Improved CBIR using Multileveled Block Truncation Coding

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ABSTRACT

The paper presents improved content based image retrieval (CBIR) techniques based on multilevel Block truncation coding using multiple threshold values. Block truncation Coding based features is one of the CBIR methods proposed using color features of image. The approach basically considers red, green and blue planes of image together to compute feature vector. The color averaging methods used here are BTC Level-1, BTC Level-2, BTC Level-3.Here the feature vector size per image is greatly reduced by using mean of each plane and find out the threshold value then divide each plane using threshold value, color averaging is applied to calculate precision and recall to calculate the performance of the algorithm. Instead of using all pixel data of image as feature vector for image retrieval, these six feature vectors can be used, resulting into better performance and if increased the no of feature vector get better performance .The proposed CBIR techniques are tested on generic image database having 1000 images spread across 11 categories. For each proposed CBIR technique 55 queries (5 per category) are fired on the generic image database To compare the performance of image retrieval techniques average precision and recall are computed of all queries. The results have shown the performance improvement (higher precision and recall values) with proposed methods compared to BTC Level-1.

Keywords: ***Content Based Image Retrieval (CBIR), BTC Level-1, BTC Level-2, BTC Level-3.***

1. INTRODUCTION

From ancient era images make main role in human communication. It was basic and common way to express the information. Today with advance development in information and communication technology the information is in the form of digital data. Large amount of digital data is generated, transmitted ,stored ,analyzed and accessed. Mostly information is in multimedia nature such as digital images, audio, video, graphics. From various sources large amount images are generated .It take large volume for storage purpose. This store information in the form of images are more complex to retrieve and it is difficult to store in large volume. The need for efficient retrieval of images has been recognized by managers of large image collections. To develop efficient indexing techniques for the retrieval of enormous volumes of images being generated these days, we need to achieve reasonable solutions to these above-mentioned two problems. Content based image retrieval gives solution of above problem .

Content Based Image Retrieval (CBIR) is used to provide a high percentage of relevant images in response to the query image. The goal of an image retrieval system is to retrieve a set of images from a collection of images such that this set meets the user's requirements. The user's requirements can be specified in terms of similarity to some other image.

The challenge to image indexing/management is studied in the context of image database, Image retrieval systems can be divided into two main types: Text Based Image Retrieval and Content Based Image Retrieval[10].

Text Based Image Retrieval is the traditional image retrieval system. In retrieval systems by adding text strings describing the content of an image. This system having drawbacks first It is very time consuming technique. Second as per perception of information from same image different person having different meaning. Due to these drawbacks, Content Based Image Retrieval (CBIR) is introduced.

A Content Based Image Retrieval (CBIR) gives query as Image and output is number of matching images to query image. In a CBIR, features are used to represent the image content. The features are extracted automatically and there is no manual intervention, thus eliminating the dependency on humans in the feature extraction stage. The typical CBIR system performs two major tasks. The first one is feature extraction (FE), where a set of features, called feature vector, is generated to accurately represent the content of each image in the database. A feature vector is much smaller in size than the original image. The second task is similarity measurement (SM), where a distance between the query image and each image in the database using their signatures is computed so that the top "closest" images can be retrieved [3], [13], [14], [15].

Similarity Measure is very important task in CBIR. Many current CBIR system use Euclidean distance on the extracted feature set as a similarity measure. The Direct Euclidian distance between image P and query image Q can be given as equation 1. Where Vpi and Vqi are the feature vectors of image P and query image Q respectively with size ‘n’.

$$ED = 1/2\sqrt{\sum_{i=1}^{n}(Vpi - Vqi)2} \qquad (1)$$

where, Vpi and Vqi be the feature vectors of image P and Query image Q respectively with size ‘n’.

The thirst of better and faster image retrieval techniques is increasing day by day. Some of important applications for CBI technology could be identified as art galleries , museums, archaeology , architecture design , geographic information systems ,weather forecast , medical imaging , trademark databases, criminal investigations, image search on the Internet .

