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A Semantic Multi-Query Image Search System with Analytical Function for Representative Query Color Generation

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Abstract

The effective analyzing query method is indispensable to image search system that is needed to retrieve appropriate images. The image search system commonly uses a content based search for the retrieval with a single query. In case of culture related images those treasure set of impressions behind the feature contents, the image search needs to provide more flexible query model to apprehend what the user wants to retrieve. This paper presents a new model for representing the user impressions by providing a semantic multi-query image search system. The proposed multi-query model provides an analytical function to semantically generate the representative query color features. The function consists of four steps: (1) The normalized 3D-Color Vector Quantization for local extraction of color features in an image, (2) Measurement of color distribution among image queries by calculating average and standard deviation of extracted color features, (3) Adaptive adjustment of representative colors by measuring the density of the color distribution, and (4) Identification of representative colors by applying cluster based similarity measurement of the color density. To perform our proposed semantic multi-query image search system, we examine our system with a SIMLIcity Dataset containing 1000 images with 10 categories. We also apply our semantic multi-query model to the Indonesian cultural paintings for the applicability of the culture based image search.

Keywords: image search system, semantic multi-query model, representative color identification.

1. Introduction

The increasing growth of the internet technology extends inter-media exchanges including image data. An efficient image searching, browsing, and retrieval systems are widely developed in order to provide better ways and approaches for such kinds of activities. Many researchers and developers developed an efficient image searching, browsing, and retrieval systems 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 [9] presented an image search system utilizing color information inside an image. VisualSeek [10] introduced a system by diagramming spatial arrangements from representation of color regions. NETRA [11] developed a CBIR system with combination of color and texture features. Virage [12] presented extraction of features with color, texture, and shape for the image retrieval engine. CoIRS [13] also introduced an image search system with combination of color, shape and structure features using a cluster oriented image retrieval system. Veltkamp and Tanase [14] and Liu et al [15] presented a survey to many image retrieval systems using diverse features.

The image search system commonly uses a content based search for the retrieval with a single query. In case of culture related images those treasure set of impressions behind the feature contents, the image search needs to provide more flexible query model to apprehend what the user wants to retrieve. Dealing with this problem, Hayashi et al. [6] has been proposed a combined-image query by providing operators in the query creation process. Barakbah et al. [7] presented a multi-image query for retrieval with providing a series of emotional contexts. Sasaki et al. [16] presented a dynamic image-query creation and metadata extraction method with semantic correlation computation between color-combinations and impressions of multiple image data. The queries are created by the combination of multiple image sets and operations, which are intersection, accumulation, average, difference of color elements of sample images. Ngunyen et al. [17] presented a dynamic image-query creation method for imagination-based image search system and its application for travel information associated with scenery images.

2. Proposed System

In this paper, we present an image search system with a new model for representing the user impressions by providing a semantic multi-query image search system. The proposed multi-query model provides an analytical

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function to semantically generate the representative query color features. The proposed multi-query model provides an analytical function to semantically generate the representative query color features. A new computational function is presented to manipulate the multiple image queries given by users. Figure 1 shows the system architecture of our semantic multi-query image search system.

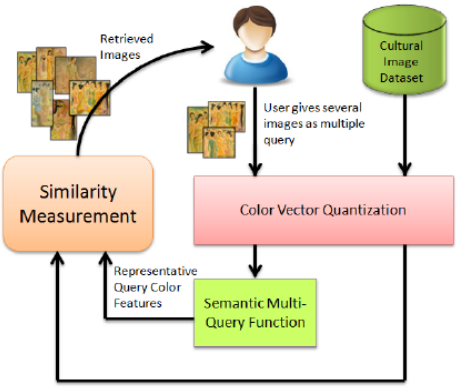

Figure 1. System architecture of the proposed semantic multi-query image search system

3. System Design

A new model for representing what the users want to retrieve is presented by providing a semantic multi-query image search system. To realize the more flexible query system, we propose a semantic multi query function to semantically generate the representative query color features. The proposed semantic multi query function consists of four steps to proceed the multiple image queries given by users and then generate the representative query color features, as shown in Figure 2.

