Image Retrieval System Based on Density Slicing of Colour Histogram of Images Subareas and Colour Pair Segmentation

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Abstract: *Techniques to identify objects within an image and searching for similar objects in the database is not claiming a lot of progress, due to the limitations of the capabilities of the existing techniques and algorithms in image processing and computer vision to perform such task. In this paper, a new technique based on slicing the images to equally sub-areas, then applying the density slicing to the colour histogram of these areas combined with the colour pair technique is presented. We tried to overcome problems related to the original colour pair segmentation, as well as overcome problems related to the computational complexity in histogram localization through proposing density slicing or multiple thresholds. In this paper, new techniques proposed, new ranking formula, and a complete framework with the interface consideration.*

Key Words: *Colour pair segmentation, content-based image retrieval, city block, density slicing.*

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1. Introduction

Large image databases were created and used in many applications including multimedia encyclopedia, geographical information system and others. The needs for an automated image retrieval system became a challenging research topic.

There are several problems with the traditional approach using textual information. Firstly, describing images based on content is difficult, that because the same image has different meanings for different people. Secondly, depicting the spatial relationship among the objects is not easy task. Therefore, an efficient and automatic procedure is required for retrieving images from databases. So, the image retrieval based on content is more desirable and promising area of research.

General object recognition among image still difficult, the review for the content based image retrieval done by [12] shows that object segmentation for broad domains of general images is not likely to succeed, with a possible exception for sophisticated techniques in a narrow domains. Moreover, [9] stated that extracting regions from an image is a very hard problem to solve. The process of manually extracting object is a time-consuming process and tedious, therefore, it is not applicable to be used with a large image database collection. Most image segmentation techniques able to identify region boundaries, edges between objects, and number of other factors related to colour, texture, shape, connectivity, etc. While, general object recognition still difficult, it is easy and practical to capture and use some image features like colour distribution to identify objects with relative accuracy. The content-based image retrieval is approached in this paper through the colour, which is considered as one of the most important primitive features of the image. Image slicing and density slicing of the colour histogram combined with colour pair technique is proposed to increase the efficiency of the original colour pair technique and to examine the spatial relationship among images. The experimental results of applying the new technique show that we may overcome the limitations of the original colour pair technique.

2. Related Research Work

Enser [4] reviews methods for providing subject access to pictorial data, developing a four-category framework to classify different approaches. He discusses the strengths and limitations both of conventional methods based on linguistic cues for both indexing and searching. His conclusions are that, while there are serious limitations in current text-based techniques for subject access to image data, significant research advances will be needed before visually based methods are adequate to achieve this task.

Aigrian *et al* [1] discuss the main principles of automatic image similarity matching for database retrieval, emphasizing the difficulty of expressing this in terms of automatically generated features. They review a selection of current techniques for both still image retrieval and video data management. They conclude that the field is expanding rapidly, but that many major research challenges remain, including the difficulty of expressing semantic information in terms of primitive image features, and the need for significantly improved user interfaces.

Eakins [3] proposes a framework for image retrieval, classifying image queries into a series of levels, and discussing the extent to which advances in technology are likely to meet the users' needs at each level. He concludes that automatic CBIR techniques can already address many of users' requirements.

Idris [7] provides an in-depth review of CBIR technology, explaining the principles behind techniques for colour, texture, shape and spatial indexing and retrieval in some detail. They identify a number of key unanswered research questions, including the development of more robust and compact image content features, more accurate modeling of human perceptions of image similarity, the identification of more efficient physical storage and indexing techniques, and the development of methods of recognizing objects within images.

Tat-seng [2] proposed a computer-aided segmentation technique to segment the image content based on modification of the colour pair segmentation technique.

3. Colour-Pair Segmentation Technique

The main purpose of this technique is to extract the most distinct colour pair from the adjacent cells in the image query and compare it with the colour pair extracted from the image database.

