

Thangka Image Retrieval Method Based on Sub-block Dominant Color

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Abstract. In the light of the problem of lacking spatial knowledge of global color histogram and the characteristics of Thangka images, a method based on overlapping partition dominant color is presented. Translating color space from RGB to HSV, it designs overlapped sub-block to get the dominant color in each block. According overlapping partition model, the weight of every sub-block can be computed. Meanwhile, the reduced quadratic form distance method is applied to decrease arithmetic complexity. Similarity is calculated based on the dominant color feature of each partition. Experimental results show this approach is better than the method based on global dominant color; it can greatly reduce the dimension of color feature, and keep high retrieval precision simultaneity.

Introduction

Color is an important feature describing image content, and it is also the people's main perception of image. It is that color has merits of rotation and scale invariance and high computation speed with low requirements on storage space for complex images, so it is widely used in image classification and retrieval technologies based on content.

At present, many scholars home and abroad have put forward various color-based image retrieval technologies. For example, Swain early realized an image retrieval system using color histogram, and the similarity between images was measured by histogram intersection [1]. The calculation of global color histogram is quite simple, however, it does not involve the spatial information of colors. Stricker M proposed the block-based color histogram and color moment method [2]. Namely, segment image into several sub-blocks, and then compute every sub-block's color histogram respectively. This approach is simple and feasible, but the unsatisfactory is that it increases the cost of time and space and fails to find rotated or translated images that are similar to query images. Main color matching method is proposed by Kankahalli [3]. Extract image's main color with cluster analysis, and apply the dominant color to similarity matching between images. Like literature [1], this method does not reflect colors' space content, although it is simple.

In order to overcome the defects existing in methods above, achieve a better retrieval results, the approach based on sub-block dominant color is put forward by many scholars [4-8]. Divide image into fixed sub-blocks, and then calculate the distance between two sub-blocks according to corresponding dominant color feature. Then the distance between two images can be computed using weighted summation.

Compare with natural landscape and building pictures, Thangka images' color is rich and structure is complex. In this paper, a method of color feature extraction is presented in the light of Thangka. In HSV space, segment images into several partitions, and then extract sub-block's dominant color, build a Thangka image retrieval system finally using main color feature. Finally, comparing this method with the global dominant color, the experimental results show that this approach increases color spatial information, indeed improves the Thangka retrieval performance.

Algorithm Description of Method Based on Sub-Block Dominant Color

The Conversion and Quantification of the Color Space

RGB space is a common color representation. But this representation is deficient in visualization. Given a RGB value, people cannot perceive the corresponding color because that RGB space does not represent color with consistent scale. So this space does not meet human psychological perception. In order to make the definition of color fit more closely with human perception in this algorithm, it is necessary to convert the image color from RGB space to HSV space. Define $v^* = \max(r, g, b)$, and $r, g, b \in [0, 1, \dots, 255]$, The conversion formula (1), (2), ..., (7) are showed below.

$$r^* = \frac{v^* - r}{v^* - \min(r, g, b)} \quad (1)$$

$$g^* = \frac{v^* - g}{v^* - \min(r, g, b)} \quad (2)$$

$$b^* = \frac{v^* - b}{v^* - \min(r, g, b)} \quad (3)$$

$$h^* = \begin{cases} (5 + b^*), & r = \max(r, g, b), g = \min(r, g, b) \\ (1 - g^*), & r = \max(r, g, b), g \neq \min(r, g, b) \\ (1 + r^*), & g = \max(r, g, b), b = \min(r, g, b) \\ (3 - b^*), & g = \max(r, g, b), b \neq \min(r, g, b) \\ (3 + g^*), & b = \max(r, g, b), r = \min(r, g, b) \\ (5 - r^*), & b = \max(r, g, b), r \neq \min(r, g, b) \end{cases} \quad (4)$$

$$h = 60 \times h^* \quad (5)$$

$$s = \frac{v^* - \min(r, g, b)}{v^*} \quad (6)$$

$$v = v^* / 255 \quad (7)$$

After the color space transformation above, $h \in [0, 360]$, $s, v \in [0, 1]$.

