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Performances of Different Color Representations in Image Retrieval and Classification: A Comparative Analysis

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ABSTRACT

Content Based Image Retrieval is one of the most popular field for research and implementation due to enormous changes happening in multimedia based applications. In CBIR images are retrieved based on the visual feature similarity. Color, texture and shape are the most commonly considered low level features. Among them color is said to be the more dominant feature in describing the visual information of the image. These features were extracted by representing an image in different color spaces such as RGB, HSV, YCbCr Lab and xyz etc. Color information extracted from these planes varies from one another. In this paper we presented Content Based Image Retrieval (CBIR) system based on the color features computed by Cumulative Color Histograms (CCH) from different color spaces including RGB, HSV, YCbCr, CIE-LAB and CIE-XYZ independently and also by fusing the features of all color spaces. Two standard distance measures Euclidean and City block are used as feature similarity measures. The proposed method performance is analyzed by comparing the precision, Mean Average Precision (MAP) and recall for individual color spaces and their fusion. It is clearly observed that fusion of color features worked very well rather individual color space features and among individual color spaces HSV almost equally performed well when compared with the fusion of all features for most of the queries. We used COREL database with 1000 images in ten different categories for experimental evaluation.

Keywords: Color spaces, Cumulative Color Histogram (CCH), Euclidean distance, City block distance, feature fusion.

INTRODUCTION

Content Based Image Retrieval CBIR has gained lot of importance over past few decades due to its unique advantages over text based retrieval tasks. A text based retrieval systems require manual annotations which has become an impossible thing as multimedia data is increasing enormously. CBIR has become a good option to retrieve similar images from huge image repositories which is based on the image content similarity. Content of image categorized in three levels as low level visual features such as color, texture and shape, mid level features as morphological features and high level semantic features by including prior knowledge into the retrieval process. Gupta et al [1], Hsu et al [2] proposed knowledge based image retrieval. Color features are the most powerful features to represent image content and has given at most importance in content based image retrieval. Low-level visual features such as color, texture, shape and spatial relationships are directly related to perceptual aspects of image content. QBIC Query by Image Content is one of the most popular CBIR system that allows queries based on example images, sketches and patterns developed by Flickner et al [3]. Color features of an image are the intensity values of a pixel obtained in any color plane representation of a image using non-luminance color spaces such as RGB, HSV, HSI, rgb and XYZ and luminance-chrominance color spaces of YCbCr, LUV, YUV, YIQ, YCgCb and Lab*planes. According to Muller et al [4], HSV or CIE Lab and LUV spaces represent color in much better way with respect to human perception. CIE - LAB and CIE - XYZ are device independent color spaces.

In image processing, a color histogram is a representation of distribution of colors in an image. For digital images it is basically number of pixels that have colors in each of a fixed list of color ranges that span the image's color space. Color histograms are typical features used for classifying different ground regions from aerial or satellite photographs. In case of multispectral images, histograms may be four dimensional. Color histograms can be used in object recognition and image retrieval systems. Smith et al [26]. discussed the advantages and drawbacks of color histograms, that includes robustness, fast, less memory requirements, straight forward implementation and best suited for global color

description where the drawbacks include high dimensional feature vectors, loss of spatial information about color spread, immune to lightening variations and comparison of histograms is computationally extensive.

Jai Li et al [33] created COREL database at University of Pennsylvania State University, Stanford consisting 10,000 images and a subset of 1000 images in .jpg format with different sizes.

RELATED WORK

Albiol et al [13] described correct choice of color space for a particular retrieval process. Hare et al [28] proposed that visual features extracted from simple RGB space will also leads to efficient retrieval for a particular type of queries. By considering this we observed image retrieval based on RGB histograms. Color based image retrieval based on HSV color space presented in discussed by Lie et al [7], Yu et al [8], Sural et al [9], Ma et al [10] and An et al [11]. Sudhir et al used a YUV color space for image retrieval. Phung et al [12] used YCbCr as a color space for skin color classifications. A Bayesian approach for skin color classifications and face detections in YCbCr space analyzed by Chai et al [14]. Kekre et al [15] proposed color based image retrieval based on Block Truncation Coding (BTC) in YCbCr color space. The CIE-Lab color space [29] endows the space of colors with a perceptually meaningful measure of color similarity and works very well with human color discrimination performance. Chareyron et al did watermarking on color images by segmenting the images in CIE-XYZ color space.

