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Image Classification using Block Truncation Coding with Assorted Color Spaces

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ABSTRACT
The paper portrays comprehensive performance comparison of image classification techniques using block truncation coding (BTC) with assorted color spaces. Overall six color spaces have been explored which includes RGB color space for applying BTC to figure out the feature vector in Content Based Image Classification (CBIC) techniques. A generic database with 900 images having 100 images per category spread across 9 different categories have been considered to conduct the experimentation with the proposed Image Classification technique. On the whole nine hundred queries have been fired. The average success rate of class determination for each of the color spaces has been computed and considered for performance analysis. The results explicitly reveal performance improvement (higher average success rate values) with proposed color-BTC methods with luminance chromaticity color spaces compared to RGB color space. Best result is shown by YUV color space based BTC in content based image classification.

Keywords
CBIC, BTC, Color Space, RGB, Kekre's LUV, YCbCr, YUV, YIQ, Kekre's YCgCb

1. INTRODUCTION
In earlier times the number of images used to be in thousands from which the query image were searched. Enormous growth in the number of images has been noticed due to the use of digital cameras, internet etc. Retrieval of images from such a vast database has become very much cumbersome. In this situation it is essential to classify images into semantic categories and objects (e.g. mountains, animals, humans, airplanes) in order to manage and organize the collection of images in a database**[1]**. Image classification techniques can be used to classify the total number of image content in a database into limited number of major classes **[2]**. Image classification and categorization is essential to speed up the image retrieval process.

2. RELATED WORK
Image classification process requires interaction with the image data in terms of features which strongly relates to the inherent properties of the image itself. The term 'feature' in this perspective may be considered as color, shape, texture of an image. Averaging and Histogram techniques are used to realize the color facet of an image **[3,4,5]**. Texture can be obtained by using transforms **[6,7]** or vector quantization **[8,9]**. Shape aspects are achieved with gradient operator or morphological operator**[10]**. Earlier approaches have studied K-means clustering using Block Truncation Coding (BTC) and color moments to classify images into various categories **[11]**. Only RGB color space has been considered in previous works and performance comparison of classification with various color spaces is not performed.

2.1 Block Truncation Coding (BTC)
Block Truncation Coding is an efficient image coding algorithm. It was developed in 1979, during the initial years of image processing [12]. The algorithm involves an image to be segmented primarily into n×n (typically,4×4) non –over lapping image blocks [13,14]. Coding of the small image blocks are done one at a time. RGB space is the most favorable color space for most color images to get recorded and possibly considered as the most familiar color space. As it has been portrayed previously, image is divided into small blocks by BTC and coding is done one at a time. A single binary bitmap of the same size as the block is formed for single bitmap BTC of color image and two colors are computed to approximate the pixels within the block. An Inter Band Average Image (IBAI) is first created to form a binary bitmap in the RGB space and the threshold value is found to be a single scalar value. The pixels in the IBAI

are compared with the threshold value to create the bitmap [15].

2.2 Color Spaces

Color perception is defined as a brain process that initiates in the cone receptors of eyes. Red, green and blue phosphor emission is used by a computer to describe a color. A technique to identify, generate and visualize color is known as color space. Three co ordinates or parameters are generally required to specify a color. The position of the color within the color space used is described by the parameters.

Six different color spaces are considered in this work. The color spaces are RGB, LUV, YCbCr, YUV, YIQ and YCgCb. A short description of the color spaces and the inter conversion formula used to derive them is described in sections 2.2.1 to 2.2.6

2.2.1 RGB Color Space

The RGB color space comprises of the base colors viz., red, green and blue. If none of the base colors are used, the resultant color is black. Mixing all the base colors with full intensities confers to white color. Any desired color can be created if the base colors can be mixed in different intensities.