Considering colors are abundant in an image, especially for true color image, the number of color histogram's dimensions is very big. Therefore, it is necessary to quantify HSV space to cut down the amount of calculation and improve the efficiency of retrieval. Quantify the three components asymmetrically separately: divide H into eight levels, S and V into levels. Specific color quantization and coding methods are showed in the following formula (8),(9) and (10).

$$H = \begin{cases} 0 & h \in [316, 20] \\ 1 & h \in [21, 40] \\ 2 & h \in [41, 75] \\ 3 & h \in [76, 155] \\ 4 & h \in [156, 190] \\ 5 & h \in [191, 270] \\ 6 & h \in [271, 295] \\ 7 & h \in [296, 315] \end{cases} \quad (8)$$

$$S = \begin{cases} 0 & s \in [0, 0.2) \\ 1 & s \in [0.2, 0.7] \\ 2 & s \in (0.7, 1] \end{cases} \quad (9)$$

$$V = \begin{cases} 0 & v \in [0, 0.2) \\ 1 & v \in [0.2, 0.7] \\ 2 & v \in (0.7, 1] \end{cases} \quad (10)$$

A 1-D feature vector L is created with the quantified level of HSV, as shown in formula (11).

$$L = Q_s Q_v H + Q_v S + V \quad (11)$$

$Q_s = Q_v = 3$, and Q_s, Q_v represent the quantified level of s and v . For every HSV value, there is a corresponding L . So H, S, V distribute in the vector L , which has 72 values. In other words, we

quantify the all colors in images to 72 colors, and based on these quantified colors, calculate the dominant color of every sub-block.

Division Strategy of Thanka Image

Global color histogram only involves the statistical information of color, does not reflects the spatial distribution. In order to resolve this problem, it is necessary to segment images into several sub-blocks. Traditional division strategy is to segment image into $m \times n$ sub-blocks, but it doesn't emphasize the body part in middle of image. For Thangka images, the Buddha can be divided into different sub-blocks, which lead to destruction of the integrity of image body.

Generally main part of image is in the center while other parts are surrounding. The number of sub-block will directly affect operation efficiency and retrieval effect. It is because that if the number of sub-block is small, which cuts down storage space at the cost of low space resolution; On the contrary, if the number is big, it inevitably increases storage space and makes the main part of Thangka into different blocks, which results in degradation of the retrieval performance. Considering the complex structure and generous colors, an overlapping division method suitable for Thangka is presented.

First of all, segment Thangka images into 8×4 sub-blocks evenly, which are showed in Fig.1.

Fig.1 32 sub-blocks

P11	P12	P13	P14
P21	P22	P23	P24
P31	P32	P33	P34
P41	P42	P43	P44
P51	P52	P53	P54
P61	P62	P63	P64
P71	P72	P73	P74
P81	P82	P83	P84

Fig.2 The occurrence number of sub-blocks

1	2	2	1
1	2	2	1
2	3	3	2
2	3	3	2
2	3	3	2
2	3	3	2
1	2	2	1
1	2	2	1

Based on these 32 sub-blocks, overlapping blocks are:

$$A = \{p_{11}, p_{21}\}, B = \{p_{14}, p_{24}\}, C = \{p_{71}, p_{81}\}, D = \{p_{74}, p_{84}\},$$

$$E = \{p_{31}, p_{32}, p_{41}, p_{42}, p_{51}, p_{52}, p_{61}, p_{62}\}, F = \{p_{12}, p_{13}, p_{22}, p_{23}, p_{32}, p_{33}, p_{42}, p_{43}\},$$

