# An Improved Algorithm Based on Color Feature Extraction for Image Retrieval

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*Abstract*—**With the rapid development of computer vision and digital technology, producing the vast amounts of image data, how to realize a rapid, easy and high effective algorithm of image retrieval has been the issue of study, just so the main goal of this paper is to implement an effective improved algorithm based on color feature. There are two main types of algorithm based on color feature: global algorithm and local color algorithm, including RGB, HSV color space and so on. This improved algorithm fully considers the global and local color information, fusing the fuzzy color histogram and block color histogram, decreasing the color feature dimension. This paper compares uniform HSV histogram, non-uniform quantization HSV histogram, fuzzy HSV histogram, block color moment, the improved color feature in image database COREL1000. According to the analysis of experiment results based on the precision of first N terms, the improved algorithm has the best retrieval accuracy and low feature dimension.**

***Keywords—image retrieval; color feature; color space; retrieval accuracy;***

Since the 1970s, the image retrieval has always been the hot spot of researchers in the field of image. Recent years, especially with the rapid development of digital technology, computer vision and big data technology, meanwhile smart phone and wearable smart devices play a more and more vital role in our daily life. The data of image and video is increasing in a geometric progression, which leads to the prosperity of application of image retrieval in informational society, so in present exploring an efficient, accurate and intelligent retrieval algorithm for image retrieval is the pressing needs. The traditional text-based image retrieval (TIBR) [1] adds retrieval pressure to developer and wastes a large amount of time in labeling picture. The content-based image retrieval (CIBR) method not depends on manual annotation, extracting the underlying characteristics of the image and improving the efficiency of image retrieval greatly [2]. The ultimate aim of image retrieval is to provide a convenient and efficient retrieval system for user, which has a widely application prospect.

The content-based image retrieval system [3-4] can divide into two key technologies, including feature extraction and retrieval technique, after extracting image underlying feature, storing the feature data in database and taking advantage of retrieval technique to query similar images. The primary extraction of the character contains color, texture and shape, of which the color has strongly connection with the main object of image and background [5]. The color is insensitive to the size of the image itself, rotation and translation [6], which means the robustness of color is powerful. Therefore this paper explores a new image retrieval algorithm based on color vision characteristics that can be implemented under the condition of rather smaller dimensions for efficient image retrieval.

We organize the paper as follows. In section 2, we introduce related knowledge of color feature space and review some commonly used color feature extraction methods. Section 3 details an improved algorithm of color feature. Experimental design and performance analysis of existing proposed algorithm will be discussed in the fourth section. Finally in section 5, we draw conclusions about experiment of color algorithm.

## I. COLOR FEATURE

### A. Color Space

The extraction of different color space for color generates different methods, extracting from the image color features depends on the color space. The common color space contains HSV, RGB and YCbCr. The RGB space is the basis of image processing, and other mostly can be transformation from this color space [7], such as RGB histogram and RGB vector angle histogram. In order to adapt to the human visual characteristic, considering hue, saturation and value, researchers developed the HSV color space. [8] A fast formula of conversion from RGB to HSV defined as:

$$V = \max(R,G,B)\,, S = \frac{V-\min(R,G,B)}{V} \tag{1}$$

$$r' = \frac{V-R}{V-\min(R,G,B)} \quad g' = \frac{V-G}{V-\min(\mathrm{R,G,B})} \quad b' == \frac{V-B}{V-\min(\mathrm{R,G,B})} \tag{2}$$

Then

$$H' = \begin{cases} 5+b', R = \max(R,G,B) \; and \; G = \min(R,G,B) \\ 1-g', R = \max(R,G,B) \; and \; G \neq \min(R,G,B) \\ 1+r', G = \min(R,G,B) \; and \; B = \min(R,G,B) \\ 3-b', G = \min(R,G,B) \; and \; B \neq \min(R,G,B) \\ 3+g', B = \min(R,G,B) \; and \; R = \min(R,G,B) \\ \quad 5-r', \quad others \end{cases} \tag{3}$$

Where $H = 60 \times H'$, it is obvious that $H \in [0, 360^{\circ}]$, $S \in [0,1]$, $V \in [0,1]$.

