Hmmd - Hmmd explanation

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Image retrieval based on chrominance feature of the HMMD color space

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***Abstract*— This paper proposes a new chrominance feature extraction method in HMMD color space. Image dependent multi-level thresholding is performed in the HMMD color space to obtain the 64-level quantized images. The occurrence count of each color pixel represents the color information of those quantized images. This technique is tested over Wang's database of 10 different category images. The distance measure of this feature between the query and database image are calculated. Then, the proposed method performance is evaluated using average precision and recall. Moreover, the proposed method is a benchmark against the state - of - the - art color feature extraction methods and gives approximately 6.3% to 18.05% and 7.54% to 14.52 % high precision and recall than the conventional techniques.**

Keywords*— Distance measure, HMMD color space, Precision, Quantization, Recall.

I. INTRODUCTION

Content based image retrieval (CBIR) system plays a vital role in the fields like crime prevention, medical imaging, data mining, defense, agriculture and online image searching and browsing etc. [1]. Content of an image is expressed in four extraordinary types corresponding to color, texture, structure and spatial design and they hold unique information about the image [2]. Similar to these four features, color space also plays an equal important role in CBIR. Color space is responsible for image representation in different form i.e. RGB, HSV, YCbCr and Lab, etc. RGB is the source of the other color spaces. However, it is not well suited for processing the real word images [3]. Thus color space conversion is widely used in image retrieval applications. Hence, accuracy of the image retrieval system is depending on feature extraction from the suitable color space [4]. This paper uses the HMMD color space which is more appropriate for image retrieval task [5]. Color is an expressive feature representation of the image which gives great visual treat to human perception than other features used in CBIR system. The traditional color relied CBIR techniques uses the color histogram (CH) to define color characteristic [6]. This feature is invariant to rotation and image size [6, 7] and it can be extracted in two ways (global and local) [8]. If the two different images having same pixel distribution, CH is lacking in differentiating unique features of these two images because it considers only the count of the color pixels [9]. Spatial location [10] of the pixel is also taken in to account for feature extraction. However, this feature is also having high time complexity and feature vector space. Quantized color image is used to represent the color feature of the image in length as same as the quantization level. Most of the quantization method follows the traditional uniform quantization to the entire color channel directly [11-13]. This degrades the color information available in the image [14]. This paper introduces the image dependent adaptive multi-thresholding and quantization process in the HMMD color space to improve the performance of the chrominance details based CBIR system.

This paper is organized in the following way: Section I gives the brief introduction about the CBIR system. Chrominance feature extraction methods are explained in section II. The proposed quantization method is described in section III. Section IV gives the experimental outcome of the proposed work. Conclusion of this work is given in section V.

II. RELATED WORK

Color descriptors, quantization techniques and color space used in image retrieval applications are described below. HMMD color space [5] consists of four color components named as H-hue, M-maximum, M-minimum and D-difference. HMMD color space components are derived from the RGB values this, conversion [5] is shown in (1) - (5).

$$Maximum = \max(R, G, B) \tag{1}$$

$$Minimum = \min(R, G, B) \tag{2}$$

$$Difference = Maximum - Minimum \tag{3}$$

$$\text{Average} = (\text{Maximum} + \text{Minimum})/2 \tag{4}$$

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$$
\begin{aligned}
&if\,(Maximum == R\,\&\&\,G > B)\\
&Hue = 60*(G-B)/(Maximum-Minimum)\\
&elseif(Maximum == R\,\&\&\,G < B)\\
&Hue = 360+60*(G-B)/(Maximum-Mininum)\\
&elseif(G == Maximum)\\
&Hue = 60*(2.0+(B-R)/(Maximum-Minimum))\\
&else\\
&Hue = 60*(4.0+(R-G)/(Maximum-Minimum))
\end{aligned}
\tag{5}
$$

where, R- red, G-green and B-blue channel of the RGB color space image. Hue holds the pure color information whereas, whiteness, blackness, Chroma and intensity information are defined in maximum, minimum, difference and Average components respectively. It supports all applications of the MPEG-7 standard.

Color structure descriptor (CSD) [15] uses the table 1 information is to quantize the image [5]. Hue component takes the value from 0 to 1 whereas difference and average components values are vary from 0 to 255. Difference channel is split into 5 subspaces according to this subspace hue and average components are quantized into different levels. Then the structuring element (SE) was applied over the image in the overlapping manner. It represents the color feature in form of increasing the count value of the each color bin by 1 if it is present in the any one of the location within the SE. It is different from the traditional histogram methods in the way of not considering the occurrence frequency of the particular pixel value. The time complexity of this technique is high.