$$G = \{p_{33}, p_{34}, p_{43}, p_{44}, p_{53}, p_{54}, p_{63}, p_{64}\}, H = \{p_{52}, p_{53}, p_{62}, p_{63}, p_{72}, p_{73}, p_{82}, p_{83}\},$$

$$I = \{p_{32}, p_{33}, p_{42}, p_{43}, p_{52}, p_{53}, p_{62}, p_{63}\}.$$

In above blocks, E, F, G, H, I are overlapping. The central part of image is surrounded three times but four corners are surrounded only one time during the course of segmentation in this approach. It not only avoids the destruction of the integrity of the Buddha of Thangka, but it also emphasizes body part at the same time.

Secondly, assign different weights to different sub-block. In general, the body of image should have a larger weight while the surrounding parts have relative small weights. After segmentation, for every sub-block $P_{ij}, i=1,2,\dots,8, j=1,2,3,4$, its corresponding occurrence number in the process of segmentation k_{ij} is showed in Fig.2.

According to Fig.2, we can get every sub-block's weight using formula (12).

$$w_{ij} = k_{ij} / \sum_{i=1}^8 \sum_{j=1}^4 k_{ij} \quad i=1,2,\dots,8, j=1,2,3,4 \quad (12)$$

Extraction Dominant Color and Computing Similarity

Dominant color is what has a higher frequency and plays a more important role in semantic information expressing. It represents original image with fewer colors or one color, but it is visually very similar to original image, which greatly reduces the dimension of color. When we observing one image, vision system tend to catch some colors representative and ignore subordinate color details. Apply dominant color to the retrieval of Thangka with lots of colors.

The method of extracting dominant color in this paper is that: translate color space from RGB to HSV, adopt above division strategy to segment image into 32 sub-blocks, and finally assign weight for per sub-block. Calculate color histogram with 72 kinds of colors for every block, and then find the color accounting for most pixels. Namely, the color is the dominant color of this sub-block, it is the color feature of this sub-block too.

When retrieving, calculate the main color for all blocks first, and then compute distance of corresponding sub-block. Similarity between images is measured using weight sum method based on distances of all sub-blocks. Query image is Q , and base image is P , quadratic form distance is showed in formula (13).

$$D = (P - Q)^T A (P - Q) \quad (13)$$

Q, P represent separately the histogram information of query image and base image. A is the similarity matrix, and $A = [a_{ij}]$ is the distance between indexes i, j in color histogram. Due to the large time consumption of A , simplify $a_{ij} = 2^{-|i-j|}$, as shown in the following formula (14).

$$D_i(P, Q) = P_i^2 + Q_i^2 - 2P_iQ_i a_{P,Q_i} \quad (14)$$

$D_i(P, Q)$ is distance of corresponding sub-block i . For weight of every block, the final distance between images is computed using weight sum method in formula (15).

$$D(P, Q) = \sum_{i=1}^{32} w_i D_i(P, Q) \quad (15)$$

The Steps of Retrieval Algorithm Based on Sub-block Dominant Color for Thangka

Here, we get the framework of the retrieval method based on sub-block dominant color for Thangka in Fig.3.