### B. Color Histogram

HSV color space feature extracts from image based on the global, an important method of retrieval, which is easy to extract, convenient to compare the similarity and insensitive to rotate and resize of image. Let $(f_{xy})_{M\times N}$ represent the image, where the $f_{xy}$ is the composite value of HSV color space. The size of picture is defined as $M \times N$ . The comprehensive value of HSV

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is obtained by uniform quantization whose detailed information describes as follow:

Given quantitative value $qh = 32, qs = 8, qv = 1$

$$QH = qh \times \frac{H}{360}, QS = qs \times S, QV = qv \times V \quad (4)$$

$$f_{xy} = QH \times qv \times qs + QS \times qv + QV \quad (5)$$

Then, using the formula (6) to express the histogram of HSV color space, which defined as:

$$\mathrm{h_c} = \frac{1}{M \times N} \sum_0^{M-1} \sum_0^{N-1} \delta\left(f_{ij} - c\right), \forall c \in C \quad (6)$$

Where $C$ means all the value of the comprehensive of HSV.

### C. Color Moment

Stricer and Orengo [9] proposed another effective and simple method, color moment, using statistical approach. It is found that color information is distributed in the low color moment, especially for first, second and third order. Thus, Mean, Variance and skewness enough to represent the distribution of color feature in an image.

Considering RGB color space, a simple statistics information of color can be derived as:

$$\mu_i = \frac{1}{n} \sum_{j=1}^{n} h_{ij} \quad (7)$$

$$\sigma_i = \left(\frac{1}{n} \sum_{j=1}^{n} (h_{ij} - \mu_i)^2\right)^{\frac{1}{2}} \quad (8)$$

$$s_i = \left(\frac{1}{n} \sum_{j=1}^{n} (h_{ij} - \mu_i)^3\right)^{\frac{1}{3}} \quad (9)$$

Where $h_{ij}$ is the value of *ith* color channel in *jth* pixel, and n is the total number of pixels. With the channel of RGB, every channel has three low order moments, so the color moment of image has 9 components.

## II. AN IMPROVED ALGORITHM OF COLOR FEATURE

In section 3, we review two global color feature that are color histogram of HSV and color moment of RGB. These methods ignore the local spatial information of image which deceases the precision of retrieval. Furthermore, In the HSV color histogram feature, the dimension of 256 is too high, increasing the complexity of similarity calculation and wasting the space of feature storage. So exploring an improved algorithm that reduces the dimension of color feature and combines the color information of whole and part is essential.

First, we solve the fault in high color dimension. In this section, in order to reduce the dimension of feature effectively, we introduces fuzzy color histogram. Through this method, the color feature can be down to 24 dimensions.

### A. Fuzzy Color Histogram

The algorithm mainly divides into three parts, including RGB color space transformation to HSV, fuzzy filtering of 10 bins, and fuzzy filtering of 24 bins.

#### 1) The transformation of RGB model to HSV model

Although the formulation of RGB to HSV is a slightly different with the transformation of section 2, the principle of this two methods is same, the value range of S and V, 0 to 255, is not same as traditional HSV transformation. The detailed steps to compute it show as follow:

$$V = \max(R, G, B), S = 255 - \frac{255 \times \min(R,G,B)}{\max(R,G,B)} \quad (10)$$

Case1:

$R = \max(R, G, B)$ *and* $G < B$, $\mathrm{H} = \frac{60 \times (G-B)}{\max(R,G,B) - \min(R,G,B)}$.

Case2:

$R = \max(R, G, B)$ *and* $G \geq B$, $\mathrm{H} = \frac{359 + 60 \times (G-B)}{\max(R,G,B) - \min(R,G,B)}$.

Case3:

$G = \max(R, G, B)$, $\mathrm{H} = \frac{119 + 60 \times (B-R)}{\max(R,G,B) - \min(R,G,B)}$.

Case4:

$B = \max(R, G, B)$, $\mathrm{H} = \frac{60 \times (G-B)}{\max(R,G,B) - \min(R,G,B)}$.

The initial condition of calculating HSV value is dividing image into blocks of $40 \times 40$ areas, then converting RGB space to HSV space for all 1600 areas and obtaining its average value. With the fuzzy filtering, the following can acquire the information of color feature.

#### 2) Fuzzy Filter Of 10 Bins

The working process of 10 fuzzy filter is based fuzzy theory [10] that through three HSV channel we can obtain the fuzzy color histogram of ten that means black, gray, white, red, orange, yellow, green, cyan, blue, magenta. This principle is shown in Fig. 1.