2. BLOCK TRUNCATION CODING (BTC)

Block truncation coding (BTC) is a relatively simple image coding technique developed in the early years of digital imaging more than 29 years ago. Although it is a simple technique, BTC has played an important role in the history of digital image coding in the sense that many advanced coding techniques have been developed based on BTC or inspired by the success of BTC [1]. Block Truncation Coding (BTC) was first developed in 1979 for grayscale image coding. This method first divides the image to be coded into small non-overlapping image blocks (typically of size 4× 4 pixels to achieve reasonable quality.) The small blocks are coded one at a time. For each block, the original pixels within the block are coded using a binary bit-map the same Upper Mean Color as the original blocks and two mean pixel values. In the original implementation the block mean and the variance of the pixels are used to preserve the first and second moment of the blocks. The descriptors here follow a later version of BTC, which was shown to give better performance [1].

The method first computes the mean pixel value of the whole block and then each pixel in that block is compared to the block mean. If a pixel is greater than or equal to the block mean, the corresponding pixel position of the bitmap will have a value of 1 otherwise it will have a value of 0. Two mean pixel values one for the pixels greater than or equal to the block mean and the other for the pixels smaller than the block mean are also calculated. At decoding stage, the small blocks are decoded one at a time. For each block, the pixel positions where the corresponding bitmap has a value of 1 is replaced by one mean pixel value and those pixel positions where the corresponding bitmap has a value of 0 is replaced by another mean pixel value.

3. CBIR using BTC RGB Level-1(BTC-6) [2,3,8,16,20]

In original BTC we divide the image into R, B, and G components and compute the interband average image (IBAI) which is the average of all the components(R, G, and B) and mean of interband average image is taken as threshold. By using three independent R, G and B components of color images to calculate three different thresholds and then apply BTC to each individual R, G and B planes. Let the thresholds be MR, MG and MB, which could be computed as per the equations given below.

$$MR = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n}R(i,j) \qquad (2)$$

$$MG = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n}G(i,j) \qquad (3)$$

$$MB = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n}B(i,j) \qquad (4)$$

Here three binary bitmaps will be computed as BMr, BMg and BMb. If a pixel in each component (R, G, and B) is greater than or equal to the respective threshold, the corresponding pixel position of the bitmap will have a value of 1 otherwise it will have a value of 0.

$$BMr(i,j) = \{ \begin{array}{l} 1, if ....R(i,j) > MR \\ 0,....if ...R(i,j) <= MR \end{array} \qquad (5)$$

$$BMg(i,j) = \{ \begin{array}{l} 1, if ....G(i,j) > MG \\ 0,....if ...G(i,j) <= MG \end{array} \qquad (6)$$

$$BMb(i,j) = \{ \begin{array}{l} 1, if ....B(i,j) > MB \\ 0,....if ...B(i,j) <= MB \end{array} \qquad (7)$$

Two mean colors one for the pixels greater than or equal to the threshold and other for the pixels smaller than the threshold are also calculated [15]. The upper mean color UM(UR, UG, UB) is given as follows.

$$UR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n}BMr(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}BMr(i,j)*R(i,j) \qquad (8)$$

$$UG = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n}BMg(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}BMg(i,j)*G(i,j) \qquad (9)$$

$$UB = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n}BMb(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}BMb(i,j)*B(i,j) \qquad (10)$$

And the Lower Mean LM= (LR, LG, LB) is computed as following equations

$$LR = \frac{1}{m*n - \sum_{i=1}^{m}\sum_{j=1}^{n} BMr(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}\{1-BMr(i,j)\}*R(i,j) \qquad (11)$$

$$LG = \frac{1}{m*n - \sum_{i=1}^{m}\sum_{j=1}^{n} BMg(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}\{1-BMg(i,j)\}*G(i,j) \qquad (12)$$

$$LB = \frac{1}{m*n - \sum_{i=1}^{m}\sum_{j=1}^{n} BMb(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}\{1-BMb(i,j)\}*B(i,j) \qquad (13)$$

These Upper Mean and Lower Mean together will form a feature vector or signature of the image. For every image stored in the database these feature vectors are computed and stored in feature vector table.