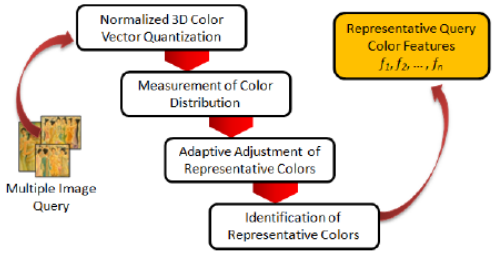

Figure 2. A Semantic multi query function to generate the representative query color features

3.1. Normalized 3D Color Vector Quantization

This step is used for extraction the color features of image dataset and multiple image query given by users. In this step, the color information of the image dataset and the image query is extracted using the histogram from 3D-Color Vector Quantization of RGB color space, and then quantized in 64x64x64 size of the RGB color space to 125 positions in the RGB color space, shown in Figure 3. The formula of image quantization can be shown by Eq. 1.

$$H_i = \sum_{j=1}^{j=n} H_j \begin{cases} H_j = 1 \leftarrow \min(\mathrm{D}(RGB_j, RGB_i)) \\ H_j = 0 \leftarrow \text{Otherwise} \end{cases} \quad (1)$$

Where H_i is histogram of 125 positions in RGB color space, H_j is the image pixel, n is the number of pixels, $\mathrm{D}(RGB_j, RGB_i)$ is the distance between RGB color of pixel $_j$ and RGB of 125 color position.

Considering that the sizes of image queries could be various, calculation of the local average is needed to normalize the features.

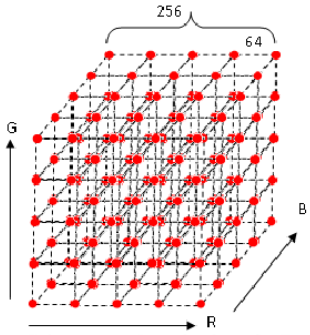

Figure 3. 3D-Color Vector Quantization of RGB color space

3.2. Measurement of Color Distribution

This step measures the information of color distribution by statistically calculating average by Eq. 2. and standard deviation by Eq. 3. of extracted color features. This step is important to find the dominant colors among image queries and the variance to those dominant colors.

$$Avg = \frac{\sum_{i=1}^{imgquery} locAvg_i}{imgquery} \quad (2)$$

$$SD = \frac{1}{imgquery} \sqrt{\sum_{i=1}^{imgquery} (locAvg_i - \overline{locAvg})} \quad (3)$$

Where *Avg* is color average, *SD* is standard deviation , *imgquery* is the number of image query, *locAvg* is color local average.

3.3. Adaptive Adjustment of Representative Colors

After calculating the average and standard deviation of extracted color features, we need to measure the density of the color distribution to find the representative colors. The ideal representative colors should fulfill two conditions:

(1) The color feature has a high average value that means that the color appears in many pixels.

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(2) The color feature has a low standard deviation value that means that the color is almost dominant in every image queries.

Considering those two conditions, we can calculate the density of the color distribution by Eq. 4.

$$Density = \frac{avg(f_i) + \alpha}{sd(f_i) + \alpha} \quad (4)$$

where $avg(f_i)$ is average value of color feature f_i, $sd(f_i)$ is standard deviation of color feature f_i and α is a small determination to avoid zero-division.

3.4. Identification of Representative Colors

After calculation of the density of the color feature, this step is used to identify the representative colors. We apply a cluster based similarity measurement of the color density. Because we cannot exactly determine how many clusters are appropriate for the color density, the automatic clustering is needed to identify how many cluster should be used. In this case, we use our automatic clustering Valley Tracing algorithm [8]. After clustering the color density, the automatic filtering is applied to filter the non-representative clusters out those are locates near zero vector. The rest of the cluster is selected and the members of those clusters are the representative color features.

4. Experimental Study

To perform our proposed semantic multi-query image search system, we examine our system with two kinds of datasets which are SIMLIcity Dataset and Indonesian cultural painting Dataset. The use of each dataset in our experimental study is intended different purposes. The SIMLIcity Dataset is used to analyze the retrieval performance of our proposed semantic multi-query image search based on the feature content. While the use of the Indonesian cultural painting Dataset is intended to analyze the retrieval performance based on the similarity of semantic impression treasured in the image queries and the retrieved images.