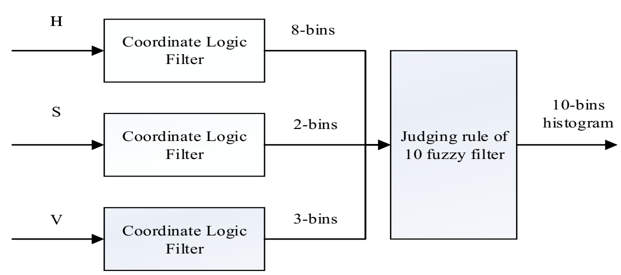


Fig. 1. 10 fuzzy filter principle

When making transition from one color to another color, the fuzzy theory considers that the value of H shifts fast, creating the radial edge of color. Instead of calculating exact value of HSV space, we get 8 fuzzy area of H, which is divided into red to orange, orange, yellow, green, cyan, blue, magenta, and blue to red. Every two adjacent regions have cross section, and a more intuitive display as shown in Fig. 2.

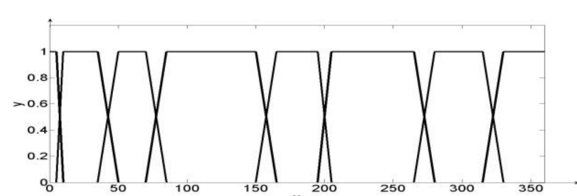


Fig. 2. H channel distribution of radial edge

Fig 2 shows that each area has the minimum H value of local area, the maximum of last area, the minimum H value of next area, and the maximum H value of local area, jointing the four value to get 8 vector space areas, which are ((0,0,5,10), (5,10,35,50), (35,50,70,85), (70,85,150,165), (150,165,195,205), (195,205,265,280), (265,280,315,330), (315,330,360,360)). Given an arbitrary H value of 0-360, we can determine which area H belongs to. When H value down into the region of $x_1$ to $x_2$, the weight of color zone is 1, other cases will be a smaller value. Fig. 3 shows the detailed calculation method. The fuzzy theory of V and S channel is same as H channel, where the vector interval of S is divided into ((0,0,20,110) , (20,110,255,255)) and V is divided into ((0,0,50,80), (50,80,255,255), (20,110,255,255)).

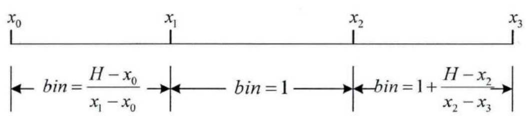


Fig. 3. Calculation method of H area

From the above analysis, the value of HSV is given, so it is urgent to constructing a HSV synthesis rule. The priority of HSV from high to low is V, S, and H. TABLE I shows the judging rule of 10 fuzzy filter, noting that the final combined value is the minimum of HSV.

TABLE I. THE JUDIING RULE OF 10 FUZZY FILTER

| V area | S area | H area | Color |
|---|---|---|---|
| 1 | — | — | Black |
| 2 | 1 | — | White |
| 3 | 1 | — | Gray |
| 2 or 3 | 2 | H | According to the H area |

### 3) *Fuzzy Filter Of 24 Bins*

24 bins fuzzy filter is further strengthening of 10 bins filter, whose channel is output color of 10-bins fuzzy filter, S channel and V channel, making the output to 24 dimensions. The principle of 24 bins fuzzy filter is shown in Fig. 4.

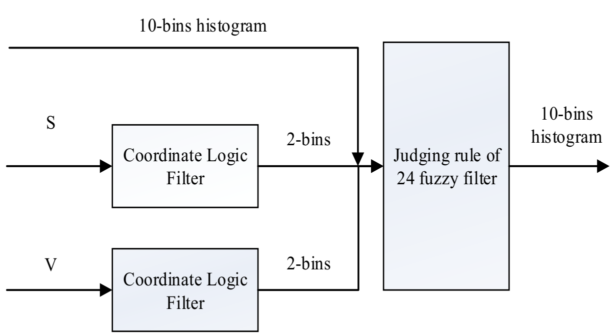


Fig. 4. 10 fuzzy filter principle

Except black, gray and white, each color has the level of deep, medium and light. In this part, the vector space area of S and V both are ((0,0,50,138) , (50,138,255,255)). The decision of the area to which it belongs is similar to 10 fuzzy filter. Table II shows the judging rule of 24 fuzzy filter, because the color of black, white and gray has been determined by 10-bins fuzzy filter, noting that except black, white and gray the final combined value is the minimum of SV multiplying the output value of 10-bins fuzzy filter. In TABLE II the seven colors stand for red, orange, yellow, green, cyan, blue and magenta, so the 24 colors contain black, white, gray and three different color saturation of the seven colors.