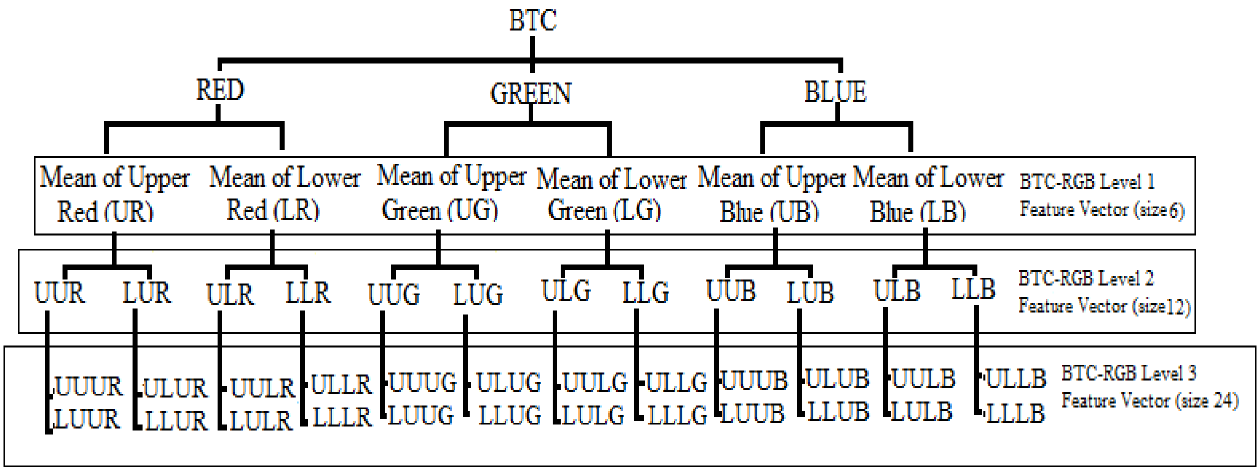

Figure 1.Multilevel BTC-CBIR

4. CBIR using BTC- RGB- Level 2 (BTC-12)

In BTC-RGB-Level 2 the image data is divided into 12 parts using the six means obtained in BTC-RGB-Level 1

Here the bitmap are prepared using upper and lower mean values of individual colour components. For red colour component the bitmap 'BMUR' and 'BMLR' are generated as given in equations 14 and 15. Similarly for green colour component 'BMUG' & 'BMLR' and for blue colour components 'BMUB' & 'BMLB' can be generated.

$$BMUR(i,j) = \{ \begin{matrix} 1, if ....R(i,j) > UR \\ 0,....if...R(i,j) <= UR \end{matrix} \qquad (14)$$

$$BMLR(i,j) = \{ \begin{matrix} 1, if ....R(i,j) > LR \\ 0,....if...R(i,j) <= LR \end{matrix} \qquad (15)$$

Using this bitmap the two mean colours per bitmap one for the pixels greater than or equal to the threshold and other for the pixels smaller than the threshold are calculate [15]. The upper mean color UM (UUR, ULR, UUG, ULG, UUB, ULB) are given as follows.

$$UUR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMUR(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n} BMUR(i,j)*Iur(i,j) \qquad (16)$$

$$ULR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMLR(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n} BMLR(i,j)*Ilr(i,j) \qquad (17)$$

And the first two components of Lower Mean LM= (LUR, LLR, LUG, LLG, LUB, LLB) are computed using following equations

$$LUR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMUR(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}\{1-BMUR(i,j)\}*Iur(i,j) \qquad (18)$$

$$LLR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMLR(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n}\{1-BMLR(i,j)\}*Ilr(i,j) \qquad (19)$$

These Upper Mean and Lower Mean together will form a fature vector for BTC-12. For every image stored in the database these feature vectors are computed and stored in feature vector table.

5. CBIR using BTC- RGB-Level 3 (BTC-24)

Similarly the feature vector for BTC-24 can be found by extending the BTC till level 3 as shown in figure 1. Each plane will give the 6 elements of feature vector. For Red plane we get (UUUR, LUUR, ULUR, LLUR, UULR, LULR, ULLR, LLLR).

6. IMPLEMENTATION

The implementation of the three CBIR techniques is done in MATLAB 7.0. The CBIR techniques are tested on the augmented wang [15] image database of 1000 variable size images spread across 11 categories of human being, animals, natural scenery and manmade things. To compare the techniques and to check their performance we have used the precession and recall. The features of an efficient CBIR system such as accuracy, stability and speed. To assess the retrieval effectiveness, we have used the precision and recall as statistical comparison parameters for the BTC-6, BTC-12 and BTC-24 techniques of CBIR. The standard definitions of these two measures are given by following equations.