(1) SIMLIcity Dataset

SIMLIcity Dataset containing 1000 images. These images are manually divided into 10 categories which are African people, beaches, historian buildings, buses, dinosaurs, elephants, roses, horses, mountains, and foods. For the experimental study, we use four images for each category as images query. We determine 15 top correct retrieved images for the query. We used the cosine distance metric to measure the similarity between the image query and the image dataset. Cosine distance metric formula can be shown by Eq. 5.

$$Similarity = \cos\theta = \frac{A.B}{||A||\,||B||} = \frac{\sum_{i=1}^{n} A_i \times B_i}{\sqrt{\sum_{i=1}^{n}(A_i)^2}\sqrt{\sum_{i=1}^{n}(B_i)^2}} \quad (5)$$

Where n is the number color metadata (125), A is representative color, B is local average of image database.

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

$$err = \sum_{i=1}^{15} err_i \begin{cases} err_i = 0\ , cat(retrv_i) = cat(query) \\ err_i = 0\ , Otherwise \end{cases} \quad (6)$$

We also make scoring to represent the precision of image retrieval by Eq. 7.

$$scr = \sum_{i=1}^{15} scr_i \begin{cases} = 15 - i + 1\ , cat(retrv_i) = cat(query) \\ = 0\ , Otherwise \end{cases} \quad (7)$$

Where err is the number of errors, scr is a score of precision, $cat(retrv_i)$ is category of retrieved image and $cat(query)$ is category of image query.

Figure 4-13 shows the multi-image query (shown by Qid) and the retrieved images respectively for all categories in SIMLIcity Dataset. Table 1 shows the performance of our proposed semantic multi-query image search system involving the error and the precision of the retrieval results. The performance of our proposed approach are compared with the same queries, but it is considered as single-query images. From the experimental result, the multi-query gave better performance in most categories for the retrieval results rather than the single-query.

Figure 4. The image query and the retrieved images for people category

Figure 5. The image query and the retrieved images for beach category

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Figure 6. The image query and the retrieved images for building category

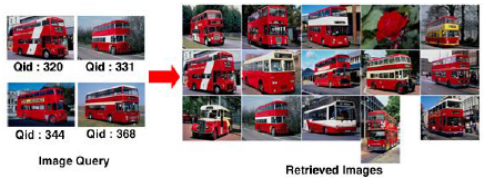

Figure 7. The image query and the retrieved images for bus category

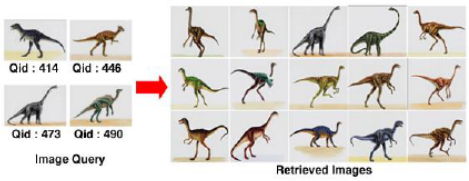

Figure 8. The image query and the retrieved images for dinosaur category

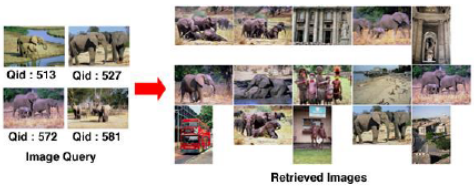

Figure 9. The image query and the retrieved images for elephant category

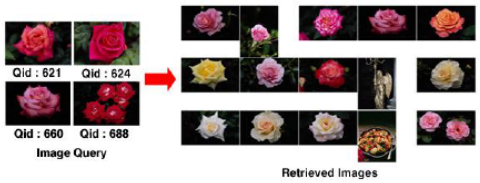

Figure 10. The image query and the retrieved images for flower category

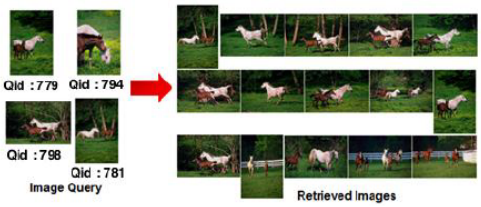

Figure 11. The image query and the retrieved images for horse category

Figure 12. The image query and the retrieved images for mountain category

Figure 13. The image query and the retrieved images for food category

(2) Indonesian Cultural Painting Dataset

We also apply our semantic multi-query model to the Indonesian cultural paintings for the applicability of the culture based image search. We used the Indonesian cultural paintings consisting 213 images painted by 48 Indonesian painters. We made 3 experiments for the Indonesian Cultural Printing dataset with different image queries. Figure 14 shows the results of retrieved images for the different combinations of image queries.