TABLE I. HMMD COLOR SPACE QUANTIZATION

Difference subspace	Quantization levels							
	184		120		64		32	
	H	A	H	A	H	A	H	A
0 [0-6)	1	8	1	8	1	8	1	8
1[6-20)	8	4	4	4	4	4	4	2
2[20-60)	12	4	12	4	6	4	3	4
3[60-110)	12	4	12	4	4	4	2	2
4[110-255]	24	2						

In Color layout descriptor (CLD) [16], DCT compression was applied over the mean values of the 64 sub-blocks. This sub-block formation is performed on individual channels of the YCbCr color space. Then zig-zag scanning based quantization is applied on 64-DCT coefficients. Low-level information of the DCT coefficients is taken for the distance measure calculation.

Yue et al. [12] have suggested the local and global color histogram method for extracting the color details from HSV color space image. Here, each color channel was uniformly quantized according to the level of quantization used in that particular channel. Singha et al. [13] have used the 512 bin quantized histogram on HSV color space to represent the color information of an image. 8-levels of uniform quantization are performed on the individual color component. Color moments based image retrieval is introduced by Shih and Chen [17]. Color coherence vector (CCV) [18] is used to classify the pixel into number of groups by seeing the connection between color pixels. Threshold of the coherence vector plays a major role in pixel classification. Spatial arrangement of the color pixel and its value are effectively combined to form the color correlogram feature vector [19]. Distance information of this method slows the feature extraction and retrieval time. K-Means clustering based color descriptor is also having high time complexity to converge in the fixed mean value [20].

III. PROPOSED WORK

A. Color space conversion

The proposed work uses HMMD color space for chrominance feature extraction process. Initial step of the proposed work is color space conversion. The RGB to HMMD conversion [5] is obtained by using (1) - (5). Subsequently, Chroma, intensity and hue details are separated for further processing. Figure 1 shows the color feature extraction process of the proposed work.

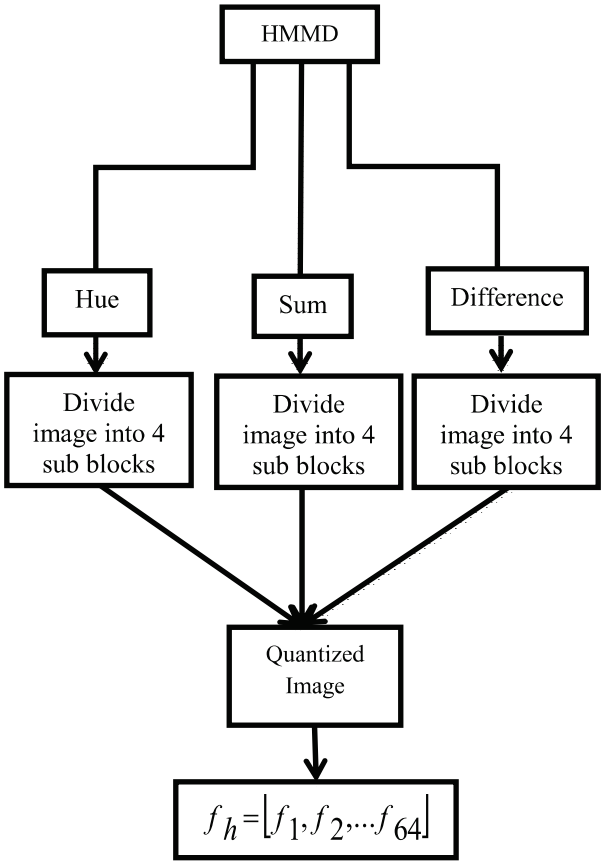

Fig 1 Proposed color feature extraction method

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B. *Threshold generation*

Separated channels are divided into 4 equal size blocks and adaptive multi-thresholding process is applied over this 4 blocks. In multi-thresholding, threshold values are derived from the pixel information present in the sub blocks. In the proposed work, three threshold values are used to group the pixels under 4 different labels (i.e. 1, 2, 3 and 4). Threshold value of the each block is not fixed because it will change according to the minimum and maximum pixel values present in that block which is contrast to quantization used in [11-13]. Threshold values of each block are generated from (6) - (10).

$$Minimum = \min(subblock) \tag{6}$$

$$Maximum = \max(subblock) \tag{7}$$

$$Threshold\,1 = (Maximum + Minimum)/3 \tag{8}$$

$$Threshold\,2 = 2 \times Threshold\,1 \tag{9}$$

$$Threshold\,3 = Threshold\,1 + Threshold\,2 \tag{10}$$

C. *Image quantization*

Then, these threshold sub blocks of the each color channel are combined to form a new image with original size. Therefore, these 4 labels of the each channel are aggregated to form the quantized image with 64 colors. Finally, count of the each color pixel in that image is used to represent the chrominance information of the image. Here, the length of the feature vector is 64.

