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Customized Halftoning-Based Block Truncation Coding for Content-Based Image Retrieval using Hierarchical Clustering Algorithm

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ABSTRACT: Due to increase in large image database, the storage of such data is expensive, so that the image compression techniques come into picture. Content-based image indexing and retrieval has been an important research area, in which indexing and retrieval is performed on the basis of the contents of the images. The contents are like color, shape or texture of that image. Trying to retrieve similar images from the compressed image database is a tedious job. So introduce a technique which index and retrieve the images from such database. This paper implement a halftone based Ordered-Dither Block truncation Coding (ODBTC) technique to compress an image. The benefit of low complexity, ODBTC generate an image content descriptor for content based image retrieval (CBIR).

In the encoding step, we compress an image block into corresponding quantizers and bitmap image. Two image features namely color co-occurrence feature (CCF) and bit pattern features (BPF) are used to index an encoded image by involving the visual codebook, and this features are generated directly from the encoded data streams without performing the decoding. An efficient approach to retrieve similar images from compressed database using hierarchical clustering algorithm is proposed. Hierarchical clustering algorithm is bottom-up approach to compute similar images with improved efficiency. So this scheme is not only provide image compression, because of its simplicity, but also offer simple and effective descriptor to index images in CBIR system.

KEYWORDS: Energy Content based image retrieval, Halftoning-Based BTC, Feature Extraction, Hierarchical Clustering Algorithm, similarity Computation

I. INTRODUCTION

Content based image retrieval is become popular technology to retrieve data mostly similar to images, such that also require efficient and accurate output for our query. This project is focusing on to reduce computation time of calculation and increasing effectiveness and accuracy of image retrieval. This project introduces the ordered dither block truncation coding based halftoning method where feature extraction done by using CCF and BPF method and similarity matching method provides the match related to query image.

Block truncation coding (BTC) was initially proposed by Delp and Mitchell in 1989. Block truncation coding is a lossy kind of image compression. In block truncation coding (BTC), the first image is isolated into fixed size non overlapping blocks of size M×N. The block size selected is normally small to maintain a strategic distance from the edge blurring and blocking effect. Every block is autonomously coded using a two level (1-bit) quantizer. The two values save the first and the second moment characteristics for the first block. BTC does not give a higher addition than any of the modern image compression algorithms like JPEG or JPEG-2000, yet it is much lesser complex. Digital Halftoning is an innovation of changing over a persistent tone image to a two tone image. A ceaseless tone image and a halftoning image are comparable when the low-pass nature of the Human Visual System (HVS) is the apparent device. There are numerous types of halftoning strategies, including order dithering, dot diffusion, and error diffusion.

The CBIR framework which removes an image feature descriptor from the compressed stream has become into a vital issue. Since the vast majority of the images are recorded in the storage device in compressed format for reducing the storage space requirement. In this situation, the feature extractor essentially produces an image feature for the CBIR from compressed data stream without performing the decompression process. The Block Truncation Coding (BTC) is an image compression strategy which requires basic procedure on both encoding and decoding stages.

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Related work which is required for this research is given in section II, the implementation details in section III where system architecture and modular description is given. Section IV discusses about the algorithm. In next section V, discussion about the Experimental setup is given, where VI discuss the Results and at last provide a conclusion and future work in section VII.

II. RELATED WORK

A. A Modified Three Level Block Truncation Coding or Image Compression [1]

There are already existing compression scheme such as transform coding, vector quantization (VQ), block truncation coding (BTC), conventional block truncation coding, absolute moment BTC (AMBTC) to overcome a challenging task related to storage and quality of image. Although the techniques have the advantage of lower computation cost, it does not offer excellent quality and the bit rate cannot be decreased to the requirements of very low bit rate. To overcome these challenges we require a powerful and efficient digital compression scheme.

A new scheme is implemented in this paper to achieve the low bit rate BTC called modified three level BTC improve a coding efficiency of in terms of compression ratio. This technique is completely same as AMBTC but difference is only in decoding stage. Technique divides the pixel into non overlapping blocks, preserving the higher and lower mean of the block. Compression of image is more of this technique as it has higher compression factor than conventional BTC. And it also require less space because provide low bit rate compared to other.

B. Improved Block Truncation Coding Based on the Void-and-Cluster Dithering Approach [2]

An improved BTC algorithm such as ODBTC implement here, to provide better image quality, the void-and-cluster halftoning is combined with the BTC. Another feature of the ODBTC is the dither array Look Up Table (LUT), substitute the fixed average threshold in BTC, and the extreme pixel values in a block are adopted to substitute the high mean and low mean which significantly reduces the complexity compared to the BTC.