Content based image retrieval techniques based on color histograms implemented by Swain et al [18], Stricker et al [19], Flickner et al [3], Ogle et al [20], Pentland et al [21], Deng et al [22], Gouet et al [23], Jeong et al [24] and Yihe et al [25]. Jeong et al [24] proposed Gaussian Mixture Vector Quantization (GMVQ) used as a quantization method to extract color histograms with which spatial information is retained as compared with uniform scalar quantization. In Yihe et al [25] color histograms were computed in HSV color space by splitting the image into annular isometric regions and its shown improvement in retrieval efficiency compared with simple histograms. Stricker et al [19] proposed a color indexing scheme using Cumulative Color Histograms (CCH).

Apart from the previous work, in this paper we presented the retrieval task based on color feature extraction by computing Cumulative Color Histograms in RGB, HSV, CIE-LAB, YCbCr and CIE-XYZ color spaces and also by fusing all these. We analyzed the retrieval performance of our frame work for ten different types of queries in each color space and made some conclusions on the type of color space worked well for each of query.

LITERATURE REVIEW

Color Spaces

CIE (International Commission on Illumination) is a color standard system established in 1931 and other CIE standard color spaces are xyY, U*V*W* and Lu*v*. According to Joblove et al [6] in color spaces viewers first notice a color's hue and then characteristics which might be described as lightness, brightness, brilliance, strength, saturation, vividness, purity, etc., many of which are interrelated.

Red Green Blue (RGB) are called primary colors plane representation is the simplest representation a color image and highly sensitive to pixel intensity variations Space et al [5] described that three primary colors RGB represented in Cartesian coordinates. All three intensities need to be modified to change a single color value, due to this RGB plane is not effective in real world image processing Digital RGB values usually ranges from [0,255] with 8-bit quantization. Cyan Magenta Yellow (CMY) are known as secondary colors which are exact complements of RGB.

Joblove et al [6] proposed more robust way of image representation in Hue Saturatin Value (HSV) color plane, in this space Hue denote dominant spectral component i.e color in purest form. More saturated color has lesser white component and value (V) represent the brightness of color. Hue is a circular quantity and all these three quantities specified in cylindrical coordinate systems. Dark colors are insensitive to saturation and hue changes.

Space et al [5] presented YUV color space which is used by popular video standards PAL, NTSC and SECAM. In this Y represent luminance component and UV represent color information. The advantage with this plane is even black and white receivers can reproduce a gray image based on Y component by neglecting U and V. for digital RGB values[0,255] Y ranges from [0,255], U from [0 ,

±112] and V from [0 , ±157]. YIQ color space is a slightly modified version of YUV in which I represents in-phase and Q represent Quadrature phase components. According to Space et al [5], YCbCr is a scaled version of YUV space and in this image is represented by its luminance and chrominance values. Y is the luminance component ranging from [16,235], Cb and Cr are the chrominance components range from [16,240]. YCbCr formats prescribed in different sampling rates as 4:4:4, 4:2:2, 4:1:1.

CBIR with multilevel BTC in nine sundry color spaces RGB, HSI, HSV, rgb, XYZ, YUV, YIQ, YCgCb, YCbCr and Kekre's LUV presented in Kekre et al[16] and proven that luminance based color spaces performed well over non luminance color spaces. Manjunath et al [17] proposed Hue-Min-Max-Difference HMMD color space. In this H represent Hue, Max and Min are the maximum and minimum values among RGB and D is the difference between the max and min values. Ke, Wang, et al[30] proposed that for harmonious color schemes, perceptual Lab space works very well by transforming into geometric space. Tomasi et al [27] used CIE Lab color space for bilateral filtering to smoothen the images by preserving edges as this is color space is very much similar to human perception. Yang et al [32] described that the XYZ color space was derived from a series of experiments in the study of the human perception by the International Commission on Illumination (CIE) in 1931. Color space transformations are given below.