2.2.2 Kekre's LUV Color Space

A special case of Kekre Transform results in Kekre's LUV color Space. L stands for luminance whereas U and V represent chromaticity values of color image. If the value of U is positive it designates prominence of red component in color image and if the value of V is negative it points to prominence of green component. A conversion from RGB to LUV can be done using equation1 **[3,12,16,17]**.

$$\begin{bmatrix} L \\ U \\ V \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ -2 & 1 & 1 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (1)$$

2.2.3 YCbCr Color Space

In this color space Y signifies luminance and Cb and Cr signifiy the chromaticity values of a color image. YCbCr values are obtained by converting the RGB components with the equation 2**[3,15]**.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.2989 & 0.5866 & 0.1145 \\ -0.1688 & -0.3312 & 0.5000 \\ 0.5000 & -0.4184 & -0.0816 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (2)$$

2.2.4 YUV Color Space

One luminance (brightness) and two chrominance (color) components are defined in YUV color space. Composite Color video standards like PAL, NTSC, and SECAM use the YUV color model **[18]**. The equation of RGB to YUV Color Space conversion is given as equation 3.

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ -0.14713 & -0.22472 & 0.436 \\ 0.615 & -0.51498 & 0.10001 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (3)$$

2.2.5 YIQ Color Space

NTSC composite color video standard use this color space electively. I represents phase and Q stands for quadrature. Quadrature is the modulation method used for transmission of the color information **[19,20]**. Equation 4 gives the necessary conversion.

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ 0.595716 & -0.274453 & -0.321263 \\ 0.211456 & -0.522591 & 0.31135 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (4)$$

2.2.6 Kekre's YCgCb Color Space

In this color space Y signifies luminance and Cg and Cb denotes chromaticity values **[19,21]**. The equation for conversion is given in equation 5.

$$\begin{bmatrix} Y \\ Cg \\ Cb \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (5)$$

3 Proposed Technique

The proposed technique of classification involves the use of R, G and B as three independent components of color images and then three different threshold values are calculated for each of them. Let us consider the thresh holds as TavR, TavG and TavB respectively. The equations for the computations of threshold values are given in equation 6,7 and 8.

$$TavR = (1/m*n)*\sum_{i=1}^{m}\sum_{j=1}^{n} R(i,j) \quad (6)$$

$$TavG = (1/m*n)*\sum_{i=1}^{m}\sum_{j=1}^{n} G(i,j) \quad (7)$$

$$TavB = (1/m*n)*\sum_{i=1}^{m}\sum_{j=1}^{n} B(i,j) \quad (8)$$

Three binary bitmaps viz., BBr, BBg, BBb are calculated in equation 9,10and11. The pixel values which are higher than or equals to the threshold value in each color component (R, G and B) posses the value 1 and the pixel values that are lower than the corresponding threshold value are assigned with 0 **[18]**.

$$BBr(i,j) = \begin{cases} 1, if \; ....R(i,j) >= TavR \\ 0, ...if \; ...R(i,j) < TavR \end{cases} \quad (9)$$

$$BBg(i,j) = \begin{cases} 1, if \; ....R(i,j) >= TavG \\ 0, ...if \; ...R(i,j) < TavG \end{cases} \quad (10)$$

$$BBb(i,j) = \begin{cases} 1, if \; ....R(i,j) >= TavB \\ 0, ...if \; ...R(i,j) < TavB \end{cases} \quad (11)$$

After calculating these values two mean colors are derived. The upper mean color is for the pixels having values higher than or equal to the corresponding threshold and the lower mean color is for the pixels having values lower than the corresponding threshold value are derived with equation 12,13,14.

$$Rupmean = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BBr(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n} BBr(i,j)*R(i,j) \quad (12)$$

$$Gupmean = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BBg(i,j)} * \sum_{i=1}^{m}\sum_{j=1}^{n} BBg(i,j)*G(i,j) \quad (13)$$

$$Bupmean = \left(\frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BBb(i,j)}\right) * \sum_{i=1}^{m}\sum_{j=1}^{n} BBb(i,j)*B(i,j) \quad (14)$$

The lower mean color is derived with equations 15 , 16 and 17 .

$$Rlomean = \frac{1}{m*n - \sum_{i=1}^{m}\sum_{j=1}^{n} BBr(i,j)} * \sum_{i=1}^{n}\sum_{j=1}^{m} (1 - BBr(i,j))*R(i,j) \quad (15)$$

$$Glomean = \frac{1}{m*n - \sum_{i=1}^{m}\sum_{j=1}^{n} BBg(i,j)} * \sum_{i=1}^{n}\sum_{j=1}^{m} (1 - BBg(i,j))*G(i,j) \quad (16)$$

$$Blomean = \frac{1}{m*n - \sum_{i=1}^{m}\sum_{j=1}^{n} BBb(i,j)} * \sum_{i=1}^{n}\sum_{j=1}^{m} (1 - BBb(i,j))*B(i,j) \quad (17)$$

These two mean colors form a feature vector or signature of the image. The process is repeated for all the images in the database for all the color spaces used to figure out a feature vector for each of them in each color space. The other color components considered in the approach is being derived by converting RGB to color components of considered color spaces.