TABLE II. THE JUDIING RULE OF 24 FUZZY FILTER

| V area | S area | Output color of 10-bins fuzzy filter | Color |
|---|---|---|---|
| 1 | — | Seven colors | Seven deep colors |
| 2 | 1 | Seven colors | Seven light colors |
| 2 | 2 | Seven colors | Seven medium colors |

Through the above analysis, we overcome the drawback of high dimension for color extracting. In the next step the block color moment is proposed to make up the deficiency of color location information

## *B. Block color moment*

In this paper, we propose a closer related block color moment, using the method of average division, which divides picture to $3 \times 3$ sub-blocks. Just as the Fig. 5 shows, for each sub-blocks, calculating the three order color moments that is $\mu_r, \sigma_r, s_r, \mu_g, \sigma_g, s_g, , \mu_b, \sigma_b, s_b$ . From the first to last sub-blocks, arranging the color moments by the order. This approach extends color moment to 81 dimensions and is effective to solve the problem of local color information.

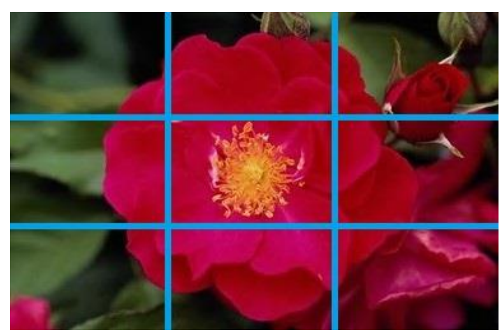

Fig. 5. Block color moment

## *C. The Combination of Fuzzy Color Histogram and Block color moment*

Integrating the HSV and RGB color space, taking full account of color information of global and local, we take a way of fusion algorithm that combines fuzzy color histogram and block color moment. The new fusion algorithm has the advantages of low dimensions, small storage space and useful color location information. Its algorithm process is as Fig. 6.

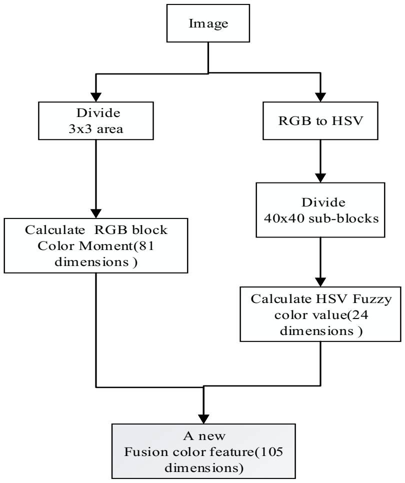


Fig. 6. The process of the improved algorithm

## III. EXPERIMENT RESULTS AND ANALYSIS

### A. *Retrieval technique & Test environment*

In this experimental, we stored the extractive data and index of color feature space by the Lucene, a highly efficient Java search library, which also provides powerful retrieval function All the algorithm are implemented by Java language, TABLE III explains the test environment configuration.

TABLE III. ENVIRONMENT CONFIGURATION

| CPU | Memory | Operating system | GPU |
|---|---|---|---|
| Intel(R) Core(TM) i7-2600 CPU @ 3.40GHz 8 core | 4095 MB | Windows 8 Professional 64 bit | NVIDIA GeForce GT 420 |

### B. *Performance evaluation*

In order to evaluate the proposed algorithm, we must select the appropriate image database and the criteria of performance evaluation. In this paper, a various kinds of image database, COREL1000, is used, choosing the Euclidean distance as the methods of similarity comparison. It is not easy to judge the performance of image retrieval algorithm. At present precision, there are several recognized evaluation criteria of image retrieval algorithm, including recall, hit accuracy, ANMRR, the precision of first n terms. In our experiment, we choosing the precision of first N terms as evaluation criteria, which is defined as Formula 11.

$$P_{N(q_i)} = \sum_{j=1}^{N} \frac{\emptyset(I_j,R)}{N} \qquad (11)$$

$$\emptyset(I_j,R) = \begin{cases} 0, \ if \ I_j \notin R \\ 1, if \ I_j \in R \end{cases} \qquad (12)$$

Where N means the returned N results of image retrieval, and $q_i$ represents an example image that belongs to R set. R is the collection of the specific meaning of the database.

