



Thepade's Ternary Block Truncation Coding with various degrees and Color Spaces for Content Based Image Retrieval

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Abstract: Proficient Content Based Image Retrieval system is a much needed system for plenty of image retrieval supporting applications, which retrieve images more rapidly from giant image databases. Block Truncation Coding (BTC) is one of the prominent and simple techniques used most of the time. This method is built on color properties of an image for image retrieval. In this paper a novel Static Thepade's Ternary Block Truncation Coding with degree values (varied as $n=1$ to 5) and Dynamic Thepade's Ternary Block Truncation Coding are proposed. Total 36 variations of proposed image retrieval methods, using five degree values for Static Thepade's Block Truncation Coding and Dynamic Thepade's Block Truncation Coding with six color spaces (RGB, LUV, YCbCr, YCgCb, YCbCr, YUV and YIQ) are experimented on image database having 1000 images in 10 different categories. Experimental results have shown better performance in YCbCr color space followed by YUV. The best image retrieval is by Dynamic Thepade's Ternary Block Truncation Coding in YCbCr color space.

Keywords: Content Based Image Retrieval (CBIR), BTC, Static Thepade's Ternary Block truncation Coding (STBTBC), Dynamic Thepade's Ternary Block Truncation Coding (DTBTBC), Color Spaces.

I. Introduction

With the help of advances in modern technologies, capturing and storage/ transmission of an image become easier but accessing/ indexing and retrieval of required image become more challenging. Reason behind it is; image databases are having outsized structure and deficiency of proficient techniques to retrieval of images from an image databases. Content based image retrieval (CBIR) systems are used to overcome these and many other limitations from traditional image retrieval systems [1], [2]-[5], [11]. CBIR can be successfully used in many professional applications such as Trademark image registration, Intellectual property, Architectural and Engineering design, Fashion and Interior Design, Journalism and Advertising, Art galleries, Museums and image search on Internet. Also it can be used in social applications such as Crime Prevention, Crime Detection/ Investigation, Geographical Information System (GIS), Weather forecast, Medical Imaging, Biometric Identification Systems using Finger prints, Palm print and Face. Also it becomes one of the promising and important research area for various fields like computer vision, image processing and image databases [1], [2], [3], [8], [9]-[20]. In this paper a novel technique is proposed to provide efficient image retrieval from an image database using Thepade's ternary block truncation coding (TTBTBC) in static and dynamic forms.

II. Content Based Image Retrieval (CBIR)

The traditional image retrieval technique does not meet the users demand as it produces lots of garbage data as a result. Those systems are not precise so there is need of system which retrieves the images based on contents of an image and gives efficient results. Content Based Image Retrieval (CBIR) is different from the traditional database and text based image retrieval system. Users are able to submit their request in the form of a query image or sketch. Techniques used in Content Based Image Retrieval (CBIR) systems to generate a feature vector of an image are completely automatic and based on actual visual contents (features) of an image. With the help of automatically generated features images are searched from large scale image database. CBIR system complete its task in two steps; first is feature extraction, in this step set of features called feature vector is generated to represent the content of each image in the image database (all the generated feature vectors are kept in feature vector table), and second is similarity measurement, in this distance between query image and each image in the database is computed using their feature vector and it is used to retrieve the top closest matching of an images. Kato used CBIR system first time by using color and shape as a feature of an image [2]-[5], [8], [10]-[19].

CBIR uses two approaches for feature extraction of images as Special domain and transform domain. Special domain approaches mainly consist of techniques like Gray block truncation coding (BTC) [6], Color block truncation coding [1], [6], [7], [9], [12], [13], [15], [17]-[19], Multilevel BTC [1], [6], [7], [13], [14], [17]-[19], EVEN-ODD BTC [1], [17], [20] and BTC extended to color clumps [1]. The transform domain technique gives

high energy compaction in transformed image so it can be useful for image feature size reduction purpose in CBIR. One of the disadvantage of transform domain methods is, it consume more time than special domain. Most of the CBIR systems are based on Euclidean distance for similarity measurement. Euclidean distance between two images is calculated by following equation [2]-[5]

$$ED = \sqrt{\sum_{i=1}^n (V_{pi} - V_{qi})^2} \quad (1)$$

Where, V_{pi} = Feature vector of image P, V_{qi} = Feature vector of image Q and n = size.