The colour pair segmentation technique has been proposed by [8] including three stages:

- Pre processing of the image and sets the database. Each image is divided into a number of cells x by y pixels each (set x= y= 30). For each cell, we need to compute the colour histogram, and compare it with the threshold value (equal to 10), then eliminate the cells, which is less than the threshold (this will eliminate unwanted cells of colour). Store the cell colour information for each image in a database.
- Select the set of colour pairs representing the image query. For each set of adjacent cells extract all the sets of colour pairs and form a list of it, then eliminate the sets of colour pairs in which number of occurrence is less than the threshold. Then select the most distinct colour pairs from the list. A colour pairs define to be more distinct than the other colours if their Euclidean distance of its colours in the CIE L*u*v colour space is larger than the other (calculate the maximum occurrence). The Y colour pairs are used to represent the image query.
- Search the image database for the occurrence of Y colour pairs. For each colour pairs, search through the image's cell colour database for its appearance as colour in adjacent cells. The colour pair is marked to be present in the image if it appears in sufficiently large connected regions of more than (k= 8). Again k, used to eliminate image noise. If more than 80% of the colour pairs marked as present in a particular image, then the image is retrieved. Then the marked images presented for the users.

3.1. Problems with the Colour Pair Segmentation Technique

- Colour pair segmentation can be a beneficial approach to be used in image retrieval when the image database is small. With a huge database the speed of the retrieval will be a big burden to handle because of the computational complexity of this approach. In [6] Mentioned that the colour histogram is a high-dimensional distribution (256 colours or 64 colours), the distance measured is computationally expensive.
- The original technique for the colour pair segmentation is not considering Y, the most distinct colours for the database in the comparison, instead it is compared with the whole colour pairs extracted from the image in the database. Which, for sure affect the speed and accuracy of the retrieval process.
- The background colour may be used as colour pairs, which is most of the time irrelevant to the objects within the image.

4. Density Slicing (Multiple Thresholding)

The density slicing technique taking from [10] can be summarized as follows:

Let [0, L-1] represent the gray scale. Suppose that M planes are defined at levels $l_1, l_2, l_3, l_4, \ldots L_M$ and let l_0 represent black $[f(x, y)=0]$ and l_{L-1} represent white $[f(x, y)=L-1]$. Then, assuming that $0<M<L-1$, the M planes partition the gray level scale to $M+1$ intervals (regions) $[R_1, R_2, \ldots, R_{M+1}]$ gray levels to colour assignments are made according to the relation:

$$f(x, y) = c_k \ \ if \ \ f(x, y) \in R_k \tag{1}$$

where c_k is the colour associated with the kth intensity interval R_k defined by the partitioning planes at $l = k-1$ and $l = k$.

5. Density Slicing of Colour Histogram Combined with Colour-Pair Technique

Colour histogram extracts information about colour distribution not colours location [5]. This will lead to undesirable result when we need to examine the spatial distribution of colours in the image. As a solution to this problem, we may consider dividing the image to sub-areas. Locality information is captured for each subarea, more subareas more accuracy in capturing the information related to the image.

In our proposed technique, the images database as well as the image queries are divided into 4x4 equally subareas. Furthermore, to reduce the computational complexity, density slicing technique is used, in which the colour distribution is sliced to a fixed number of bins. By applying this technique the comparison between the two-colour histograms will be based on a small set of bins, so the comparison is faster, since we are not considering all bins in the colour histograms. The new approach is also considering regions to compare not the whole colour pairs in the image query and images database. Furthermore, the new technique more suitable to identify similarity between images based on spatial distribution of the colours.

The new technique may be presented as follows:

1. Divide the image to 4x4 subareas.
2. Then calculate the colour histogram for each subarea which can be numbered from 1 to 16 in left-right, top-down sequence. Calculation of the colour histogram will be based on the *density slicing*. We choose to use 8bit images with 255 shades, based on density slicing the pixels reside before the particular bin is added to that bin, this will make the computational less expensive than using all colour bins.
3. Choose the most distinct two colours-based on the number of pixels holding these colours-from each subarea.
4. Store the resulting colour histogram value for each image in a database. At the end of this stage, for each image we should obtain 32 colour pairs, two for each area in that image.
5. Repeat 1 to 2 for image query.
6. Compare the two colour pairs for each sub area in the image query with the relevant sub area in the database using city block. At the end of this stage, the number of similar regions is identified.
7. Retrieve an image from the database if the similar regions are more than or equal to 8.

