	0.805	0.787	0.745	0.531

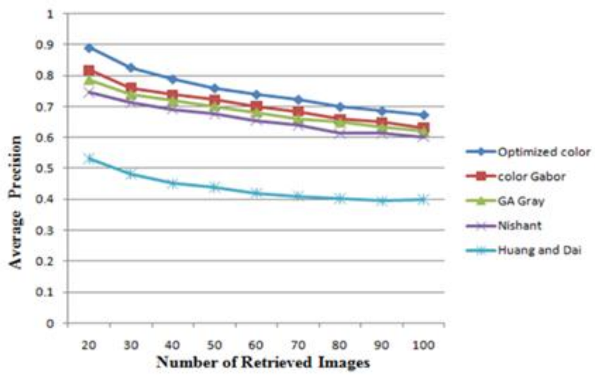

Figure 7: Comparison of average precision among different models on COREL database

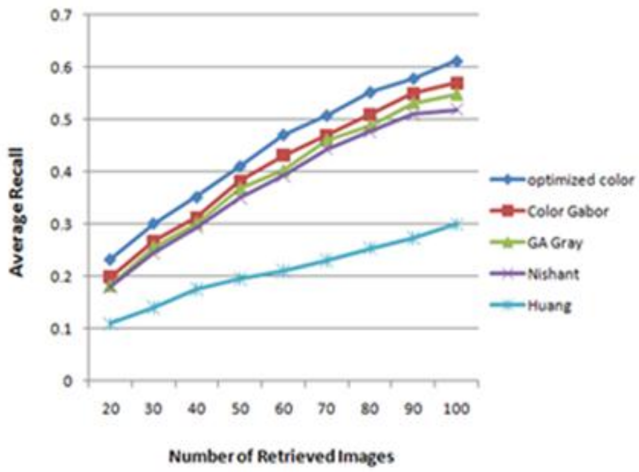

Figure 8: Comparison of average recall among different models on COREL database

Figure 7 displays the average precision rate of the proposed TCF method and existing models by varying the values of L from 20 to 100. The average recall rate under similar settings is portrayed in Figure 8. The evaluation results unveil that the proposed TCF method is an enhanced method when compared to other existing models.

CONCLUSION

A novel Query by image content system using a tuned color Gabor filter has been presented. The image retrieval quality and its specific relevance to domain dictate the performance of the QBIC system when implemented in real world. The experimental results prove that the proposed TCF method yields better APR and ARR compared to the traditional image retrieval methods that are implemented using Gray Gabor filter in specific orientation and scale and Optimized gray Gabor filter. Furthermore, the comparison results of proposed TCF method with a color Gabor filter in specified orientation and scale considering it as base algorithm has also been presented.

REFERENCES

[1] M.Banerjee, M.K.Kundu, and P.K.Das, "Image Retrieval with Visually Prominent Features using Fuzzy set theoretic Evaluation," The Indian Conference on Computer Vision, Graphics and Image Processing, India,2004

[2] R.Calabretta, "Genetic Algorithms. Knowledge Management, Organizational Intelligence and Learning, and Complexity," Unesco 96 Encyclopedia of Life Support Systems, Oxford, UK, Eolss Publishers, 2002.

[3] K.M.Chisti, K.S.Srinivas, and G.Prasad, "2D Gabor filter for surface defect detection using GA and PSO optimization techniques," AMSE Journals, 2015, Vol. 58, pp.67-83.

[4] C.Faloutsos, M. Flickner, W.Niblack, D.Petkovic, W. Equitz, and Barber, "Efficient and Effective Querying by Image Content," Technical Report, IBM Research Report,1993.

[5] M.Flickner, H.Sawhney, W.Niblack, J.Ashley, Q.Huang, B. Dom, and M.Gorkani, "Query by image and video content: The QBIC system," IEEE Computer, Vol. 28, No. 9,1995, pp.23-32.

[6] R.Gonzales, and R.E.Woods, Digital Image Processing, 2nd Edition, New Jersey Prentice Hall,2002

[7] K.Haridas and T.A.Selvadoss, "Well-organized content based Image retrieval system in RGB color histogram, Tamura texture and Gabor feature," International Journal of Advanced Research in Computer and Communication Engineering, Vol.3, Issue.10,2014

[8] T.Huang, and Y. Rui, "Image retrieval: Past, present, and future," Proceedings of the International Symposium on Multimedia Information Processing, 1997, pp. 1–23.

[9] D.Madhavi and M.R.Patnaik, "Image retrieval using GA optimized Gabor filter," Indian Journal of Science and Technology, Vol. 9,2016, pp.1-11.

[10] B.Manjunath and W.Ma, "Texture features for Browsing and retrieval of image data," IEEE transactions on pattern analysis and machine intelligence, Vol. 18, No. 8, 1996,pp. 837-842.

[11] H.Moghaddam, T. Khajoie and A.Rouhi, "A new algorithm for image indexing and retrieval using wavelet correlogram," Proceedings of the International Conference on Image Processing, Vol. 3, 2003,pp. 497-500.

[12] A.Ouyang and Y.Tan, "A novel multi-scale spatial - color descriptor for content-based image retrieval,"

Proceedings of the 7th International Conference on Control, Automation, Robotics and Vision, Mexico, Vol. 3,2002, pp. 1204-1209.

[13] N.Shrivastava and V.Tyagi, “An efficient technique for retrieval of color images in large Databases,” Computers and Electrical Engineering, Elsevier,2014.

[14] C.The and T.Roland, “On image analysis by the methods of moments,” IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 10, No. 4, 1988,pp. 496-513.

[15] D.M.Tsai, C.P. Lin and K.T.Huang, “Defect Detection in Colored Texture Surfaces using Gabor Filters,” The Imaging Science Journal, Vol. 53, 2005,pp.27-37.

[16] Wang database from: http:wang.ist.psu.edu.

[17] W.X.Yang, Y.J. Yu and H.Y.Yang, “An Effective image retrieval scheme using color, texture & shape features,” Computer Standards& Interfaces, Vol. 33, Issue 1, 2011,pp.59-68.

[18] H.Yu, M.Li, H. Zhang and J.Feng, “Color texture moments for content-based image retrieval”, Proceedings of the International Conference on Image Processing, Rochester, Vol. 3, pp. 929-932, New York, USA,2002.