III. Block Truncation Coding

It was invented in 1979 and initially used for grayscale image. It is simple and efficient method. Many advanced CBIR techniques have been developed with Block Truncation Coding [6]. This method acquires the statistical properties of the image blocks; these properties describe the characteristics of an image and called as image features which are used for Content Based Image Retrieval [8]. Binary bit maps are used in this technique to generate two means per color component [for each red, green and blue component] which will form a feature vector based on contents of an image. In this more general approach R, G and B components are consider separately to calculate three mean thresholds as T_R , T_G , T_B and then apply BTC to each individual R, G and B planes as shown in equations 2, 3 and 4 for the image of size $m \times n$ [1], [6], [7], [9], [12], [13], [15], [17]-[19].

$$T_R = \frac{1}{m \times n} \sum_{i=1}^m \sum_{j=1}^n R(i, j) \quad (2)$$

$$T_G = \frac{1}{m \times n} \sum_{i=1}^m \sum_{j=1}^n G(i, j) \quad (3)$$

$$T_B = \frac{1}{m \times n} \sum_{i=1}^m \sum_{j=1}^n B(i, j) \quad (4)$$

In this technique three binary bitmaps will be computed as BM_r (red), BM_g (green) and BM_b (blue). 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. Same can be represented in mathematical form as shown in equations 5, 6 and 7 [1].

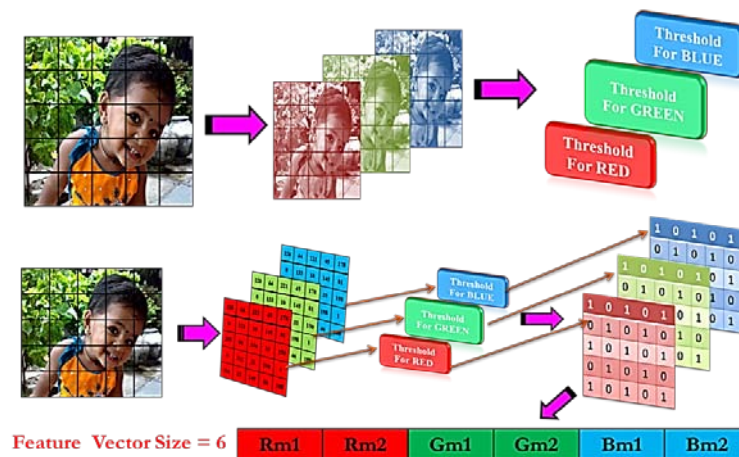
$$BM_r(i, j) = \begin{cases} 1, & \text{if } R(i, j) \geq T_R \\ 0, & \text{if } R(i, j) < T_R \end{cases} \quad (5)$$

$$BM_g(i, j) = \begin{cases} 1, & \text{if } G(i, j) \geq T_G \\ 0, & \text{if } G(i, j) < T_G \end{cases} \quad (6)$$

$$BM_b(i, j) = \begin{cases} 1, & \text{if } B(i, j) \geq T_B \\ 0, & \text{if } B(i, j) < T_B \end{cases} \quad (7)$$

Diagrammatically the BTC based feature vector extraction can be represented as shown in figure 1.

Figure 1 Block Truncation Coding.



