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3D-Color Vector Quantization For Image Retrieval Systems

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Abstract

In this paper we present a new approach for extracting color feature for image retrieval systems. The system introduces color feature extraction using histogram of Three Dimensional (3D)-Color Vector Quantization of RGB color space. The main idea of this approach is that the system uniformly represents image colors in certain positions of RGB's vector color space. It intends to reduce a complexity RGB colors in the image and unifies the close colors in the vector space. In advance, our system pre-proceeds noise removal to enhance the quality of an image before extracting the feature. We apply 3D-Color Vector Quantization in each block of image partition to keep a close similarity between image query and image database in the matching process for each block of partitioned image. We evaluated our system using COREL image collections containing different categories of images. The experimental results clarified effectiveness of the proposed system to improve the accuracy for image retrieval.

Key words: Image retrieval, color feature extraction, color vector quantization, color histogram.

1. Introduction

The rapid progress of the internet technology accelerates inter-media exchanges, including image data. According to a recent study, there are 180 million images on the publicly indexable Web, a total amount of image data of about 3Tb [terabytes], and an astounding one million or more digital images are being produced everyday [5]. An efficient image searching, browsing, and retrieval systems are widely developed in order to provide better ways and approaches for such kinds of activities.

The image retrieval systems based on the contents are attracting and challenging in research areas of image searching. Many content-based image retrieval (CBIR) systems have been proposed and widely applied to both commercial purposes and research systems. The system analyzes the content of an image by extracting primitive features such as color, shape, texture, etc. Most approaches have been introduced to explore the content of an image and identify the primary and dominant features inside the image.

QBIC [4] introduced an image retrieval system based on color information inside an image. VisualSeek [17] represented a system by diagramming spatial arrangements based on representation of color regions. NETRA [9] developed a CBIR system by extracting color and texture features. Virage [1] utilized color, texture, and shape features for the image retrieval engine. CoIRS [8] also introduced a cluster oriented image retrieval system based on color, shape, and texture features. Veltkamp and Tanase [12] and Liu et al [7] presented a survey to many image retrieval systems using diverse features.

In this paper, we present a new approach for extracting color feature by applying histogram of 3D-Color Vector Quantization of RGB. We uniformly represent image colors in certain positions of RGB color space. It intends to reduce a complexity RGB colors in the image and unifies its close colors. We apply this approach for each grid in the image.

The color metadata is created after feature extraction. The metadata of image query is used to measure the similarity with metadata repository of image database. For matching process between image query and image database, distance similarity is calculated. The retrieved results are ranked based on the highest similarities between image query and image database. Figure 1 describes the system architecture of the proposed image retrieval systems.

This paper is organized as follows. Section 2 describes the extraction of color feature. It also describes the pre-processing for noise removal. Section 3 provides description of the components of our image retrieval systems, which are feature metadata, query selection, and similarity measure. The experimental results with several image queries with different categories and performance analysis of the system are discussed in Section 4. Section 5 is the conclusion and future work.

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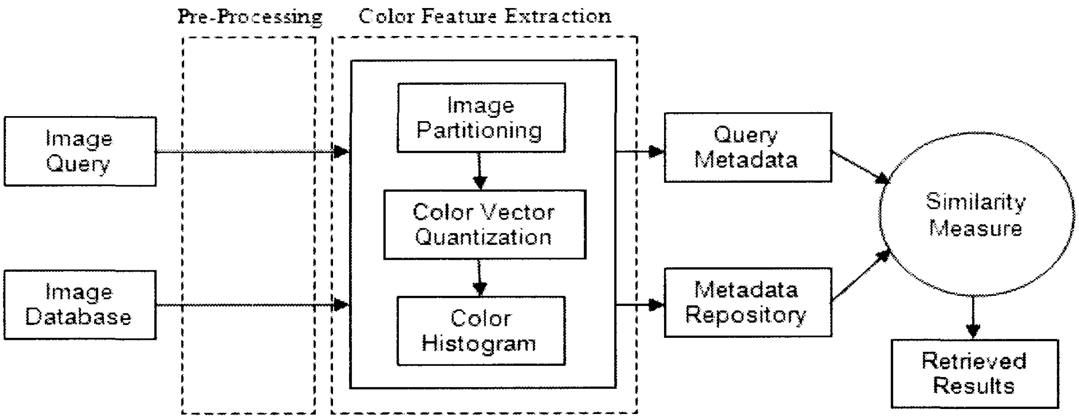