### C. *Experimental results*

In this experiment, we compare five kinds of color feature extraction, including uniform HSV histogram of 256 dimensions, non-uniform quantization HSV histogram of 72 dimensions, fuzzy HSV histogram of 24 dimension, block color moment, the improved color feature. The image database COREL1000 that has 10 kinds of category (African, Seaside, Building, Bus, Dinosaur, Elephant, Flower, Horse, Snow Mountain, Food), and each category contains 100 picture. Fig. 7 display the image database vividly, and f Fig. 8 gives an example of the image retrieval by the proposed algorithm.

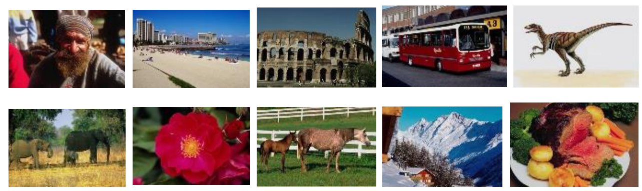

Fig. 7. Categories in the image database

Fig. 8. Image retrieval example

Experiment proves the superiority of the improved algorithm, figuring the 1000 image retrieval accuracy by the means of the precision of first N terms as evaluation criteria. Further more, we gather statistical data of average accuracy of each categories and the overall average accuracy of image database to validate the efficiency of the improved algorithm. Except retrieval accuracy, feature dimensions and color space information should also be taken into consideration. TABLE IV shows the results of these experiments, noting that accuracy is the overall average accuracy based on first 15 terms.

TABLE IV. COMPARISON OF THE FIVE ALGORITHM

| Retrieval Algorithm | accuracy | dimension | Color Location information |
|---|---|---|---|
| Uniform quantization histogram | 53.01% | 256 | NO |
| non-uniform quantization histogram | 60.01% | 72 | NO |
| Block color moment | 58.90% | 81 | YES |
| Fuzzy color histogram | 62.45% | 24 | NO |
| The imporved algorithm | 66.03% | 105 | YES |

For average precision of each categories in the image database, which can be show in Fig. 9. It is evident that the improved algorithm has a better retrieval precision than others algorithm in the most of category, which testify the superiority of improved algorithm in the local class. For example, the improved algorithm's precision of category of African is 65.33%, 5.4% percent higher than the second highest fuzzy color histogram.

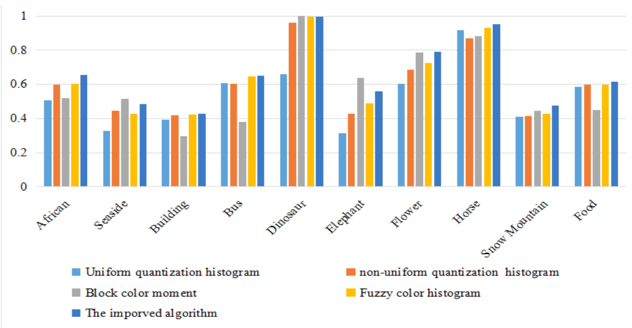


Fig. 9. The precision of first 15 terms

Fig. 10 shows the average precision of overall image database, which is the average precision of 1000 images. Test criteria included the precision of first 15 terms, 20 terms and 30 terms. Two interesting results were observed from these experiments. First, with the number of return image increasing, all the algorithm's precision decrease. The second interesting result is that the improved algorithm's precision is highest in all the return terms.

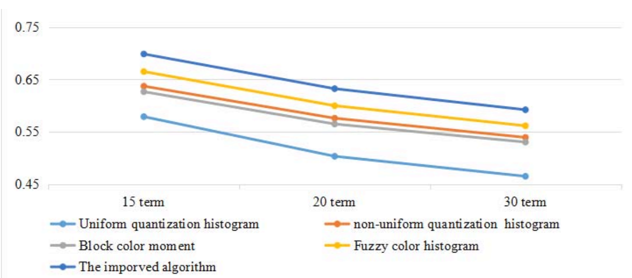


Fig. 10. The precision of first 15 terms

## IV. Conclusion

This paper presents an improved algorithm for extracting color feature, which is effective for image retrieval. Instead of using traditional color histogram and color moment, the algorithm combines the color fuzzy histogram and block color moment, which fully consider the whole color information and local color information. It solves the disadvantage of high dimension of simple color histogram and saves the storage space in image retrieval system. In experiment, we can found that no matter in each category or in overall image database, the retrieval precision of the improved algorithm both has a better performance than the others algorithm. Finally, as a color feature extraction algorithm, the improved algorithm extracting color feature from RGB and HSV color space is more comprehensive and careful.

The next steps involves a retrieval velocity adding to evaluation criteria. Meanwhile, our algorithm not extracted shape and texture feature, so in the future, we will fusing others effective feature.

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