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A Review: Color Feature Extraction Methods for Content Based Image Retrieval

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Abstract
For more than a decade Content Based Image Retrieval is topic of interest for researcher. The three primitive visual features, namely, color, texture and shape refers to the term 'content' in content based image retrieval. Although visual features cannot be completely determined by semantic features, but still semantic features are used because they are easier to integrate into mathematical formulations. Therefore good visual feature extraction is one of the important task for representing image compactly. Among the visual features, colors is the most vital, reliable and widely used feature. This paper reviews various methods, namely Global Color Histogram, Histogram Intersection, Image Bitmap, Local Color Histogram, Color Correlogram, etc., employed to extract the color feature. This paper briefly elaborates these different methods of color feature extraction and then presents a comparative study for selection of these methods in various applications.

Keywords: *Color Histogram, Histogram Intersection, Color Correlogram, Color Difference Histogram, Color Histogram for K-Mean, Color Co-Occurrence Matrix, Chromaticity Moments.*

1. Introduction

According to a Chinese proverb "A picture is worth a thousand words", hence the researchers focus more on image retrieval in comparison to text retrieval. With the generation of the huge amount of multimedia data, effective methods are required for their retrieval. Image

retrieval techniques are targeting to get accurate results in lower computational time ensuring good performance. Most of the researchers are doing in-depth research on

content based image retrieval as compared to text based image retrieval over the last decade. Most of the images are un-annotated [1] and this method extracts images feature directly from images data i.e., image feature descriptor namely, color, texture and shape. In this regard for retrieving colored images from multimedia databases, color feature descriptor of images have been used widely showing to its characteristic of robustness to background complication and independence over image size and orientation. Color features extraction methods broadly fall in two categories viz. global methods and local methods. In global methods, feature extraction process considers complete image, including global color histogram, histogram intersection, image bitmap, etc. On the other hand local methods considers a portion of the image, including local color histogram, color correlogram, color difference histogram, etc. An attempt is made to give a brief introduction of these methods and give comparative study for selection of these methods in various applications.

2. Content Based Image Retrieval

With the increased use of digital images, content based image retrieval has emerged as an active research topic in the last few decades because of the limitations innate in metadata-based systems. A CBIR system is needed to efficiently utilize information from these image repositories. In CBIR, the contents are derived from image features like color, shapes, and textures are analyzed rather than the metadata such as keywords, tags, and/or descriptions associated with the image. It aims to retrieve relevant images based on the visual and semantic contents of images. Currently, CBIR techniques are working on combination of low level features i.e. color, shape and texture, which has become a potential area of research. It is also known as query by image content and is one of the applications of computer vision. In CBIR, a user has an image called query image and he/she is interested to search the similar images from image database. A feature vector is computed of this query image and then compared with the pre-calculated feature vector of images in database. The comparison is done by using some similarity metric and accordingly the images are retrieved from the database.

3. Methods for color feature extraction

3.1 Color Histogram

Color Histogram is the most widely used technique for extracting the color feature of an image [2, 3]. It represents the image from a different perspective. It represents the frequency distribution of color bins in an image. It counts similar pixels and store it. There are two types of color histogram viz. global color histogram and local color histogram. Color histogram is proposed as a global color descriptor which analyze every statistical color frequency in an image [4]. It is used to solve the problems like change in translation, rotation and angle of view. Local color histogram focus on the individual parts of an image. Local color histograms considers the spatial distribution of pixel which is lost in global color histograms [5]. Color histogram is easy to compute and insensitive to small variations in the image so is very important in indexing and retrieval of image database [6, 7]. Apart from these advantages, it faces two major drawbacks [8]. First, overall spatial information is not taken into account. Second is that the histogram is not robust and unique as two different images with similar color distribution lead to similar histograms, the same view images with different exposure to light create different histograms.

3.2 Histogram Intersection

In [9] Histogram Intersection (HI) descriptor of the image was proposed which considers global color features using histograms. For a given pair of color histograms, X and Y with k bins for each, the HI is defined as shown in Eq. (1):

$$HI(X,Y) = \sum_{i=1}^{k} \min(X_i , Y_i) \quad (1)$$

Performance of HI is affected by the selection of color space employed like HSV (Hue, Saturation and Value) or CIELab color spaces [9] increases the performance because they are orthogonal among the three color components. Moreover the number of bins considered also laid impact on performance as although a large number of bins describe the image in an elaborated manner, but it increases the computational complexity because the feature vector of the descriptor dimension also increases. Key benefits of using this feature include robustness to the geometrical modification like rotation, scaling, variation in the image resolution, etc.