Figure 1: System architecture of the proposed system

2. Color Feature Extraction

In this section, we describe a function to extract color feature in the image by 3D-Color Vector Quantization. In advance, our system pre-proceeds noise removal to enhance the quality of an image before feature extraction. We apply 3D-Color Vector Quantization in each block of image partition. We use the image partitioning in order to keep a close similarity between image query and image database in the matching process for each block of image parts. In our research, we use 4x4 blocks of image partitioning.

2.1. Noise Removal

For noise removal, we use adaptive noise removal filtering using the Wiener filter. The Weiner filter can be considered as one of the most fundamental noise reduction approaches and widely used for solution for image restoration problems [2][10]. In our system, we use 3x3 neighborhoods of filtering size. Figure 2 shows result of noise removal applied in the image.

(a) Image source

(b) Image after applying noise removal

Figure 2: Image before and after applying noise removal

2.2. Color Feature

Noise removal and 4x4 image partitioning are applied before extracting color feature. Then, for each block we extract color information using the histogram from 3D-Color Vector Quantization of RGB color space. In this paper, we use the 64x64x64 quantization size of the RGB color space so that it can be represented with 125 positions in the RGB color space, as shown in Figure 3.

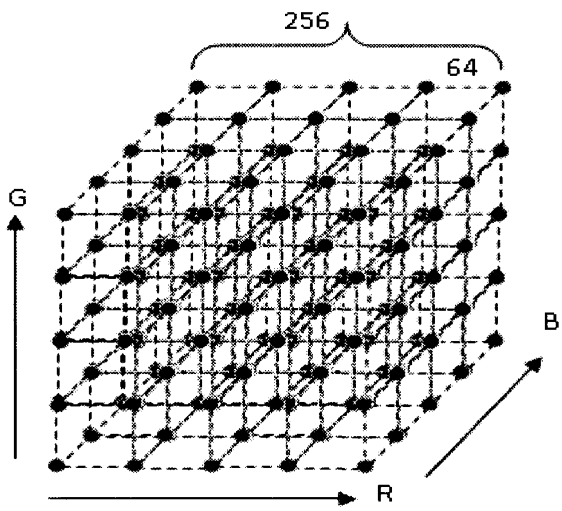

Figure 3: Illustration of 3D-Color Vector Quantization of RGB color space.

The metadata of color feature MCL_b for block b can be described as follows:

$$MCL_b = \{fc_{b,1}, fc_{b,2}, \ldots, fc_{b,125}\} \qquad (1)$$

where:

fc_i is a color feature of i-th color histogram from 3D-Color Vector Quantization of RGB vector space.

Figure 4 illustrates the mechanism of color feature extraction: image partitioning, Color Vector Quantization, and color histogram.

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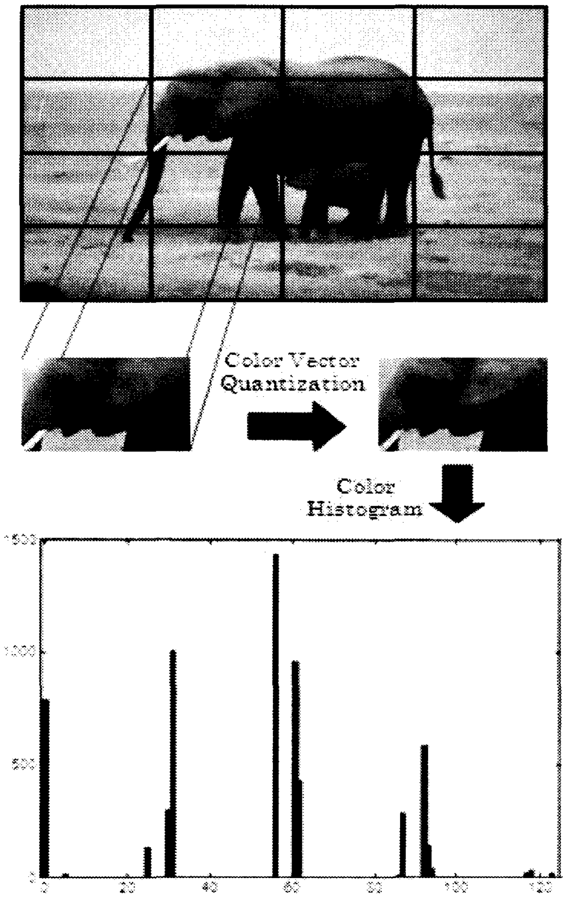