Color Histograms

Color histogram is a simple and powerful color feature. It gives the joint probabilistic distribution of intensity of three color channels in an image. Color histograms can be computed in all forms of color spaces. A color histogram is obtained by discritizing the image colors and counting the number of times each discrete color occurs in the image. Histograms are invariant to translation and rotation. Swain et al [18] proposed first color indexing process by using color histograms for stable object representations and Histogram Intersection for similarity matching and Histogram back projection for solving location problems. Rao et al [34] used three types of spatial color histograms for content based image retrieval. Gong et al [35] used color histograms for image indexing and retrieval. Mathematically a histogram is represented as m number of pixels with k times intensity ranges spread in n number of bins as given in eq.1.

$$n = \sum_{i=1}^{k} m_i. \tag{1}$$

Similarity Measures

Euclidean distance is the most common metric for measuring the distance between two vectors, and is given by the square root of the sum of the squares of the differences between vector components. Given two vectors A and B where:

$$A = \begin{bmatrix} a_1 \\ a_2 \\ . \\ . \\ a_n \end{bmatrix} \text{ and } B = \begin{bmatrix} b_1 \\ b_2 \\ . \\ . \\ b_n \end{bmatrix}$$

Then the Euclidean distance is given by the eq. 2:

$$\sqrt{\sum_{i=1}^{n} (a_i - b_i)^2} \tag{2}$$

The Manhattan distance is given by eq.3

$$Cityblock\ Distance = \sum_{i=1}^{n} |a_i - b_i| \tag{3}$$

Performance Measures

Recall and Precision are the two important parameters that decide the performance of a CBIR system. Precision (P) is defined as the number of relevant images retrieved versus total retrieved images. Recall (R) is defined as the total number of relevant images retrieved to the total number of relevant images in the database as shown in equation 4 and 5.

$$Precesion = \frac{Number\ of\ relevant\ images\ retrieved}{Total\ number\ of\ retrieved\ images} \quad (4)$$

$$Recall = \frac{Number\ of\ relevant\ images\ retrieved}{Total\ number\ of\ relevant\ images\ in\ the\ database} \quad (5)$$

Mean Average Precision MAP is one of the popular measures used in information as well as image retrieval. Hence to validate a particular color space among all we calculated Mean Average Precision MAP for our frame work.

RESEARCH METHOD

In this paper we presented image retrieval task based on color features by computing cumulative color histograms in RGB, HSV, YCbCr, Lab and XYZ color spaces and also used a combination of all the color spaces as a feature vector. Experimentation is done in Matlab.

Step1: Database is loaded into Matlab workspace

Step2: Query Image is selected.

Step3: RGB Color space is selected for color feature extraction.

Step4: Cumulative Color histograms computed for both query as well data base images by obtaining the 32-bin histograms in each plane of the color space.

Step5: Euclidean / City block distance metric is used for similarity measurement and top 20 images with least distance were retrieved.

Step6: Performance measures precision(P), Mean average precision MAP and re call (R) evaluated for the retrieved images.

Step7: Image color space transformed from RGB to HSV, YCbCr, CIE-LAB and CIE-XYZ space and steps 4 -6 were repeated.

Step 8:Image features of all individual color spaces taken as feature vector and steps 4 -6 are repeated.

Step 9: Comparative analysis is done on color spaces for Euclidean and Manhattan distance metrics.

EXPERIMENTAL RESULTS

We used COREL database for comparing our CBIR system which consists different group of images including flowers, animals, outdoor scenes, food, people, busses and mountains. We presented the comparative analysis of what color space performed well for a particular type of query based on two distance metrics.

Through this experimentation it is observed that HSV features shown more precision, MAP and recall among all other color spaces with city block distance metric. CIE-LAB and CIE-XYZ worked well for outdoor scenes like sea shores and mountains and animal queries. Apart from that it is also observed that fusing features of all color spaces shown significant change in image retrieval with which precision, MAP and recall got increased with Euclidean as well city block distance metrics.