D. *Distance measure*

Color feature distance information between the test and database image is important the factor in the sense giving similar images on the top of the retrieval result. The proposed work uses the L_2 distance metric [21] defined in (11) to compute the likeness between the two images.

$$L_2(Q, D) = \sqrt{\Sigma_{i=1}^{64} \left| f_Q - f_D \right|^2} \tag{11}$$

where, i gives the feature vector length, f_Q and f_D denotes the feature of the query and database image.

E. *Performance evaluation*

The efficiency of the proposed work is estimated by the two important evaluation methods named as precision and recall [22] which are defined in (12) and (13). They are inversely proportional to each other.

$$Precision = \frac{Total\ number\ of\ relevant\ images}{Total\ number\ of\ images\ retrieved} \tag{12}$$

$$\text{Re}call = \frac{Total\ number\ of\ relevant\ images}{Total\ number\ of\ relavant\ images\ in\ the\ database} \tag{13}$$

IV. Experimental Results

The performance of the proposed work is evaluated on Wang's database [23]. It contains 10 different category images. Each category has 100 images with size 256×384 or 384×256, example image from each category is depicted in fig.2. Name and label of the each category images in the database is given as African tribes-1, Food-2, Sea-3, Buildings-3, Bus-4, Dinosaurs-5, Elephants-6, Flowers-7, Horse-8, Mountains-9 and Food-10. The proposed method is executed in MATLAB R2009a environment with dual core processor and 64 bit windows operating system.

Fig 2 sample images from Wang's database

To evaluate the proposed work, every single image in the database is taken for testing. Moreover, the performance is compared with the conventional color extraction techniques such as color moments [17], color structure descriptor [15] and color layout descriptor [16]. Table 2 gives the mean precision and recall measures of the proposed method and the state-of-the-art color extraction techniques used in image retrieval task. Here, average precision and recall is estimated from the top 10 and 100 retrieved images respectively. Figure 3 shows the top 20 retrieved images of the proposed technique and the state -of- the- art techniques.

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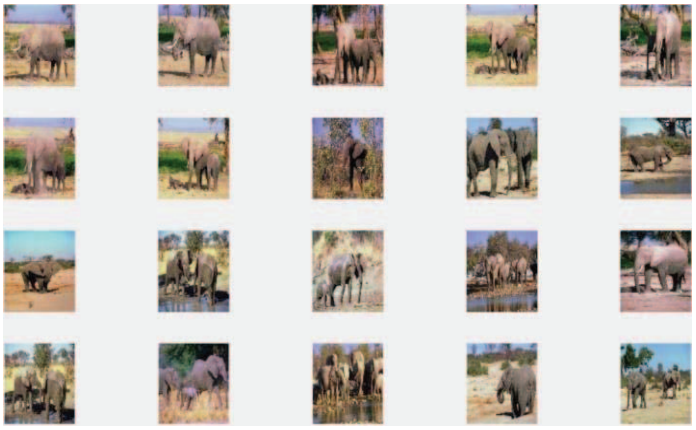
TABLE II. AVERAGE PRECISION AND RECALL OF THE COLOR DESCRIPTORS

Category Name	Color Moment [17]		CLD [15]		CSD [16]		Proposed Method	
	P	R	P	R	P	R	P	R
African Tribes	38.9	26	21.3	14.49	56.2	34.71	**76**	**49**
Sea	29.5	16.95	**52.9**	**28.26**	28.8	15.34	37	20
Buildings	38.2	21.13	34.1	15.73	**55.3**	**34.11**	50	25
Bus	58	31.92	25.5	11.25	44.7	25.8	**71**	**47**
Dinosaurs	93.8	78.54	90.7	51.03	79.4	61.43	**100**	**81**
Elephants	49.1	**30.21**	47.7	23.51	63	26.07	**70**	29
Flowers	67.9	36.03	70	28.81	53.7	25.33	**81**	**41**
Horse	74.7	40.13	**98**	70.29	64.1	33.8	95	**72**
Mountains	26	15.72	56.6	**35.73**	**61.3**	29.4	45	26
Food	46.3	27.67	12.7	5.67	32	13.85	**67**	**35**
Average Precision and Recall	52.24	32.43	50.95	28.477	62.7	35.46	**69**	**43**