C. Local tetra patterns: A new feature descriptor for content-based image retrieval [3]

Texture analysis has many techniques are used to extract the features from given image. Image texture gives information about the spatial arrangement of color or intensities in an image or selected region of an image. Discrete wavelet transform (DWT) for texture classification and image retrieval, local binary pattern (LBP), local derivative pattern (LDP), local ternary pattern (LTP) are used in facial expression analysis and recognition. The LBP, LDP, and LTP extract the information based on the distribution of edges, which are coded using only two directions (positive direction or negative direction). To overcome this limitation and improve performance of these methods by differentiating the edges in more than two directions a local tetra patterns (LTrPs) implemented.

D. LBP-Based Edge-Texture Features for Object Recognition [4]

Object recognition is a task of finding and identifying object in an image or video sequence used in content based retrieval system to retrieve given image from large database. Various feature representation such as scale-invariant feature transform (SIFT), local binary pattern (LBP), local ternary pattern (LTP), robust LBP (RLBP) are used for texture classification and face detection. But these techniques have limitation that they do not differentiate between a weak contrast local pattern and a similar strong one. Also discards the contrast information.

Therefore, two set of novel edge-texture feature, discriminative robust LBP (DRLBP) and discriminative robust LTP (DRLTP) implemented here. DRLBP and DRLTP reduce the intensity problem of object and background. In addition, they maintain contrast information of image patterns also contain edge and texture information which is desirable for object recognition. DRLTP has less noise and pixel value fluctuation as compared to LBP, LTP. This technique also has greater recognition rate and improves classification performance compared to other.

E. A smart content-based image retrieval system based on color and texture feature [5]

In this paper, three image features are proposed for image retrieval. In addition, a feature selection technique is also brought forward to select optimal features to not only maximize the detection rate but also simplify the computation of image retrieval. The first and second image features are based on color and texture features, respectively called color co-occurrence matrix (CCM) and difference between pixels of scan pattern (DBPSP) in this paper. The third image feature is based on color distribution, called color histogram for *K*-mean (CHKM).

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To enhance image detection rate and simplify computation of image retrieval, sequential forward selection is adopted for feature selection. Three image databases with different properties are used to carry out feature selection. Optimal features are selected from original features to enhance the detection rate.

III. IMPLEMENTATION DETAILS

There has been lots of increment and rapid growth in image processing area. When user enters the query into the search engine then user expects the relevant result rather than the other similar factors. Consider one example of flip-kart where user query one image of cooker then user expects that he or she will get the images of cooker whose shape, color or texture should be similar to query image. If user get the images of cooker which having shape similar to the cooker but color and texture are to be different then it will cause to loss integrity. So to improve accuracy use the halftone based ordered dither block truncation coding method.
The main objective is to improve effectiveness and accuracy of result for our query. There are multiple methods applied to increase efficiency and accuracy of content based image retrieval. New approach is focusing on to improve effectiveness and accuracy of image retrieval. The goal is to finding the similarity matching result from the query image entered by user.