Figure 4: Mechanism of color feature extraction

3. Image Retrieval System

After feature extraction, the metadata of color feature is created. These metadata are used for matching process to metadata of an image query. The retrieved images are acquired from images which have the highest similarities of the metadata to the metadata of an image query. Regarding the image query, we use Query By Example (QBE) as an image query. Regarding similarity, the cosine distance metric is only applied to calculate similarity measure for color.

3.1. Metadata Repository

After extracting the color feature, the metadata of feature is created. This process is done offline and saved to metadata repository. Because we apply 4x4 image partitioning for each image, the metadata of each feature consists of 16 blocks.

We referred to basic concept of Mathematical Model of Meaning (MMM) [6] for creation of metadata space. The information on n data items is given in the form of matrix. Each data item is provided as fragmentary metadata which is independently represented one another. The information of each data item is represented by its features. The n basic data items are given in the form of an n by m matrix M. For given n basic data items, each data item is characterized by m features. By using this matrix M, the orthogonal space is computed as the metadata space. Metadata items which are represented in m-dimensional vectors are mapped into the orthogonal metadata space.

The color metadata (MCL) is shown in Eq. (2). The attributes consist of color metadata from histogram of 3D-Color Vector Quantization of the RGB vector space.

$$MCL = \begin{bmatrix} fc_{b_1,1} & fc_{b_1,2} & \cdots & fc_{b_1,125} \\ fc_{b_2,1} & fc_{b_2,2} & \cdots & fc_{b_2,125} \\ \cdots & \cdots & & \cdots \\ fc_{b_{16},1} & fc_{b_{16},2} & \cdots & fc_{b_{16},125} \end{bmatrix} \quad (2)$$

3.2. Query Selection

We use Query By Example (QBE) for image query in our system. The QBE is the most attractive paradigm in the image retrieval systems [8]. When a user selects an image as a query, the color feature of the image is extracted and its metadata is created. The metadata of image query, then, is compared to the metadata repository of image collections.

3.3. Similarity Measure

The similarity measure is very essential to represent the most similar retrieved image to an image query. The use of the appropriate similarity measure can improve the result of image retrieval [8]. In our case, the Cosine distance metric is better for similarity measure in color metadata. Table 1 in Section 4 performs the error comparison between Euclidean and Cosine distance metrics in several image queries.

4. Experimental study

For our experimental study, we use a-general purpose image database containing of 1000 JPEG from COREL image collections. These images are manually divided into 10 categories which are people, beaches, historian buildings, buses, dinosaurs, elephants, roses, horses, mountains, and foods. For the experimental study, we use one image for each category as an image query. We determine 15 top correct retrieved images for the query.

For performance analysis, we calculate the number or errors for category of each retrieved image in line with the category of image query.

$$Error = \sum_{i=1}^{15} err_i \begin{cases} err_i = 0 \leftarrow cr_i = cq \\ err_i = 1 \leftarrow otherwise \end{cases} \quad (3)$$

where:

cr_i = category of retrieved images
cq = category of image query

We also make scoring to represent the precision of image retrieval. The scoring is calculated based on a ranking position of each retrieved image, and defined as follows:

$$Score = \sum_{i=1}^{15} scr_i \begin{cases} scr_i = 15 - i + 1 \leftarrow cr_i = cq \\ scr_i = 0 \leftarrow otherwise \end{cases} \quad (4)$$

Figure 5 shows the retrieved images of "bus" image query. It performs 12 relevant images from 15 retrieved results using cosine similarity distance.