Two mean colors one for the pixels greater than or equal to the threshold (Upper Mean UM= Rm1, Gm1, Bm1) and other for the pixel smaller than the threshold (Lower Mean LM= Rm2, Gm2, Bm2) are also calculated as shown in equations 8 and 9, in the same way upper and lower mean for green and blue components are calculated. These Upper Mean and Lower Mean together will form a feature vector or signature of size six for an image [1].

$$Rm1 = \frac{1}{\sum_{i=1}^m \sum_{j=1}^n BMr(i, j)} \sum_{i=1}^m \sum_{j=1}^n BMr(i, j) * R(i, j) \quad (8)$$

$$Rm2 = \frac{1}{m * n - \sum_{i=1}^m \sum_{j=1}^n BMr(i, j)} * \sum_{i=1}^m \sum_{j=1}^n \{1 - BMr(i, j)\} * R(i, j) \quad (9)$$

IV. Proposed CBIR method using Thepade's Ternary Block Truncation Coding

Earlier the bitmap concept proposed by Kekre, Thepade et.al [3], [5]. Here novel method is proposed by altering the degree values every time for computing higher and lower threshold values. The ternary bit maps of images are prepared based on the degree 'n' and accordingly the threshold are computed. Here for feature vector extraction the image is divided into three clusters based on the respective ternary map prepared.

A. Static Thepade's Ternary BTC (STTBTC) with degree 'n'

Assuming an Image of size m*n with three color planes as R, G and B the threshold values for each and gray scale component is computed by using equations 10, 11, 12 and 13.

$$TR = \frac{1}{m * n} \sum_{i=1}^m \sum_{j=1}^n R(i, j) \quad (10)$$

$$TG = \frac{1}{m * n} \sum_{i=1}^m \sum_{j=1}^n G(i, j) \quad (11)$$

$$TB = \frac{1}{m * n} \sum_{i=1}^m \sum_{j=1}^n B(i, j) \quad (12)$$

$$T = \frac{TR + TG + TB}{3} \quad (13)$$

In the proposed method of TTBTC with degree 'n' the computation of two threshold values per component [Upper and Lower] is given in equation 14, 15, 16, 17, 18 and 19.

$$Tshrl = TR - n |TR - T| \quad (14)$$

$$Tshrh = TR + n |TR - T| \quad (15)$$

$$Tshgl = TG - n |TG - T| \quad (16)$$

$$Tshgh = TG + n |TG - T| \quad (17)$$

$$Tshbl = TB - n |TB - T| \quad (18)$$

$$Tshbh = TB + n |TB - T| \quad (19)$$

Where n=1, 2, 3, 4 and 5.

Two mean threshold values for each red, green and blue component are produced as upper and lower thresholds. With the help of these newly color computed upper and lower threshold values ternary bit maps for each component are computed. If a pixel values of respective color component is greater than or equal to the respective higher threshold and less than or equal to the 255, the corresponding pixel position in the bit map gets a value 1; else if the pixel value is greater than the respective lower threshold and less than or equal to the respective higher threshold, the corresponding pixel position in the bit map gets a value 0; otherwise pixel position in the bit map

gets value -1. Mathematically it can be shown by equations 20, 21 and 22 respectively for Red, Green and Blue components.

$$TMr(i, j) = \begin{cases} 1, & \text{if } Tshrh < R(i, j) \leq 255 \\ 0, & \text{if } Tshrl < R(i, j) \leq Tshrh \\ -1, & \text{if } 0 \leq R(i, j) \leq Tshrl \end{cases} \quad (20)$$

$$TMg(i, j) = \begin{cases} 1, & \text{if } Tshgh < G(i, j) \leq 255 \\ 0, & \text{if } Tshgl < G(i, j) \leq Tshgh \\ -1, & \text{if } 0 \leq G(i, j) \leq Tshgl \end{cases} \quad (21)$$

$$Tmb(i, j) = \begin{cases} 1, & \text{if } Tshbh < B(i, j) \leq 255 \\ 0, & \text{if } Tshbl < B(i, j) \leq Tshbh \\ -1, & \text{if } 0 \leq B(i, j) \leq Tshbl \end{cases} \quad (22)$$

Three means per color components [lower, medium and higher] are produced as given in equations 23, 24 and 25.