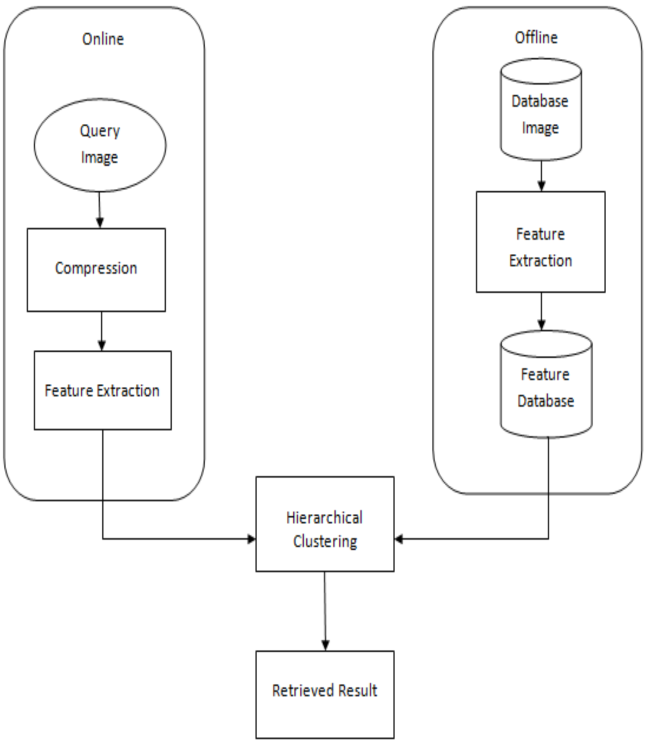

Fig.1: System Overview

A. System Overview

In this approach both online part and offline part are independent, so we can perform it parallel. At offline side, basic calculations are pre-computed using hierarchical clustering algorithm so that it will reduce the computation time and improve efficiency. Finally similarity computation will perform on output of online part and offline part. The fig.1 shows task in halftone based ODBTC approach.
In this approach we divide the task into two parts:
Online part: In online part, user's query image, compression and feature extraction at client side will be done.
Offline part: In offline part, all the work on database will be done which include database image feature extraction etc.
Advantages of proposed system

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i) The proposed agglomerative clustering algorithm utilizes the usefulness of clustering approaches to capture the finer clusters of images.
ii) The proposed system improves efficiency and accuracy of images.

B. Ordered Dither Block Truncation Coding.

ODBTC compresses an image block into corresponding quantizers and bitmap image. The main advantage of the ODBTC image compression is on its low complexity in generating bitmap image by incorporating the Look-Up Table (LUT), and free of mathematical multiplication and division operations on the determination of the two extreme quantizers. It will reduce computation time and yield better image quality. Conversely, ODBTC identifies the minimum and maximum values each image block as opposed to the former low and high mean values calculation, which can further reduce the processing time in the encoding stage. In addition, the ODBTC yields better reconstructed image quality by enjoying the extreme-value dithering effect.

ODBTC Encoding Steps: ODBTC encoding is divided into two parts one is generation of bitmap image and second is calculation of minimum quantizer and maximum quantizer.

a. Generation of bitmap image:

1. Original RGB color image of size $M \times N$ is divided into multiple non-overlapping image blocks of size $m \times n$, and each image block then processed independently.
2. The original image block $b(i, j)$ is then converted into the inter-band average image and compute grayscale image i.e. inter-band average image.

$$b_{k,l}(i,j) = \frac{1}{3}\left[b_{k,l}^{red}(i,j) + b_{k,l}^{green}(i,j) + b_{k,l}^{blue}(i,j)\right]; \quad k = 1,2,3 \ldots m; l = 1,2,3 \ldots n$$

3. On inter-band average image, ODBTC apply the thresholding with pre-computed scaled version of dither array for each image block to generate bitmap image $bm(i, j)$.

$$bm_{k,l}(i,j) = \begin{cases} 1; if\ \bar{b}_{k,l}(i,j) \geq \bar{b}_{min}(i,j) + D^d(k,l) \\ 0; if\ \bar{b}_{k,l}(i,j) \leq \bar{b}_{min}(i,j) + D^d(k,l) \end{cases}$$

b. Calculate Min and Max Quantizer:

1. By applying RGB decomposition, convert original image into three red, green and blue color images and divide each image into multiple non-overlapping image block.
2. Find minimum and maximum pixel value on each block for red, green and blue images independently.

$$x_{\min}(i,j) = \left[\min_{\forall k,l} b_{k,l}^{red}(i,j), \min_{\forall k,l} b_{k,l}^{green}(i,j), \min_{\forall k,l} b_{k,l}^{blue}(i,j)\right],$$

$$x_{\max}(i,j) = \left[\max_{\forall k,l} b_{k,l}^{red}(i,j), \max_{\forall k,l} b_{k,l}^{green}(i,j), \max_{\forall k,l} b_{k,l}^{blue}(i,j)\right]$$

for all $i = 1,2,\ldots,\frac{M}{m}$; $j = 1,2,\ldots,\frac{N}{n}$.

3. Then combine minimum value and maximum value from red, green and blue pixel value and calculate Min. Quantizer and Max. Quantizer respectively.

$$X_{min} = \left\{x_{\min}(i,j) \middle| i = 1,2,\ldots,\frac{M}{m}; j = 1,2,\ldots,\frac{N}{n}\right\}$$

$$X_{max} = \left\{x_{\max}(i,j) \middle| i = 1,2,\ldots,\frac{M}{m}; j = 1,2,\ldots,\frac{N}{n}\right\}$$

Finally, the bitmap image *bm*, the minimum quantizer *Xmin*, and maximum quantizer *Xmax* are generated as encoded data stream. This encoded data stream then transmitted to the decoder module over the transmission channel. The receiver decodes this encoded data stream to reconstruct the image. The decoder simply replaces the element of value 0 in the bitmap by the minimum quantizer, and elements of value 1 in the bitmap by the maximum quantizer.