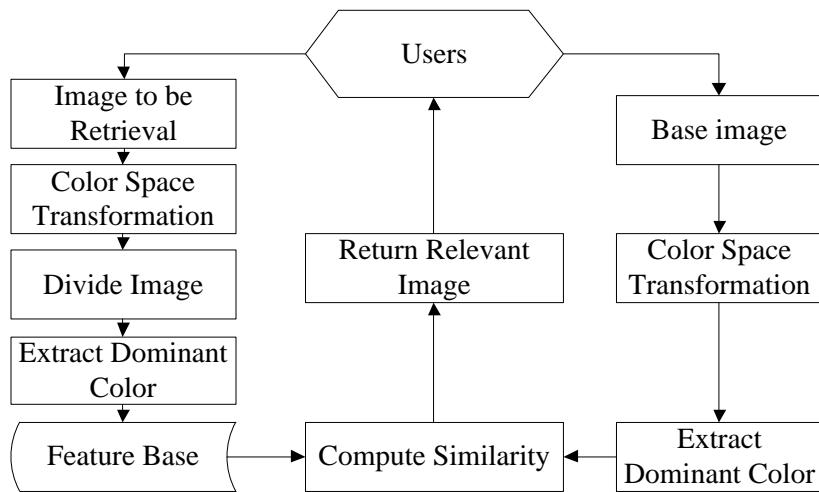


Fig.3 The framework of Thangka image retrieval algorithm

When users input a Thangka image into retrieval system, the algorithm can retrieval similar images to users according to the following steps:

Step1. Convert Thangka images into .bmp format.

Step2. Process Thangka images using Gaussian filter to remove noises.

Step3. Normalize Thangka images to 240×320 .

Step4. Translate and quantify Thangka images' color: transform color space from RGB to HSV, and quantify these components into 72 colors respectively.

Step5. Divide Thangka image into 32 sub-blocks evenly. On this 32 blocks basis, $A, B, C, D, E, F, G, H, I$ are the overlapped blocks, in addition, compute the weight for different sub-block according to formula (12).

Step6. After computing the dominant color for every sub-block, we can get a main color matrix of an image.

Step7. Measure the similarity of base images and image to be retrieved using formula (14).

Step8. Calculate the distances between query image and every image in base, and order these distances, return relevant 15 images with relative small distances to users.

Analysis and Comparison of the Experimental Results

According to the method above, we realize a Thangka image retrieval system based on sub-block dominant color, namely method One. In order to compare with the global dominant color, we also build another Thangka image retrieval system, namely method Two. All experiments ran on PC with Core i7 3.4GHZ CPU and 4GB memory.

Recall and precision are the basic criteria for evaluation of retrieval quality in image retrieval systems. Recall ration reflects the ability of retrieval system to retrieve relevant images, while the precision ration reflects retrieval system ability to refuse irrelevant images. The higher the precision ratio and recall ration are, the better image retrieval results will be. However, for most image retrieval systems, these two ratios cannot reach maximum at the same time. In general, if precision is higher, the recall is low. On the contrary, recall is higher with precision low. When designing retrieval system, we should optimize these two ratios as far as possible.

In our experiments, these two image retrieval methods have the identical image library and image to be retrieved. The query image is Gem Source Tara. There are 100 Thangka images in the image library and 17 relevant images. The number of return image in two systems is 15. Experimental results of method one is showed in Fig.4, Fig.5, Fig.6, and the comparison of two methods is showed in table 1.

From the table 1, we know clearly that method One has a higher precision ratio and recall ratio than method Two. Through the comparison, a conclusion is: the method based on sub-block dominant color is better, and it meets users' needs in general, so it is suitable for Thangka image retrieval.



Fig.4 query image: Gem Source Tara



Fig.5 retrieval system interface



Fig.6 The partial simple of Thangka image retrieval based on method One

Table 1. Comparison of the two methods

method	Image library	Result number	Return relevant image	Precision ratio%	Recall ratio%
One	100	15	13	86.7	60
Two	100	15	9	65	45

Conclusion

Compare with general natural images, color is a more important feature for Thangka retrieval. However, global main color reflects the statistical information of color without spatial distribution. It is necessary to divide image into several sub-blocks to solve the problem. Traditional partition strategy is segment image evenly, for Thangka with complex structure, this strategy tends to destruct the body integrity of Thangka. Taking the characteristics of Thangka images into consideration, an overlapping partition model is proposed. According to the occurrence number of sub-block calculate the weight in the model, and finally measure the distance using reduced quadratic form method. Experimental results show that this method cuts down the dimension of color feature and calculation amount, what is more, it indeed has a higher precision ratio and recall ratio than method based on global dominant color. So this method is better and meets the needs of users in general.

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