$$\text{Precesion} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (20)$$

$$\text{Recall} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (21)$$

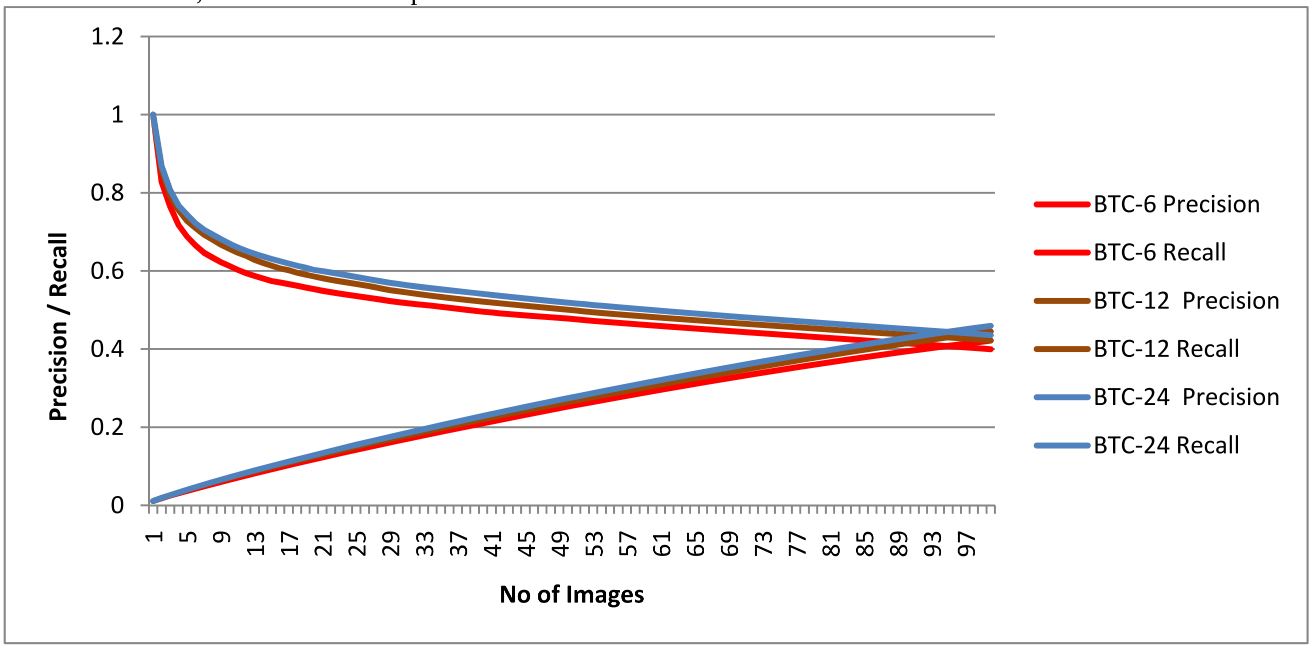

Figure 2. Precision/Recall plotted against number of retrieved images for all discussed CBIR methods

7. RESULTS AND DISCUSSION

The methods BTC-6 ,BTC-12 ,BTC-24 were applied to the image database of 1000 images. Following graphs shows the result of precision and recall for each method.

figure 2 shows the precision & recall for discuss CBIR techniques using BTC at various level plotted against no of retrived images. Here. the difference in performancesof this image retrival method can not be distinguish clearly.Hence Fugure-3 gives the zoomed out version of crossover points of precision & recall values from figure-3 it can clearly be seem that higher precision & recall values are obtain in proposed CBIR techniques as compare to convensional level-1 BTC. The hight of crossover points of precision and recall plays very important roll in performance comaparision of CBIR methods. Better performance is indicated by higher crossover points value. Figure-4 shows the crossover points of proposed CBIR method plotted for comparision. Where it can clearly be observed that higher level of BTC gives better image retrival indicated by higher precision-recall crossover points. Higher level of BTC-CBIR gives better performance which can be seen by higher precision ad recall values for BTC-24 as shown in table-1, where the precision and recall values for nmber of retrieved images are given.