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Except for the image compression, ODBTC compressed data stream, i.e., the bitmap image and two extreme color quantizers, is then used as an image descriptor for BPF and CCF respectively. In this paper, easy method for CBIR is implemented using the image feature extraction derived from the ODBTC encoded data stream.

C. Feature Extraction from compressed image.

Color-Cooccurrence Feature:

In the proposed scheme, from the two ODBTC color quantizers CCF is computed. Firstly using a specific color codebook generated using LBG-VQ algorithm, the minimum and maximum color quantizers are indexed and using this indexed values construct the color co-occurrence matrix. Next, the CCF is constructed from the color co-occurrence matrix at the end of computation.

Color indexing process:

1. Find closest matching between minimum quantizer value of each image block over red, green, blue channel and codebook.

$$\tilde{\imath}_{min}(i,j) = \underset{q\,=\,1,2,\ldots N_c}{\arg min} \left\| x_{\min}(i,j), C_q^{min} \right\|_2^2$$

for all $i = 1,2,..,\frac{M}{m}$; $j = 1,2,..,\frac{N}{n}$.

2. As similarly, find closest matching between minimum quantizer value of each image block over red, green, blue channel and codebook.

$$\tilde{\imath}_{max}(i,j) = \underset{q\,=\,1,2,\ldots N_c}{\arg min} \left\| x_{\max}(i,j), C_q^{max} \right\|_2^2$$

for all $i = 1,2,..,\frac{M}{m}$; $j = 1,2,..,\frac{N}{n}$

3. Calculate color co-occurrence matrix as CCF given by,

$$CCF(t_1,t_2) = Pr\left\{\tilde{\imath}_{min}(i,j) = t_1, \tilde{\imath}_{max}(i,j) = t_2 \,\middle|\, i = 1,2,..,\frac{M}{m};\ j = 1,2,..,\frac{N}{n}\right\}$$

for all $t_1, t_2 = 1,2,..,N_c$.

Bit Pattern Feature:

Next feature is called Bit Pattern Feature (BPF), characterizes the edges, shape, and image contents. Bitmap image is indexed using bit pattern codebook and result BPF. These bit pattern codebooks are generated using binary vector quantization and many bitmap images are involved in the training stage. At the codebook generation stage, all code vector components may have intermediate real values between zero (black pixel) and one (white pixel) as opposed to binary values. At the end of training stage, the hard thresholding performs the binarization of all code vectors to yield the final result.

BPF indexing process:

1. Find similarity between bitmap of each image block *bm(i, j)* and codeword Q_q.

$$\tilde{b}(i,j) = \underset{q\,=\,1,2,\ldots N_b}{\arg min} \delta_H\{b_m(i,j), Q_q\}$$

for all $i = 1,2,..,\frac{M}{m}$; $j = 1,2,..,\frac{N}{n}$.

2. Compute occurrence probability of bitmap image indexed into bit pattern codebook. This is considered as BPF,

$$BPF(t) = Pr\left\{\tilde{b}(i,j) = t \,\middle|\, i = 1,2,..,\frac{M}{m};\ j = 1,2,..,\frac{N}{n}\right\}$$

for all $t = 1,2,..,N_b$.

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Vol. 4, Issue 7, July 2016

D. The Similarity Measure of the Features

The similarity between two images (i.e., a query image and the set of images in the database as target image) can be measured using the relative distance measure. The similarity distance plays an important role for retrieving a set of similar images. The query image is firstly encoded with the ODBTC, yielding the corresponding CCF and BPF. The two features are later compared with the features of target images in the database.

$$\delta(query, target) = \alpha_1 \sum_{t=1}^{N_c} |CCF^{query}(t) - CCF^{target}(t)| + \alpha_2 \sum_{t=1}^{N_c} |BPF^{query}(t) - BPF^{target}(t)|$$

Where α_1 and α_2 are similarity weighting constants. A set of similar images to the query image is returned and ordered based on their similarity distance score, i.e. the lowest score indicates the most similar image to the query image.