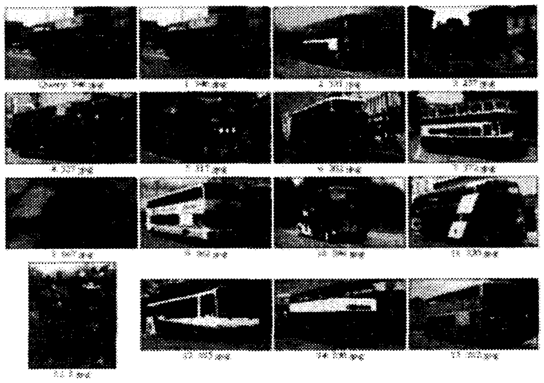


Figure 5: Retrieved results of bus image query

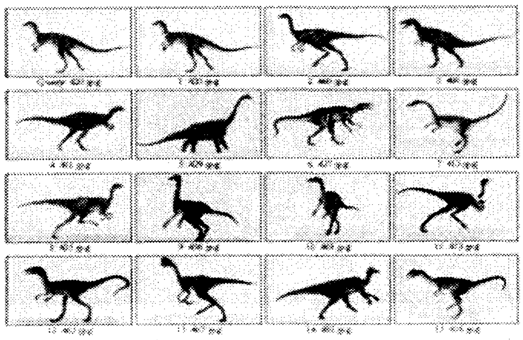
Figure 6 shows different queries of animals. The results are all relevant retrieved images respectively for dinosaur and horse image query, and 10 relevant images for elephant image query.

We also tried the other experiments of several image queries which are beach, mountain, building, flower, people, and food. Figure 7 shows different queries of panoramic images which it performs 14, 11, and 13 relevant retrieved results respectively for beach, mountain and building image query. Figure 8 shows more examples of diverse image queries. It performs 15, 11, and 14 correct retrieved images respectively for flower, people, and food.

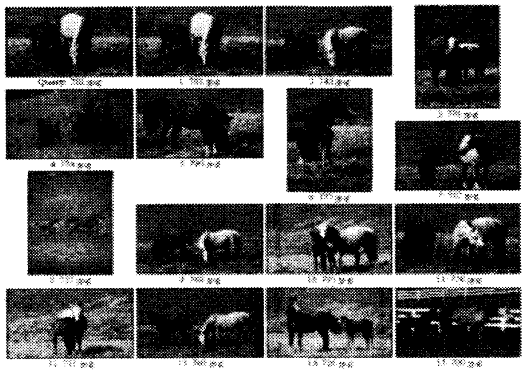
We perform errors of all experiments in Table 1 using Cosine and Euclidean distance metrics. It shows that the Cosine distance metric can lead to better results of relevant retrieved images rather than the Euclidean metric. The scores of each experiment are shown in Table 2.

Table 1: Error comparison using different distance metrics

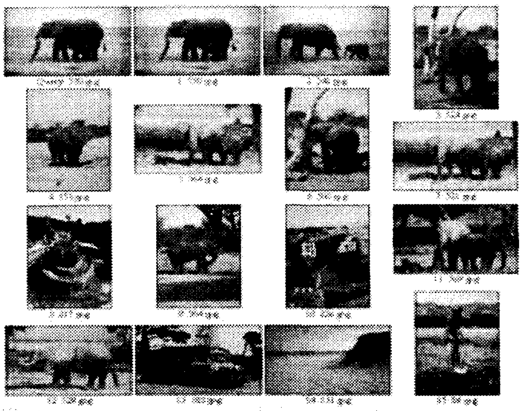
Image Query ID	Image Category	Cosine	Euclidean
57	People	4	4
102	Beach	1	7
248	Building	2	3
346	Bus	3	1
420	Dinosaur	0	0
530	Elephant	5	7
641	Flower	0	2
788	Horse	0	0
804	Mountain	4	6
962	Food	1	1
Total Error		22	31



(a) Retrieved results of Dinosaur image query



(b) Retrieved results of Horse image query



(c) Retrieved results of Elephant image query

Figure 6: Retrieved results of animal queries

Table 2: Score comparison using different distance metrics

Image Query ID	Image Category	Cosine	Euclidean
57	People	89	94
102	Beach	119	83
248	Building	113	105
346	Bus	95	112
420	Dinosaur	120	120
530	Elephant	100	83
641	Flower	120	112
788	Horse	120	120
804	Mountain	82	80
962	Food	115	114
Total Score		1073	1023