$$LR = \frac{1}{\sum_{i=1}^m \sum_{j=1}^n \mathbf{1}, \text{ iff } TMr(i, j) = -1} \sum_{i=1}^m \sum_{j=1}^n R(i, j), \text{ iff } TMr(i, j) = -1. \quad (23)$$

$$MR = \frac{1}{\sum_{i=1}^m \sum_{j=1}^n \mathbf{1}, \text{ iff } TMr(i, j) = 0} \sum_{i=1}^m \sum_{j=1}^n R(i, j), \text{ iff } TMr(i, j) = 0 \quad (24)$$

$$HR = \frac{1}{\sum_{i=1}^m \sum_{j=1}^n \mathbf{1}, \text{ iff } TMr(i, j) = 1} \sum_{i=1}^m \sum_{j=1}^n R(i, j), \text{ iff } TMr(i, j) = 1 \quad (25)$$

Similarly the lower, medium and higher means for green and blue components can be computed as [LG, MG, HG] and [LB, MB and GB]. Finally a feature vector will have nine values as [LR, MR, HR, LG, MG, HG, LB, MB, HB]. Here the degree 'n' is considered to be 1, 2, 3, 4 and 5 to extract the color contents of the image.

B. Dynamic Thepade's Ternary BTC (DTTBTC)

In static Thepade's Ternary BTC, degree values are varies from n=1 to 5. These are predefined constant values, which are used every time for calculating two threshold mean values [upper and lower] for each Red, Green and Blue components.

Here in this newly proposed method, degree value is computed dynamically. Initially absolute ratio of each color components threshold mean value and gray scale threshold mean value is computed and the biggest among all the three threshold mean values is selected as a degree value for the computation of upper threshold and lower threshold of each Red, Green and Blue components. Mathematically it can be represented as shown in equation 26.

$$n = \begin{cases} \left\lfloor \frac{|Tr|}{T} \right\rfloor, & \text{iff } |Tg| < |Tr| > |Tb|. \\ \left\lfloor \frac{|Tg|}{T} \right\rfloor, & \text{iff } |Tr| < |Tg| > |Tb|. \\ \left\lfloor \frac{|Tb|}{T} \right\rfloor, & \text{iff } |Tr| < |Tb| > |TG|. \end{cases} \quad (26)$$

This dynamically computed 'n' is used to compute two threshold values per color component [upper and lower mean] as shown in equation 14, 15, 16, 17, 18 and 19. By using upper and lower mean values of each Red, Green and Blue color components ternary bit maps of respective color components are prepared by using equations 20, 21 and 22. Three means for each Red, Green and Blue component [lower, medium and higher] are computed as shown in equation 23, 24 and 25.

V. Experimentation

The experimentation of said CBIR technique is done in MATLAB 2012 and computer having Intel core i5 (2.30 GHz) processor, 4GB of RAM and 1GB of NVidia GEOFORCE graphics card.

VI. The Image Database

Image database used is P.S. Wang's image database with 1000 images in 10 various categories [100 images per categories]. Different categories are as Tribe Peoples, Beach, Monuments, Buses, Dinosaurs, Elephant, Rose, Horses, Mountains and Food Dish. Figure 2 shows some of the sample images from image database used [21].

Figure 2 Sample Images from Database.



VII. Performance Comparison Criteria

Precision and recall are widely used parameters in evaluating the correctness of CBIR systems. Cross over point value of average precision and average recall gives effectiveness of system. Precision is a measure of accuracy whereas recall is a measure of completeness. Precision basically is a measure of the number of retrieved images that are relevant to the search. Same can be shown by using following equation 27 [1]-[4], [7], [9]-[11], [13], [14]-[19].