IV. PROPOSED ALGORITHM

Agglomerative clustering algorithm:

Agglomerative hierarchical clustering is a case of hierarchical clustering techniques. The technique works as repeatedly clustering the documents from top or bottom. The tree formed by this technique can be investigated at various levels. The technique work as follows:

i. Start by assigning each image to a cluster, so that if we have N images, we have N clusters. Each cluster initially contains just one image.
ii. Let the distances (similarities) between the clusters the same as the distances (similarities) between the images they contain.
iii. Find the closest (most similar) pair of clusters and merge them into a single cluster, this process is repeated for each image in database.
iv. Compute distances (similarities) between the new cluster and each of the old clusters.
v. Repeat steps iii and iv until all images are clustered up to a specified threshold.

V. RESULTS

Customized Halftoning Based Block Truncation Coding For Content Based Image Retrieval system improve result accuracy and efficiency than existing technique. ODBTC technique is used to compress an image as it exploiting encoded data stream to construct image descriptor. Over image descriptor CCF and BPF are performed to extract features of images. By using hierarchical clustering algorithm, featured database is calculated and stored it as pre-computed. Subsequently system returns a set of similar images from the pre-computed database based on their similarity. Proposed scheme provide best precision rate and by adopting clustering on database, system require less time to retrieve similar images from database. Finally, the image retrieval performance is tested when several images are turned as queries.

A. Data Set

This research uses image dataset which is freely available on internet. These image databases contain various textural and natural images of different appearance in the grayscale and color space with different image sizes. All images in the databases are divided into several images, in which all images under the same categories are regarded as similar images.

B. Comparison with Former Scheme.

In this experiment, images from each category in database are turned as the query images. The average precision rate is computed among all query images with the number of retrieved images set at L = 5. Table II shows the comparisons among the proposed scheme and the former BTC method in terms of the average precision rate with L = 5. As it can be seen in this Table, the proposed method does not consistently achieve the best average precision rate on each image class; however, the proposed method yields stable average precision rates as indicated with a small value of standard deviation. In addition, the proposed method achieves the best retrieval accuracy compared to the former existing BTC schemes even though the image descriptors are simply derived from low level visual features, i.e., color distribution and ordered dither bit pattern of block-based ODBTC encoded data stream. In addition, the ten images are turned as query images in comparison with BTC method.

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In this case, the average precision rate of BTC is 0.61, while the proposed scheme achieves 0.73 under the same experimental setup. Thus, the proposed scheme achieves a better image retrieval accuracy compared to that of the former BTC scheme.

Category → / Methods ↓	People	Beach	Building	Bus	Dinosaur	Elephant	Flower	Horse	Mountain	Food	Average
BTC[15]	0.60	0.42	0.61	0.7	0.9	0.67	0.62	0.54	0.34	0.67	0.61
ODBTC	0.74	0.46	0.71	0.82	0.99	0.73	0.87	0.75	0.47	0.76	0.73

TableI: Comparison between Proposed scheme with BTC scheme in terms of Avg. Precision Rate

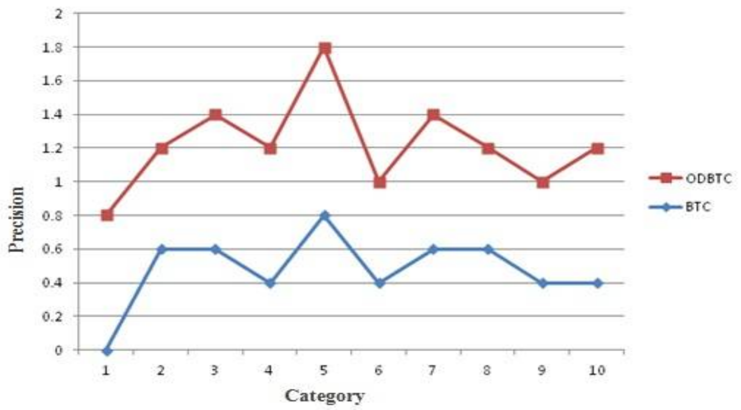

Fig.2: Comparison between BTC-based and ODBTC-based image indexing

Fig. 2 shows the average precision and recall rates of the BTC and ODBTC image retrieval methods over various image categories for corel image database. As it can be seen, the proposed method outperforms the BTC indexing method [15] over all image categories. By setting $N_c = 256$ and $N_b = 16$, the proposed method is still better compared to BTC method as shown in Fig. 14. Notably, the proposed method yields a better image retrieval accuracy compared to BTC.