3.3 Color Histogram for K means (CHKM)

For a color pixel 2^{24} different colors are possible. The color histogram for K-mean (CHKM) features of an image [10] is presented. In this method one color in the common color palette which is more similar to a particular pixel color is considered to replace that pixel color. Same process was applied to each pixel color in order to classify all pixels in the image into k cluster. The K-mean clustering algorithm [11] is employed to categorize the pixels of all databases images. The algorithm outputs the mean of all pixels in each cluster, which is set as the new initial value for further training. After these steps the color histogram is prepared. For k^{th} color bin the CHKM feature was defined as shown in Eq. (2):

$$g_k = \frac{N_k}{N} \quad (2)$$

Where, N is total pixel numbers and N_k is the number of the pixels in the kth cluster. The method describes color feature with a small number of features and hence 16 groups of colors were evenly divided in the paper leading to effectively shorten image retrieval time and enhance retrieval performance. It is simple, easy to compute and noise resistant method. The method is robust to image size variance, displacement and rotation.

3.4 Color Correlogram

A color correlogram is used as an image feature which is scalable for image retrieval on very large image databases. It expresses the spatial correlation of color changes with respect to the change in distance in contrast to a color histogram which captures only the color distribution in an image and does not include any spatial information [12]. Therefore, the correlogram is one kind of spatial extension of the histogram and is extensively used over color histogram. As the histogram is the color distribution in an image I, the correlogram is the color correlation distribution in image I. Color correlogram feature [8] was used for content based image retrieval, for which firstly histogram was computed for image which was subdivided into four equal bins. Each bin was further subdivided into four more bins and maxima of frequencies was calculated for every such subdivision. This information is stored in the form of a correlogram.

For pixel $\boldsymbol{p_1}$ and $\boldsymbol{p_2}$ of color $\boldsymbol{c_i}$ and $\boldsymbol{c_j}$ separated by distance k. the correlogram of I for i, j [12], as shown in Eq. (3):

$$\gamma_{c_i c_j}^{(k)}(I) = P\,[\,p_2 \in I_{c_j}, |p_1 - p_2| = k, p_1 \in I_{c_i}\,] \quad (3)$$

So the correlogram of the image I is a table which is indexed by color pairs and distance, where the k^{th} entry for <i, j> will denote the probability of finding a pixel of color j at a distance of k from a pixel of color i.

3.5 Color Co-occurrence Matrix (CCM)

Color co-occurrence matrix methods [10] was presented in which color difference between adjacent pixels computes the probability of occurrence of the same color pixel among adjacent pixel of the image, this probability is the image attributes considered over here. An image consists of pixel and each pixel refers to four adjacent pixel colors. A 3x3 convolution mask was generated for each pixel G(x, y) in an image as shown in Fig. 1, which was in turn divided into four blocks of 2x2 grids (pixels) with each block including pixel G(x, y). As in this paper, scan patterns of these grids is considered starting from the top left corner pixel p_1 forming seven such patterns termed as motifs of scan patterns as shown in Fig. 2. Now the image was presented by four images of motifs of scan pattern and further constructed into four two-dimensional matrices of the image size. Based on these four metrics, motifs of scan pattern compute attributes of the image and the color co-occurrence matrix is computed.

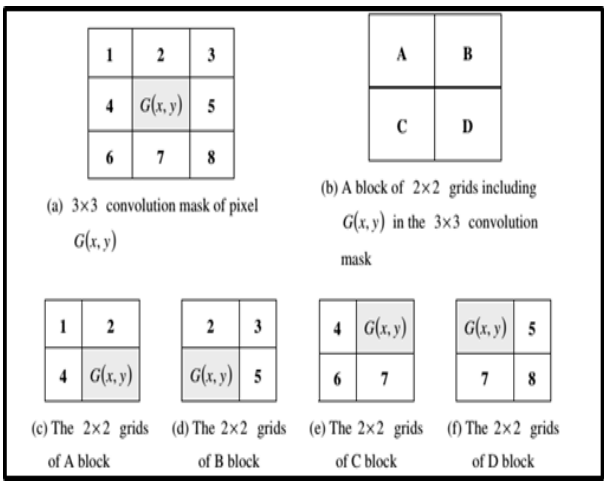

Fig. 1 3x3 convolution mask are divided in four 2x2 grids

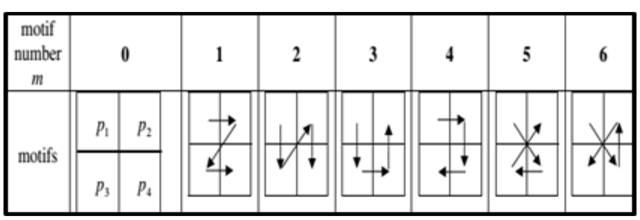

Fig. 2 The seven scan patterns

3.6 Chromaticity

Majority of image retrieval method incorporating color feature use color histogram or some variation of it. While storing extracted information for each image, such methods may need considerable space according to the image size and content for storing histogram. To overcome this problem [13], had proposed a simple and effective image retrieval method based on chromaticity moments, where only a small number of feature called chromaticity moments which capture spectral content (chrominance) of an image will be stored. This provides compact and constant in size yet effective approach in terms of both storage and retrieval processing time requirements.