For performance analysis, we use the color-impression relationship discussed in Color Image Scale [18] and extract the 10-highly computed impression words from all image queries and all retrieved images. The precision ratio is calculated from the same impressions between the image queries and the retrieved images. Table 2 shows the impression of the image queries used for each experiment in Figure 14. We then compare the similarity of the impressions between the image queries and the retrieved images. Table 3 shows the extracted impressions from the retrieved images for Figure 14(a) and the similarity rate to the impressions of the image queries (similar impressions are showed by italic font).

From Table 3, we obtained the average similarity rate 54% for the experiment in Figure 14(a). For the experiment in Figure 14(b) and Figure 14(c), we obtained the average similarity rate 70% and 71.33% respectively. From the 3 experiment using Indonesian Cultural Painting Dataset, the system is able to retrieve more than half of total images those are similar to the image queries. Of course, the system is needed to improve the precision of the retrieval considering that the system retrieved some images those are not semantically close to the image queries.

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Table 1. The comparison of error and precision value between single-query and multi-query

Category	Qid	Cosine			
		Single-Query		Multi-Query	
		Error	Precision	Error	Precision
People	8	1	111		
	26	1	107	0	120
	54	4	100		
	76	0	120		
Beach	102	1	119		
	146	4	98	4	85
	149	4	95		
	159	11	27		
Building	242	5	90		
	270	7	74	7	77
	272	7	78		
	288	7	70		
Bus	320	0	120		
	331	6	75	1	108
	344	4	94		
	368	7	65		
Dinosaur	414	0	120		
	446	0	120	0	120
	473	0	120		
	490	0	120		
Elephant	513	1	117		
	527	4	92	7	72
	572	6	99		
	581	8	75		
Flower	621	2	108		
	624	3	104	2	111
	660	2	110		
	688	3	104		
Horse	779	2	111		
	781	0	120	0	120
	794	0	120		
	798	4	105		
Mountain	858	7	81		
	878	6	92	6	80
	880	9	54		
	881	9	50		
Food	908	3	98		
	921	6	79	3	98
	941	2	116		
	973	14	15		

Table 2. Image-query and retrieved images impressions of Indonesian cultural painting

Image Query	10-Highly Impressions
Figure 14(a)	provincial, calm, familiar, aromatic, natural, restful, pristine, simple quiet elegant, nostalgic, large hearted, domestic
Figure 14(b)	subtle and mysterious, solemn, chick, exact, sober, aqueous, earnest, authoritative, formal, lofty, sleek
Figure 14(c)	provincial, simple quiet elegant, sober, earnest, subtle and mysterious, simple and appealing, chic, solemn, assiduous, formal, aqueous

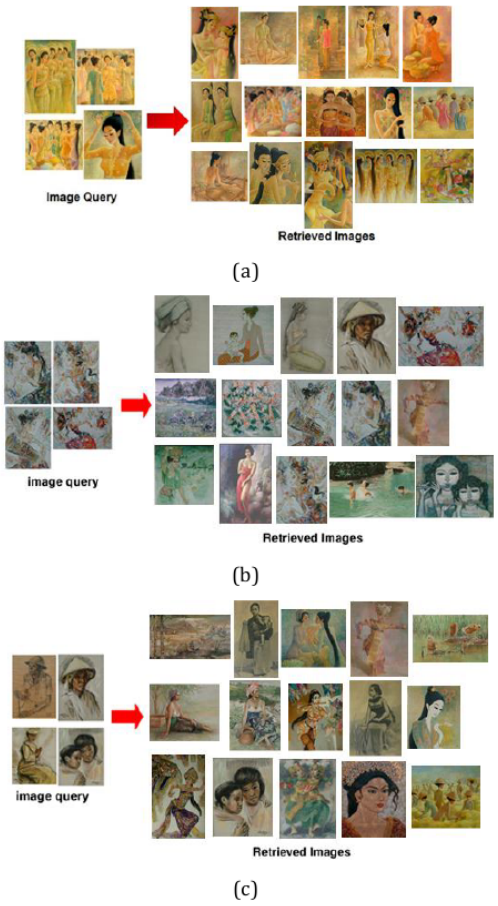

Figure 14. The image query and the retrieved images for Indonesian cultural paintings