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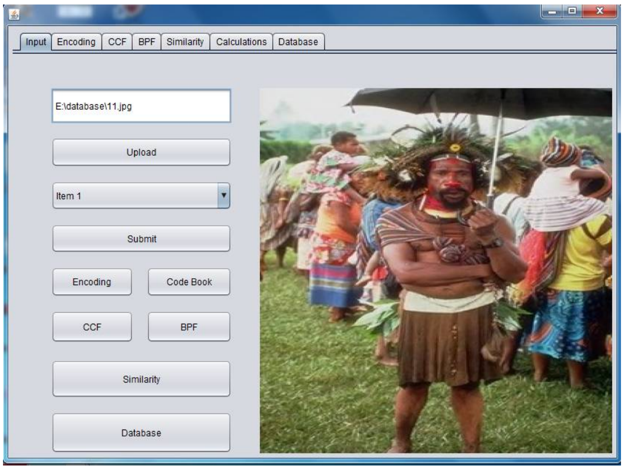

Fig.3: Uploaded Query Image

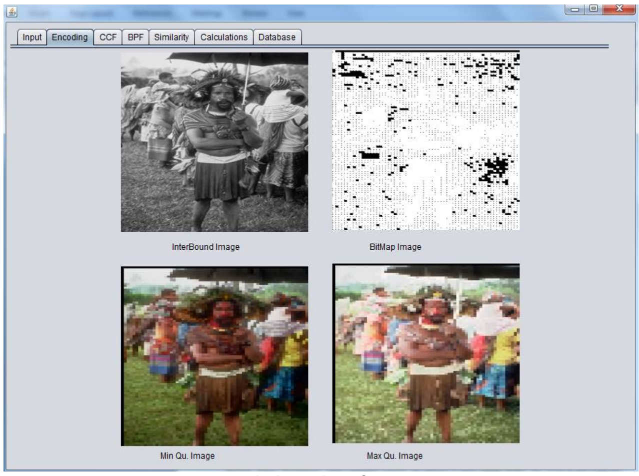

Fig.4: Encoded results of Query image

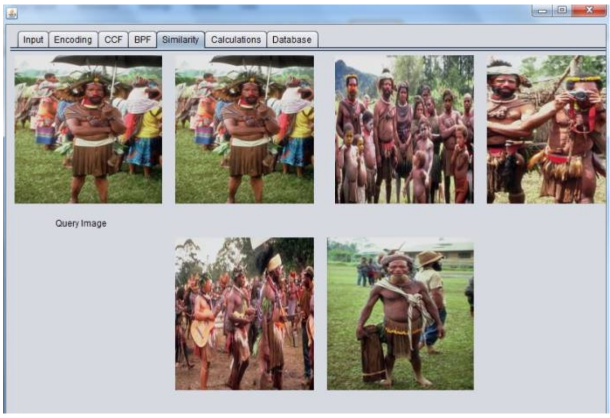

Fig.5: Resultant images similar to Query Image

Fig.3 shows snapshot of uploaded query image for which we want to retrieve similar images from compressed database. Fig.4 shows encoding output of query image using ODBTC compression as image descriptor for feature extraction. It shows generated Bitmap image and Min, Max Quantizer on which CCF and BPF is performed and calculate feature information. These calculated features are indexed to most similar images that stored in pre-computed featured database grouped using clustering algorithm. Fig.5 shows retrieved similar images to query images and ordered based on their similarity score. This system requires less time to retrieve similar images from database as database is stored precompiled using clustering algorithm.

VI. Conclusion and Future Work

Demands of multimedia applications are increasing over the Internet, the importance of image retrieval and image mining has increased. The ordered dither block truncation coding encode data stream is used to construct the image features, i.e. Bit Pattern features and Color Co-occurrence. The proposed method can contribute the best average precision rate compared to other former schemes in the literature. As a result, the proposed scheme can be considered a competitive candidate in color image retrieval application. We pay attention solely to the area where the two clusters come closest to each other by applying hierarchical clustering algorithm to featured database. Agglomerative clustering with halftone based ODBTC will again increase the accuracy and efficiency of retrieved images.

In future, this work can be extended using relevance feedback. The idea of relevance feedback is to involve the user in the retrieval process so as to improve the final result set.

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BIOGRAPHY

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Prof. N. G. Bhojane graduated in CSE from MGMs JNEC Aurangabad, (Dr. B.A.M. University Aurangabad) in 2000 and completed M.E. in Computer Network (CN) from STES, Sinhgad College Of Engineering, Vadgaon(Bk), Pune(University Of Pune) in 2012. He works with Sinhgad College of Engineering, Pune. His research interests are in the field of Soft Computing and image processing.