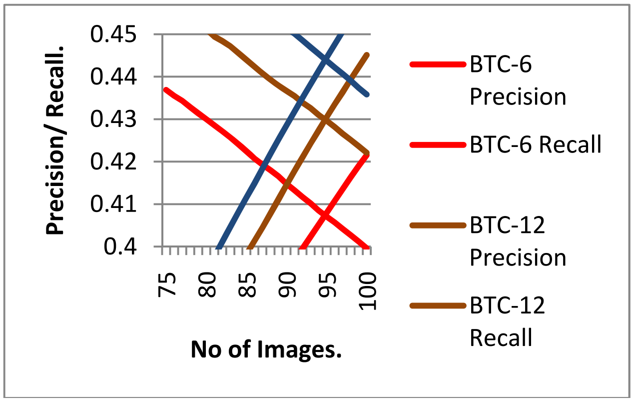

Figure 3 Crossover points of Precision-Recall plotted against number of retrieved images

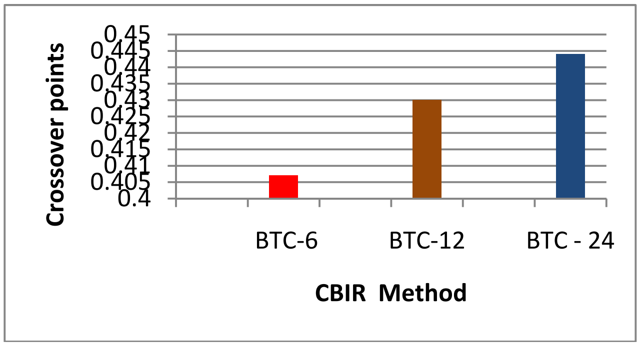

Figure 4 Performance comparison of discussed CBIR methods using Precision-Recall crossover points

Table 1: Precision-Recall Readings of 75 to 100 retrieved images

PAs	Precision			Recall		
	BTC - 6	BTC -12	BTC - 24	BTC - 6	BTC - 12	BTC - 24
75	0.436906667	0.458786667	0.47456	0.3459564	0.36306992	0.37548704
76	0.4355	0.457263158	0.47317105	0.3494402	0.36667871	0.37937572
77	0.434337662	0.455753247	0.47166234	0.353109	0.3702722	0.38314753
78	0.432846154	0.454307692	0.47003846	0.3564382	0.37390809	0.38677503
79	0.431367089	0.452873418	0.46856962	0.3597705	0.37750127	0.39047963
80	0.43	0.451225	0.4668	0.3631282	0.38083498	0.39391416
81	0.428592593	0.449469136	0.46541975	0.3664659	0.38409742	0.39765962
82	0.427195122	0.448390244	0.4637439	0.3697671	0.38792897	0.4011047
83	0.42573494	0.447180723	0.46218072	0.37299	0.39158777	0.40462745
84	0.424107143	0.445583333	0.46065476	0.3759859	0.39486872	0.40811281
85	0.422447059	0.443952941	0.45908235	0.378996	0.39810344	0.41151745
86	0.420744186	0.442406977	0.4575	0.3819087	0.40135524	0.41487726
87	0.419321839	0.440758621	0.45608046	0.3850221	0.40448058	0.41838237
88	0.417988636	0.439352273	0.45467045	0.3881815	0.40779826	0.42185675
89	0.41658427	0.437932584	0.4531573	0.3912203	0.41107514	0.42521375
90	0.4148	0.4367	0.4515	0.3938869	0.4144957	0.42842815
91	0.413263736	0.435450549	0.45008791	0.3967778	0.41789819	0.43185991
92	0.411652174	0.433913043	0.44853261	0.3995348	0.42099973	0.43506479
93	0.410215054	0.432612903	0.44691398	0.4024465	0.42431033	0.43822368
94	0.4085	0.430978723	0.44540426	0.4050527	0.42725947	0.44142704
95	0.407063158	0.429642105	0.44377895	0.4079052	0.43046642	0.44446416
96	0.405677083	0.4281875	0.44219792	0.4108105	0.43350922	0.44756065
97	0.404164948	0.426546392	0.44065979	0.4135774	0.43635921	0.45064247
98	0.402714286	0.425173469	0.43910204	0.4163394	0.43940316	0.45367792
99	0.40120202	0.423646465	0.43737374	0.4190044	0.44227819	0.45649204
100	0.3996	0.42211	0.43581	0.4215424	0.44510817	0.45943656

8. CONCLUSION

The performance of CBIR system depends on the precision and recall. Quite often the crossover point of precision and recall is taken as criteria for judging the performance of CBIR technique. These values are 0.407, 0.43, 0.444 for BTC-6, BTC-12,BTC-24 respectively. Thus BTC-24 gives the best performance proving that the BTC-RGB based CBIR can be augmented by extending BTC to multiple levels for better performance.

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