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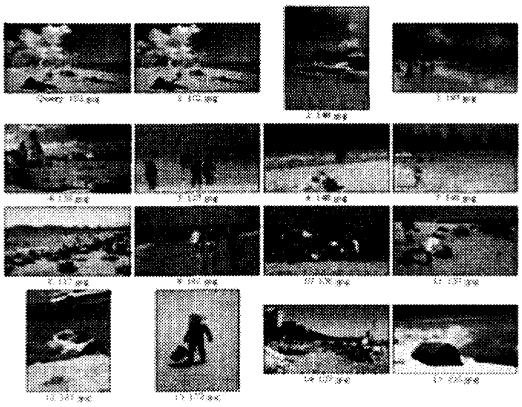
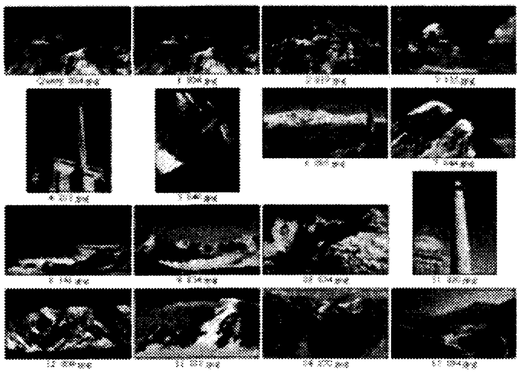


(a) Retrieved results of beach image query



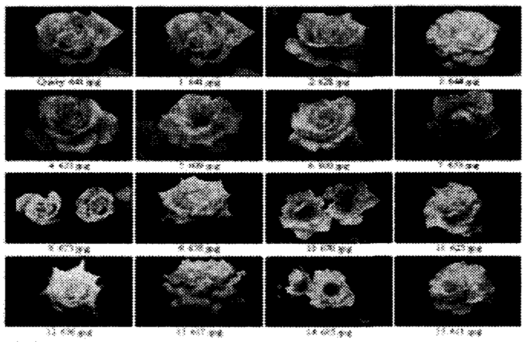
(b) Retrieved results of mountain image query

(c) Retrieved results of building image query

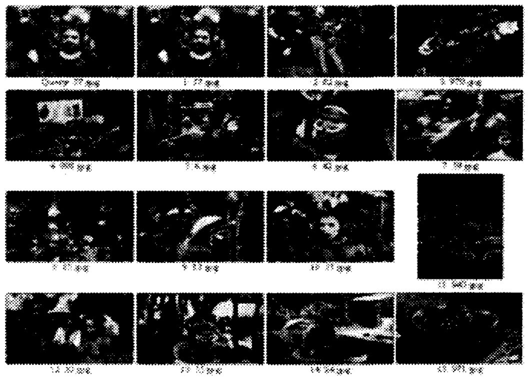
Figure 7: Retrieved results of panoramic queries

6. Conclusions and Future Works

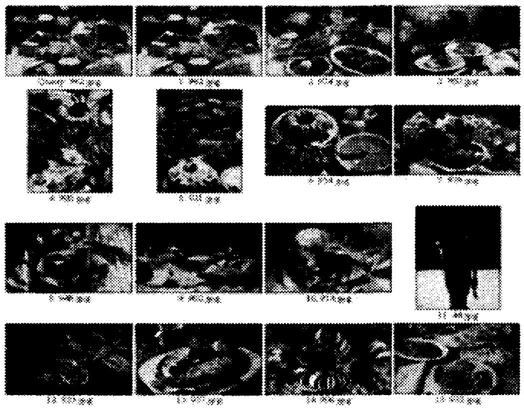
In this paper we have presented color feature extraction in the image retrieval systems using 3D-Color Vector Quantization. We applied 3D-Color Vector Quantization in each block of image partition to keep a close similarity between image query and image database in the matching process for each block of image parts. The experimental results performed the effectiveness of this proposed approach for image retrieval systems. The Cosine distance metric can reduce errors of retrieved results for the color feature. In future work, we will work with the other features of image, such as shape and texture, and develop the automatic weighting system for selecting these features automatically.



(a) Retrieved results of flower image query



(b) Retrieved results of people image query



(c) Retrieved results of food image query

Figure 8: Retrieved results of flower, people, and food image queries

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