Note: P-Precision, R-Recall

Feature vector length of the color moments, CLD, CSD and proposed method is 9, 192, 64 and 64 respectively. African tribes images are more accurately retrieved using the proposed method which gives 19.8% and 14.29% high precision and recall than the CSD [15]. CLD [16] retrieves the sea category images well compare to other techniques. Precision and recall of the building category images are high in CSD [15] which is 5.3% and 9.11% higher than the proposed method. Dinosaurs, elephants and flowers category images are highly retrieved in the proposed method but the recall of the elephant class images 1.21% high in color moment based retrieval. In [16], CLD 98% horse images are similar in the top10 retrieval results even though recall of this method is l.71% lesser than the proposed work. Similarly, CSD method gives approximately 61.3% similar images for the mountains images and the highest recall of this category is obtained using CLD technique. Meanwhile, food category images are correctly retrieved in the proposed method. Therefore, the proposed work gives approximately 6.3% to18.05% and 7.54% to 14.52% high precision and recall compare to the other color extraction methods.



(a)

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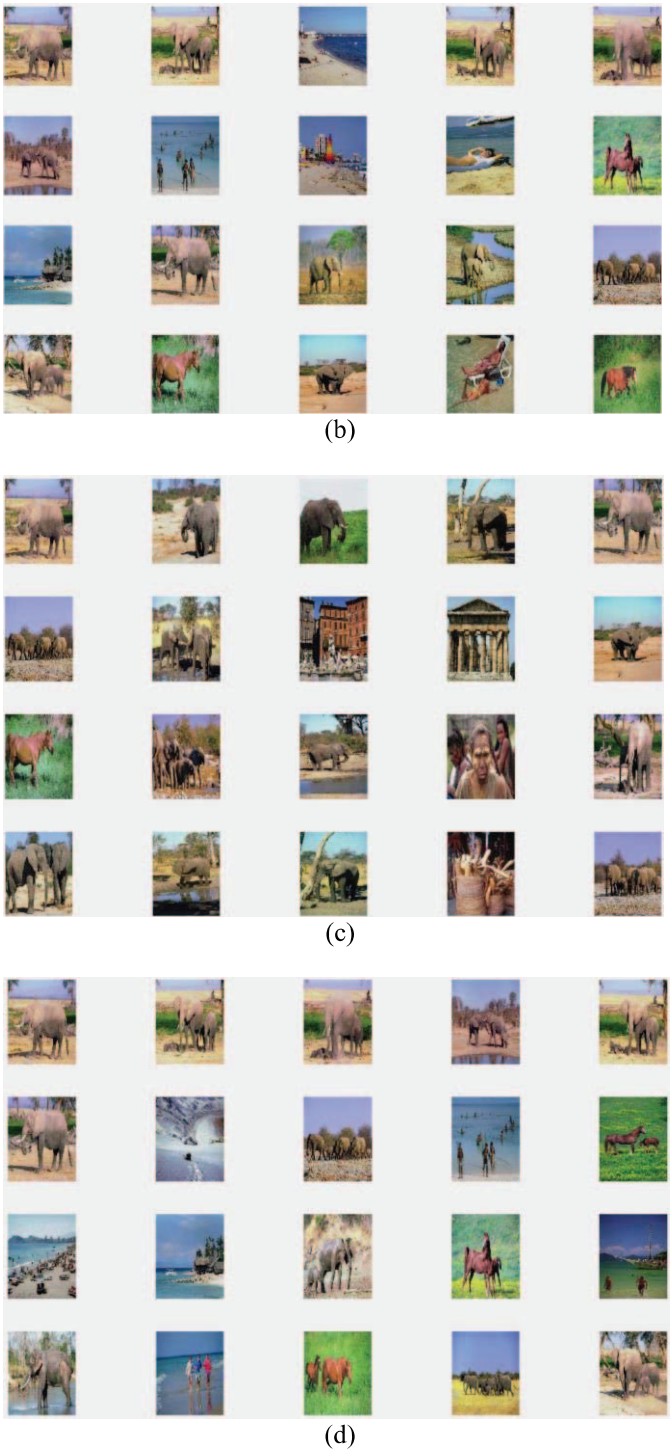

(b) (c) (d)

Fig 3 Retrieval results (a) Proposed color feature extraction method (b) color moments (c) CLD (d) CSD for the elephant query image

V. Conclusion

The new color descriptor based on image dependent multi-threshold and quantization was proposed on the HMMD color space. Each color pixel distribution count is used to give the color feature information of the image. Color feature distance between the query and database image is calculated using L_2 distance measure. Moreover, the proposed method is obtained approximately average precision 6.3% to 18.05% and recall 7.54% to 14.52% higher than color moments, color layout descriptors and color structure descriptors based image retrieval in HMMD color space.

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