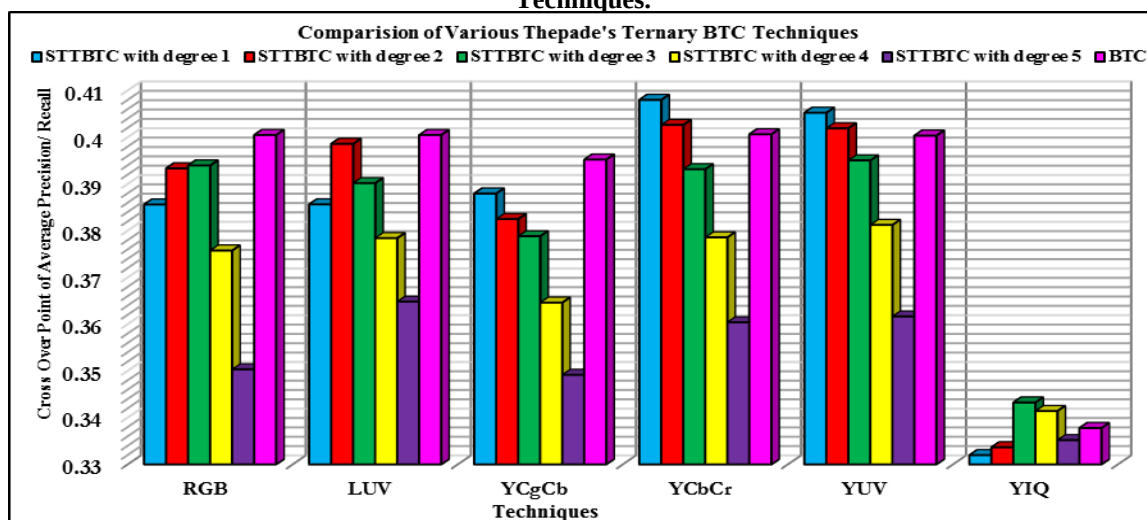
$$Precision = \frac{\text{No. of relevant images retrieved.}}{\text{Total No. of images retrieved}} \quad (27)$$

Recall as mentioned earlier is a measure of completeness. Basically it is the probability of a relevant images being returned by the query. In binary classification recall can also be called as sensitivity. The mathematical computation of recall can be understood by following equation 28 [1]-[4], [7], [9]-[11], [13], [14]-[19].

$$Recall = \frac{\text{No. of relevant images retrieved}}{\text{Total No. of relevant images in the Database}} \quad (28)$$

VIII. Result and discussions

Figure 3 Performance Comparison of the degrees considered in STTBTC based CBIR for respective Techniques.



To check performance of a proposed method each image of the 1000 images in the test-bed is fired as a query image on the image database. Mean square error is used for similarity measurements. The feature vector of each query image is compared with every database image using MSE. Average precision and Average recall values are computed and plotted for the proposed method. Intersection of average precision and recall values gives crossover point, which indicate performance of a proposed CBIR methods [1], [2], [5].

Figure 3 shows crossover point values of average precision and recall for BTC and Static Thepade's Ternary BTC with degree values 1, 2, 3, 4 and 5. As cross over point value increases performance also get increased. Static Thepade's Ternary BTC with degree value 1 by using YCbCr Color space gives best performance followed by YUV Color space with degree value 1 and YCbCr with degree value 2.

Figure 4 Performance Comparison of the degrees considered in STTBTC based CBIR for respective color spaces