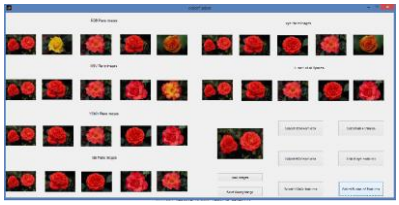


Figure5.a. *Query Images 5.b. Flowers with city block 5.c. Food with Euclidean*

Table1. *Precision and MAP with Manhattan and Euclidean distance*

SNo	Query Image	Manhattan Distance						Euclidean Distance					
		RGB	HSV	YCbCr	LAB	XYZ	All	RGB	HSV	YCbCr	LAB	XYZ	All
1	People	0.9	0.8	0.6	0.4	0.6	0.8	1	0.8	0.6	0.2	0.7	0.8
2	Beach	0.3	0.3	0.4	0.3	0.4	0.3	0.3	0.3	0.4	0.1	0.2	0.3
3	Building	0.5	0.9	0.4	0.5	0.5	0.6	0.3	0.3	0.4	0.1	0.2	0.3
4	Bus	0.8	0.9	0.6	0.6	0.3	0.8	0.6	0.8	0.5	0.4	0.3	0.8

5	Dinosaur	1	1	1	1	1	1	1	1	1	1	1	1
6	Elephant	0.7	0.5	0.6	0.6	0.7	0.7	0.6	0.4	0.5	0.6	0.8	0.7
7	flowers	0.8	0.8	0.8	0.8	0.7	0.9	0.6	0.5	0.5	0.7	0.5	0.9
8	Horses	0.6	1	0.7	0.8	0.5	0.8	0.6	0.8	0.8	0.9	0.4	0.8
9	Mountain	0.4	0.2	0.8	0.5	0.5	0.4	0.2	0.2	0.7	0.4	0.2	0.4
10	Food	0.7	0.9	0.8	0.6	0.6	0.8	0.7	0.8	0.8	0.7	0.6	0.8
	MAP	**0.6**	**0.7**	**0.6**	**0.6**	**0.5**	**0.6**	**0.5**	**0.5**	**0.6**	**0.5**	**0.5**	**0.6**

Table2. *% Recall and % ARR with city block and Euclidean distances*

S No	Query Image	City block Distance						Euclidean Distance					
		RGB	HSV	YCbCr	LAB	XYZ	All	RGB	HSV	YCbCr	LAB	XYZ	All
1	People	19	17	12	09	13	16	20	16	12	05	14	16
2	Beach	7	6	8	06	08	07	06	06	08	03	05	07
3	Building	1	18	9	10	1	13	06	06	08	03	05	07
4	Bus	16	19	13	12	7	17	12	16	11	08	06	17
5	Dinosaur	20	2	20	20	20	20	20	20	20	20	20	20
6	Elephant	15	1	13	13	14	14	13	08	11	12	17	14
7	flowers	17	17	16	17	15	18	13	11	11	14	11	18
8	Horses	13	20	15	17	11	16	13	17	16	18	09	16
9	Mountain	8	4	16	10	10	08	05	04	14	09	05	08
10	Food	15	18	17	13	12	17	14	17	16	14	13	17
	ARR	**14**	**15***	**14**	**13**	**12**	**15***	**12**	**12**	**13***	**11**	**11**	**14***

Table3. *Best choice of a color space for a query category*

S. No	Query	Color spaces with City Block distance						Color spaces with Euclidean distance					
		RGB	HSV	YCbCr	LAB	XYZ	All	RGB	HSV	YCbCr	LAB	XYZ	All
1	People	√	√				√	√	√				√
2	Beach & Mountains			√		√	√			√			√
3	Elephants, Horses & Dinosaurs	√			√	√	√	√	√	√	√		√
4	Food		√				√		√	√			√
5	Flowers	√	√				√	√			√		√
6	Buildings		√				√				√		√
7	Bus	√	√				√		√				√

CONCLUSION

In this paper we presented a Cumulative Color Histogram based Content Based Image Retrieval system using various color spaces including RGB, HSV, YCbCr, CIE-LAB and CIE-XYZ. We presented comparative analysis of the performance of CBIR system with versatile queries including people, food, animals, flowers, outdoor scenes including beaches and mountains. We analyzed the performance of our proposed system in terms of precision, MAP and recall by using two similarity measures Euclidean and City block distances. We used COREL database for our retrieval task. From this frame work we would like to conclude that color features extracted from HSV color space performed well among all individual color spaces for all the query types with city block distance metric and YCbCr features shown better retrieval with Euclidean distance. The feature vector obtained by fusing the cumulative color histogram features of all color spaces shown significant improvement in precision and recall rates and enhanced the retrieval performance at a little more expense of computational time. We also prescribed which color space shown more than 70% of precision for a given query category.

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