4 RESULTS AND DISCUSSION

4.1 Implementation

The proposed techniques for image classification are tested on an image database consisting of 900 images. Some categories of images are directly taken from Wang’s database **[22]**. In all six color spaces result into six variations of proposed image classification techniques. The experimentation is done in Matlab 7.11.0(R2010b) on Intel core 2 duo processor with 1 GB RAM. Overall 900 queries are fired to find the classification success rate. The average classification success rate of all these queries is used for performance comparison of proposed image classification techniques.

4.2 Database

A database of nine hundred images is used here. Each category consists of hundred images. The nine different categories used are Ganeshji, Sea Beaches, Sunflower, Candles, Dinosaurs, Elephants, Roses, Horses and Mountains.

Fig.1Sample Image Database

A sample of the image database with different categories used in this approach is given in Fig.1.

4.3 Performance Measure

The effectiveness of the technique is measured by the success rate. The success rate is given by equation 18.

$$SuRate = \frac{\text{No. of queries classified}}{\text{Total no. of queries considered for classification}} \quad (18)$$

Table 1 shows image category wise percentage (%) success rate for Image classification. Here average success rate values show the better performance in luminance-chromaticity color spaces (LUV, YCbCr, YUV, YIQ, YCgCb) than RGB color space. Fig.2 shows the percentage success rate for proposed Image Classification methods with respective color spaces given in graphical format.

The results clearly shows that YUV color space is having the maximum success rate compared in classification and categorization of images. LUV and YCbCr are having almost equal level of success rate. Worst performance has been shown by RGB color space.

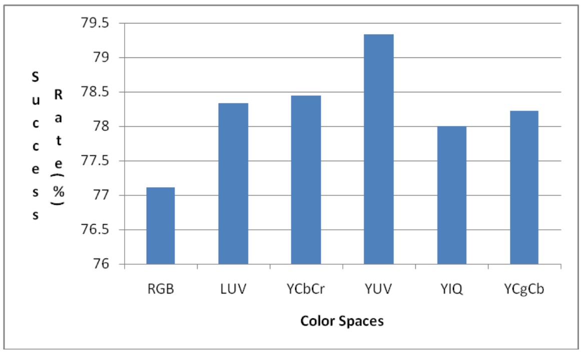

Fig.2
Color Space wise average success rate of image classification using BTC

Table 1
Percentage Success Rate for proposed image classification technique

Categories	**RGB**	**LUV**	**YCbCr**	**YUV**	**YIQ**	**YCgCb**
1(Ganeshji)	82	83	89	86	89	99
2 (Sea Beach)	61	66	65	66	61	61
3 (Sunflower)	94	99	98	98	98	99
4 (Candle)	69	82	90	82	88	82
5 (Dinosaur us)	100	100	100	100	100	100
6 (Elephant)	75	68	68	72	70	73
7 (Roses)	67	60	54	67	50	54
8 (Horses)	88	90	89	90	89	87
9 (Mountains)	58	57	53	53	57	49
Average	77.11	78.33	78.44	79.33	78.00	78.22

5. CONCLUSION

Image classification demands increasing imporatance due to its applications in almost all significant fields like pattern recognition, content based image retrieval,security, media and journalism etc. Excessive amount of irrelevant record in a database leads to complicated and time consuming search of image data in it. On the contratry, when a query is fired to the database with classification the searching remains restricted to the specialized class only to which the image belongs. Image classification using BTC is extended to other color spaces. The proposed techniques are tested on image database of 900 images. It has been conferred from the results that the luminance chromaticity color spaces performs better in terms of classification. The YUV color space gives the best performance followed by YCbCr color space among all the other color spaces used in the approach.

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