Quantisation of Different Color Spaces in Image Retrieval – An Analysis

Aishwarya Harish, S Ashwini, G.S. Anisha

Abstract: ***We study Content-Based Image Retrieval (CBIR) and in this domain, we compare the performance of different quantized color spaces. This technique is one of the best image retrieval technique that is used worldwide as it produces much better results as compared to the predecessors techniques.CBIR technique makes use of color,texture and shape as the important features for quantization. In our paper, we focus on the color of the images as color has more ability to increase the accuracy of the retrieval. We need to perform queries with images as key. This query image is usually selected from a large image database. The image database that can be used is the Corel's database (10,000 images).In the first stage of our process, we extract the color features from the image that is the query key; other images present in the dataset are also retrieved; a color descriptor represents the extracted color feature; for this purpose, we use the color histogram. Color histogram helps making the comparison between the images to be more precise. Secondly, the histogram is quantized to reduce computational complexity. The third stage involves the use of distance matrix for similarity measurement. We use Euclidean distance for similarity measure. Currently in wide use are many color spaces such as RGB, HSV, CLE Lab and CLE Luv. We also make a comparative study of how image retrieval performs using RGB and HSV color spaces. In the paper we also provide different tables based on the implementation that clearly helps us to prove which color space has a major play in better retrieval. Based on the implementation tables provided in the below sections, we reach the conclusion that HSV has better image retrieval.***

Keywords: ***Color histogram, Color feature extraction, Euclidean distance.***

I. INTRODUCTION

There has been a huge increase in the number of images online in recent year, thanks to the large number of image capturing devices. The capacity of these images has increased so much so that much useful information is being stored inside them. In order to retrieve information, many different techniques are used by people for different purposes such as crime prevention, e-business, remote sensing etc. Thus, different types of image retrieval and browsing techniques are proposed [1]. The most popular ones are text-based image retrieval (TBIR), content-based image retrieval (CBIR) and semantic-based image retrieval (SBIR) [2].

The Text-based image retrieval system came into being in early 1970s and found use in many image database systems. It gained wide popularity and took in text as key for queries for searching the images. Since keywords of a particular image can be of no relevance to a particular image at hand, this text based image retrieval system came to be superseded by Content-based image retrieval approaches. Content-based retrieval could successfully circumvent most disadvantages of text-based image retrieval. The CBIR system accepts an image as a key for query; it then proceed to search the associated database and find those images therein that are similar to it – we base the query processing on attributes of the image such as color, texture or shape.

Still, on encountering image databases of rapidly increasing breadth and great variety, the performance of these CBIR systems shows degradation– the reason for this regression is that low-level visual contents (color, shape features, texture) are insufficient in adequately encompassing high-level semantic concepts as are understood and processed most naturally by the human mind[3, 4].To address this issue, various strategies have been explored such as utilizing machine learning tools to associate low-level features and query concepts or addition of relevance feedback into the retrieval loop thus enabling a continuous learning of user intentions. Semantic image retrieval has emerged as an active research area. CBIR system is still engaged in efforts to approximate high-level human perception – for this a wide variety of mechanisms are being actively investigated.

II. FEATURE EXTRACTION

Feature extraction is at the foundation of content-based image retrieval (CBIR). Feature extraction is concerned with the generation of features – it achieves this by transforming image contents into content features [5]. The goal of feature extraction is to extract both text-based features (key-words and annotation) as well as visual features (color, shape, texture, face). The selection of one or more features to represent an image is vital to image retrieval based on content. The extracted features are represented using one or more feature descriptors [6]. Due to subjectivity issues in recognition, no specific feature has a unique best introduction. For each feature, a multiplicity of possible representations obtains- these serve to approach and characterize the feature from divers perspectives.

A. Color Feature Extraction and Color Histogram

Content-based image retrieval that focuses on the feature of color finds wide use in image analysis. Color is the primary attribute as far as human visual perception is concerned – and it has been long known that color vision is largely resistant to complications in the background, image size and its orientation. Usually, the image color is provided with

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a representation employing a suitable color model. Several color models are available that capture color information [5]. An appropriate color model must be selected and represented in a color histogram. A color model is indicated regarding 3-D organize framework and a subspace inside that framework where each shading is spoken to by a solitary point [5]. Hence, a 3-channel is required to represent a color model. Commonly used color models are RGB, HSV, CLE L*a*b, YCbCr, CLE L*u*v and so on.

The most widely used color model is RGB. It is founded on three primary colors Red, Green and Blue respectively with each channels' size 8-bits and thus the values ranges from 0 to 255. It is an additive color system in that red, green and blue light are mixed to create the wide range of colors we see on our TV screens, computer monitors, and smartphones.RGB colors are called primary colors. But suitably tuning combinations thereof, we obtain different other colors. The HSV color space is based on parameters Hue, Saturation and Value, which conform to human differentiation between colors [9].In HSV color space, Hue serves to make distinction among colors; Saturation is defined as the fraction of white light that has been mixed into a pure color. Value stands for the perceived intensity of light [10]. The Saturation value can range between 0.0 to 1.0. Due to this, the colors show diversity and can range from unsaturated (Grey) to saturated (no white component) [5]. In color space in the HSV scheme, Hue tone can vary between 0 and 360 degrees, with variety beginning with red and further experiencing yellow, green, cyan, blue and fuchsia till finally getting back to red [5]. The V component enables quantification of black mixed with hue or the brightness of the color. It is a parameter that can vary in the range 0 to 1[13].