3.7 Dominant Color Descriptor (DC)

Dominant Color (DC) is based on compactly describing image using a small number of its prominent color. This technique is inefficient while considering object-based image retrieval. Dominant color extraction procedures are composed of various tasks such as color space selection, dominant color determination, color quantization, calculating histogram of quantized image and computing each dominant color percentage. In [14] HSV color space was chosen and quantized image with 72 distinct colors and expressed DC descriptor as shown in Eq. (4):

$$DC = \{C_i, P_i\}, i = 1 \dots N \tag{4}$$

Where, C_i represent N most representative colors selected as dominant colors and P_i denotes their percentages.
A variation of this feature as a weighted dominant color descriptor was proposed [15]. In this weight was assigned to each DC in the image according to its belonging to the background or the object, with those belonging to background getting less weight and those to object getting more weight, it alleviates the background effect. This method with some other improved features when compared with original [16], and other best existing one of the DC descriptor [17] give improved results in terms of four quantitative metrics i.e., ARR(Average Retrieval Rate), ANMRR(Average Normalized Modified Retrieval Rank), MAP(Mean Average Precision) and P (10)(Precision).

3.8 Other Methods

Zernike chromaticity distribution moments [18] which is extracted from the chromaticity space. This method advantages on the factors like it provide compact, fixed length and computation effective representation of the color content of an image as only a small number of Zernike chromaticity distribution moments required to be stored and possess robustness against noise. Moreover, their magnitude is invariant under rotation and flipping.
Linear Block Algorithm (LBA) method [19] being efficient in color quantization and computation presents this color quantization method for dominant color extraction. Image bitmap as global characteristic and color distribution, the mean and standard deviation value as local characteristic is used in [20].

Three morphological color descriptors two based on multiresolution histograms for describing color and one using granulometries independently computed for each subquantized color was presented in [21]. An adaptive color histogram (ACH) based on color distribution was proposed in [22] as color feature for image retrieval. Color Difference Histogram (CDH) [23] counts the perceptually uniform color difference between two points under different background. It combines the use of orientation, color and color difference and considers the spatial layout. It elaborates the image as well as its background content.
The color extraction methods, namely, fixed cardinality (FC) and variable cardinality (VC) was proposed in [24] for extracting color features based on the image color distribution. By considering the value of a pixel in an image as a random vector, the color distribution of an image is equivalent to the probability distribution of this random vector. The two vectors preserve the image color distribution during the extraction process.

4. Comparative study of color feature extraction methods

As discussed above in section 3, color feature descriptor is mainly divided into two categories, namely, Global and Local descriptor depending on whether the feature extraction process consider complete image or a portion of it. In the global descriptor no partitioning or pre-processing stage is needed during feature extraction stage while in local descriptor it is mandatory. Global color descriptors are easy to compute and are insensitive in viewing position but since they don't include any spatial information, therefore are liable to false positives. It includes global color histogram, histogram intersection, image bitmap, etc. on the other hand local descriptor includes spatial information of an image so are more efficient, this includes local color histogram, color correlogram, color difference histogram, etc.

Other factors which are important while selecting the color feature extraction methods are storage space required, scalability, rotation invariant, computational time required and its feasibility, etc. Histogram although easy to compute, but is not robust and unique whereas color histogram using K means is robust to image size variance, displacement, rotation and noise, and this is also computationally easy approach. Also the Zernike Chromaticity distribution moments method is robust against noise and their magnitude are invariant under rotation and flipping.

The color space model selected is also importance metric which affects the color descriptor selection criteria as for Histogram Intersection method, its performance increases while using HSV or CIELab color space due to their orthogonality feature among their three color components. Dealing with storage space issue, Chromaticity method stores chromaticity moments and Zernike Chromaticity distribution moments method storing Zernike Chromaticity distribution moments capture less space and also they are effective approach on the basis of retrieval processing time.

5. Conclusion

CBIR is an active research topic in image processing, pattern recognition, and computer vision. CBIR aims at retrieving relevant images from a large image database, by measuring similarities between the query image and the database images. It is based on broadly three basic low level features, namely color, texture and shape, and color is the most important among them. The various methods used for color feature extraction are illustrated in this paper. These methods are used and selected according to the application for which they are employed for. The methods which consider the spatial information of the image are gaining more popularity, since they are advantageous in various other perspectives also. Moreover method should be robust against noise, scaling, rotation, flipping, etc., and efficient in storage space and time complexity parameters.

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