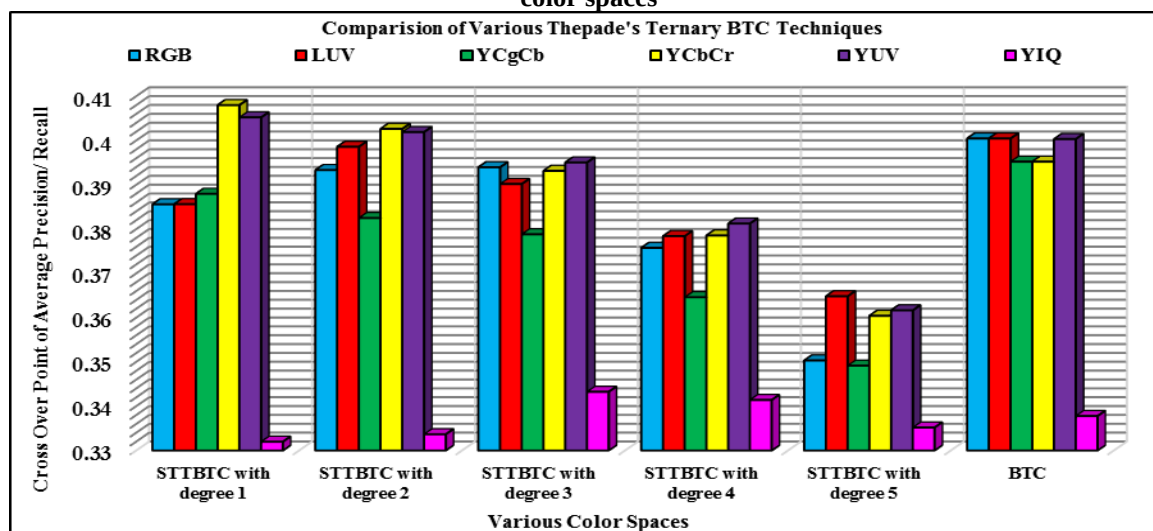
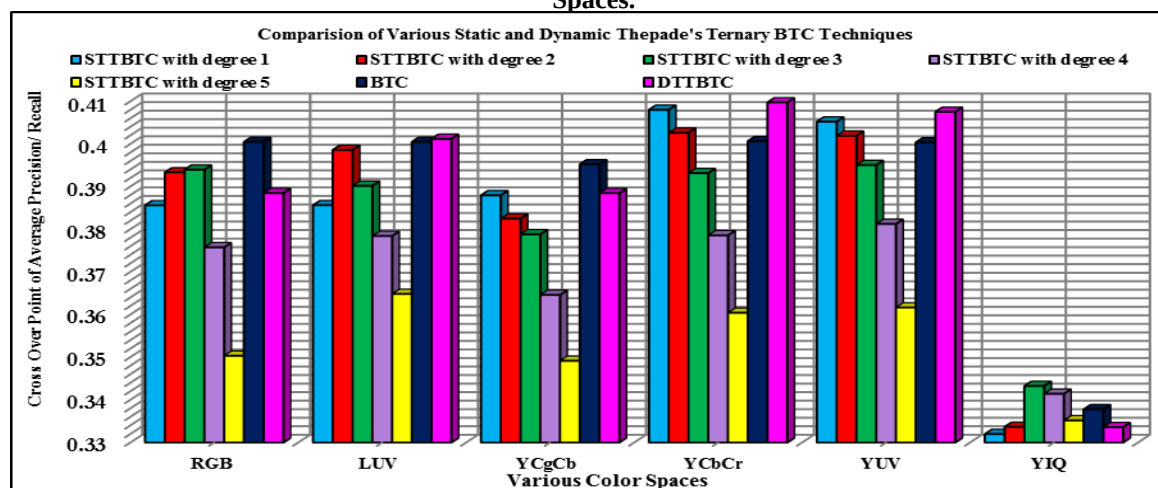


Figure 4 shows crossover point values of average precision and recall for BTC, STTBTC with degree 1, STTBTC with degree 2, STTBTC with degree 3, STTBTC with degree 4 and STTBTC with degree 5. As shown in experimental results STTBTC with degree 1 in YCbCr color space gives best performance followed by YUV with Degree 1 and STTBTC with degree value 2 in YCbCr color space.

Figure 5 shows crossover point values of average precision and recall for BTC, DTTBTC and STTBTC with degree values varies from 1 to 5. As shown in experimental results DTTBTC in YCbCr color space gives best performance followed by STTBTC with degree 1 in YCbCr and DTTBTC with YUV color space.

Figure 5 Performance Comparison of STTBTC and DTTBTC with various Color Spaces.



IX. Conclusion

Content extraction from image plays significant role in content based image retrieval. Block truncation coding is one of the widely used simple technique for color feature extraction and many variations of block truncation coding are applied till date. Here Static Thepade's Ternary Block Truncation Coding with change in degree values and Dynamic Thepade's Ternary Block Truncation Coding are used for color feature extraction. Overall

36 variations of image retrieval methods are proposed with the help of six color spaces (RGB, LUV, YCbCr, YCbCr, YUV and YIQ), five Static Thepade's block truncation coding techniques (with degree values 1, 2, 3, 4 and 5) and Dynamic Thepade's Block Truncation Coding. As shown by experimental results the YCbCr color space gives better performance in Dynamic Thepade's Ternary Block Truncation Coding based image retrieval method.

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