5. Conclusion and Future work

In this paper we have presented an image search system with a new model for representing the user impressions by providing a semantic multi-query image search system. The proposed multi-query model provides an analytical function to semantically generate the representative query color features. The function consists of four steps: (1) The normalized 3D-Color Vector Quantization for local extraction of color features in an image, (2) Measurement of color distribution among image queries by calculating average and standard deviation of extracted color features, (3) Adaptive adjustment of representative colors by measuring the density of the color distribution, and (4) Identification of representative colors by applying cluster based similarity measurement of the color density. To perform the proposed multi-query model, the image search system is performed with a SIMLIcity Dataset and Indonesian

Table 3. Similarity rate between impressions of the retrieved images and the image queries (similar impressions are showed by italic font)

Ranked Results	10-Highly Impressions	Similarity Rate
1	*Aromatic*, *provincial*, *calm*, old fashioned, rustic, *nostalgic*, *simple quiet elegant*, *large hearted*, *familiar*, classic	70%
2	*Provincial*, *simple quiet elegant*, *calm*, *nostalgic*, *aromatic*, assiduous, old fashioned, placid, dry, *familiar*	60%
3	*Provincial*, *aromatic*, *simple quiet elegant*, old fashioned, *nostalgic*, rustic, pastoral, *calm*, *large hearted*, classic	60%
4	*Familiar*, *aromatic*, *calm*, *pristine*, *natural*, *large hearted*, *provincial*, gentle and elegant, *domestic*, pleasant	80%
5	*Aromatic*, *familiar*, *calm*, delicious, *large hearted*, rustic, gentle and elegant, *domestic*, *pristine*, *natural*	70%
6	*Provincial*, *simple quiet elegant*, old fashioned, assiduous, *nostalgic*, quiet and sophisticated, pastoral, elaborate, rustic, placid	30%
7	*Provincial*, *aromatic*, *simple quiet elegant*, *calm*, *nostalgic*, old fashioned, *large hearted*, *familiar*, rustic, classic	70%
8	*Aromatic*, rustic, old fashioned, *provincial*, pastoral, practical, traditional, classic, tasteful, placid	20%
9	*Familiar*, *aromatic*, *provincial*, *calm*, *natural*, *pristine*, *nostalgic*, *large hearted*, *simple quiet elegant*, old fashioned	90%
10	*Provincial*, *simple quiet elegant*, *aromatic*, *nostalgic*, *calm*, old fashioned, dry, rustic, Japanese, sober	50%
11	*Provincial*, *simple quiet elegant*, *calm*, *nostalgic*, *aromatic*, dry, placid, old fashioned, classic, modest	50%
12	*Provincial*, *simple quiet elegant*, old fashioned, *nostalgic*, assiduous, quiet and sophisticated, pastoral, rustic, subtle and mysterious, *aromatic*	40%
13	*Provincial*, *aromatic*, old fashioned, rustic, *simple quiet elegant*, *nostalgic*, *calm*, pastoral, bitter, assiduous	50%
14	*Provincial*, *simple quiet elegant*, rustic, old fashioned, *nostalgic*, bitter, *aromatic*, dry, pastoral, assiduous	40%
15	*Provincial*, *simple quiet elegant*, rustic, old fashioned, *nostalgic*, pastoral, bitter, assiduous, quiet and sophisticated, elaborate	30%

Cultural Painting Dataset. For the SIMLIcity Dataset, the proposed semantic multi-query image search system outperformed to the single-query in most categories. For the Indonesian Cultural Painting Dataset, the proposed system is able to retrieve more than 50% correct retrieved images to the image queries. For future work, the system needs more deep analysis for use of the analytical approach of feature extraction in order to improve the precision.

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