In the literature a great variety of color representation techniques have been proposed - color histogram, color moments (CM), color coherence vector (CCV) and Color Correlogram [7]. Color histogram is the most commonly used descriptor - compact representation and low computational complexity being its attractive features. Color histogram finds use in comparing two images based on spatial information [12].

The color histogram approach uses the concept of probability to specify the intensities of the three color channels. Its formal definition is:[6] [8]

$$H_{R,G,B} = N.Prob\{R=r, G=g, B=b\}$$

Here,r, g and b stand for the three color channels in RGB color model; N is the number of pixels forming the image [14]. We construct the Histogram of images by counting the number of each color pixels in the image; separate bins are used to store each color pixels.

III. SIMILARITY MEASUREMENT AND COLOR QUANTIZATION

In general, similarity metrics find use in quantifying the distance between the query image and each indexed images as images are retrieved based on their color histogram. They include, for instance, the distance between the Histograms, Euclidean, Mahalanobis and Histogram Quadratic. We choose the image with smallest similarity value in preference to the other images in the database with respect to the query image [14]. The Euclidean metric that we use yields the following formula for the distance measurement between the image P present in the database and the query image Q:

$$\sqrt{\sum_{i=1}^{n}(H1_i - H2_i)^2}$$

Here, n = the number of pixels contained in the histogram; i represents a particular color intensity; H1 denotes the color histogram of the image that is being indexed and H2 denotes the color histogram of a particular image that has been fetched from the Corel collection [14]. We anticipate considerable impact on the performance of one method as we move from one color space to another– this has been indicated in[13, 15, 16].

A. Color quantization

Color quantization is an essential color histogram technique to reduce computational complexity and distinguish between colors acceptably. Here, we try to glean additional information about how different color spaces perform as quantization levels differ. We work with a uniform quantification of the R, G and B channels for RGB color space into several bins denoted by QR, QG and QB respectively. We can then build the image's color feature with the following equation which results in one-dimensional values [10].

$$H_{RGB} = Q_G Q_B R + Q_B G + B \quad (1)$$

Let QR, QG and QB be 4. Then, the three channels of RGB can be quantized to such a way that each channel contains values ranging 0 to 3. The three-component RGB vector is thus a one-dimensional vector; it captures the totality of the color space in terms of64 numerical values that go from 0 to 63.This enables us to construct64 bins of HRGB color histogram. A similar strategy could be employed by the following equations (2),in the quantization of HSV color spaces [10].

$$HHSV = QSQVR + QVG + B \quad (2)$$

IV. RESULTS AND ANALYSIS OF EXPERIMENTS

A. Database and Performance Assessment Matrics

We assess the performance of our experiment in this section using the Coral dataset having huge number of images with great variety in content - from animals to landscapes to outdoor sports [17]. Wang database, a partial collection of 1000 images called from Coral photo database of Coral stock, was used for experimenting. It contains manually selected 100 images for all the 10 classes including African beach, construction, bus, dinosaur and so on. Coral-10000 dataset which contains 100 categories each containing 100 images was also used for experimenting.

To assess the performance of image retrieval in RGB, HSV and CLE L*a*b color spaces, Precision and Recall methods were employed. To quantify Precision and recall, we use the following equations:

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$$\text{Precision} = \frac{\text{Number of similar images retrieved}}{\text{Total number of images retrieved}}$$

$$\text{Recall} = \frac{\text{Number of similar images retrieved}}{\text{Total number of similar images in the database}}$$

We used every image belonging to each category in the dataset as the query image; for each image, its precision and recall for each query image were found and stored in respective matrix. We then proceeded to estimate, for each category, the average values of precision as well as the recall percentage. Finally, we calculate the average for all query images. We also represent graphically, the average precision and recall percent at 20.

B. Color Space Selection and Experiment Results

Experiment1:

We use RGB, HSV and CLE L*a*b color space to evaluate the influence of quantization in the performance of the image retrieval. Below listed tables give the average precision and recall values after performing the above mentioned process.

Average retrieval precision at 20 for HSV color space

Table I

Color Quantization	Precision at 10	Precision at 20
32	0.599	0.54
64	0.655	0.58
128	0.678	0.598

Average retrieval precision at 20 for RGB color space

Table II

Color Quantization	Precision at 10	Precision at 20
32	0.61	0.5393
64	0.63	0.56
128	0.67	0.592

Precision of each class for RGB and HSV color spaces

Table III

Class	RGB	HSV
Africans	0.59	0.7215
Beaches	0.40	0.269
Buildings	0.348	0.4135
Buses	0.5	0.693
Dinosaurs	0.998	0.853
Elephants	0.482	0.473
Flowers	0.533	0.6595
Horses	0.856	0.789
Mountains	0.336	0.3255
Food	0.643	0.6415

V. CONCLUSION

Image retrieval is a vast and fast developing area of study and research. Above, we described the use of color histograms in processing image based queries and compared different color spaces in supporting these queries. Our studies clearly show that the HSV color space gives the best performance among available color spaces. We note that there is still great scope for further investigations and enhancements in this area. We can do more research on this area by using other color spaces such as the CIELAB , CIELUV, Adobe RGB etc. In this way,by doing more research one can find which color space gives more accuracy and precision.

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