6. Similarity Measurement and Ranking Technique

To decide if two regions (one from the image query and the relevant from image database) are similar or not, the distance between the two feature vectors based on city block distance function is calculated.

Definition (L1-Norm based on City Block function): As shown in [13] the difference can be measured by distance measure in the n-dimensional space (the bigger the distance between two vectors, the greater the difference). Given two vectors A and B, where: $A = [a_1 a_2 a_3 .... a_n]$ and $B = [b_1 b_2 b_3 .... b_n]$. Then the distance between A and B can be calculated based on city block as follows:

$$D = \sum_{i=1}^{n} |a_i - b_i| \quad (2)$$

It was mentioned in the previous reference that the city block is faster compare with other distance measure function like Euclidean distance function, while the result is almost the same. Since we are looking to enhance the speed of retrieval, city block gained our selection.

As a summary for our similarity and ranking approach, the system measured the distance between two vectors to decide if the region of interest is similar or not. If the region is similar then it will be labeled, otherwise it will be ignored. Then the decision to retrieve an image from the database will be based on how many regions from that image labeled as similar. If more than 8 regions labeled then retrieve that image, otherwise ignore. Given that we have 16 regions in an image, to rank the retrieved image we extract the following technique:

1. If the number of similar regions between the image query I_q and images in the database I_d are different then the similarity ranking will be based on the following formula:

$$Sim(I_q, I_d) = \frac{No.\ of\ similar\ regions}{16}\ X\ 100\ \% \quad (3)$$

Table 1 shows sample of images in the database with number of similar regions compared with the query image.

2. If there are two or more images having the same number of similar regions then the ranking technique need to consider the distance between the query image and the database rather than just considering the number of regions. Our approach to solve this problem as follows:

1. Based on the distance between the query and database images, compare between the distances of these images.
2. Since we are using distance function we will consider the images with closer distance as the most relevant, so the images with the similar number of regions will be arranged from left to right, up to down in the interface based on the distance measurement.
3. Finally, we have to consider that the new arrangements will not affect other images ranked based on the number of similar regions. For example, suppose that image (a) and image (b) have 15 similar

regions, based on Table 1, the two images will be in position 2. Using the proceeding approach our algorithm will compare the distance between these two images and the query based on the colour histogram. If $D_a > D_b$ then image (b) proceeding image (a). Otherwise, image (a) will proceed image (b). Then position 2 will be expanding to be position 2 and 3. After that, these two positions will be assigned to the two images (a, b) based on their distances from the query. Finally, image 3 in the previous table will move to position 4.

Table 1. Example shows images regions and ranking

Image	No. of Similar Regions	Ranking based on *Sim(Iq , Id)*	Position
Image 1	16	100%	1
Image 2	15	93.75%	2
Image 3	14	87.5%	3
Image 4	13	81.25%	4
Image 5	12	75%	5

7. System Design and Interface Considerations

To construct a visual query the interface should be flexible and allow refinement for the search result. The user may use the query result as a new query. Furthermore, the same interface to perform the query should show the query results. In general there are two scenarios for any image retrieval interface:

- The user has a sample image to use. So, the user can use the whole image or part of it in searching.
- The user has a vague idea a bout the image in his mind.

Based on the above two scenarios. Our interface will provide query by example as well as query by template images. Moreover, the user can use the template images and modify, alter, or add some parts using a sketchpad provided within the interface. Figure 1 shows the architecture of the system. The implementation has been done using MATLAB 6.1 on Pentium III PC with 64 RAM, running Window 98. MATLAB is an efficient program for vector and matrix data processing. It contains ready functions to manipulate matrix and to visualize image. It also allows modular structure to be used. Based on these facts MATLAB has been chosen as the software prototype to implement our systems. Figure 1 shows the system overview.

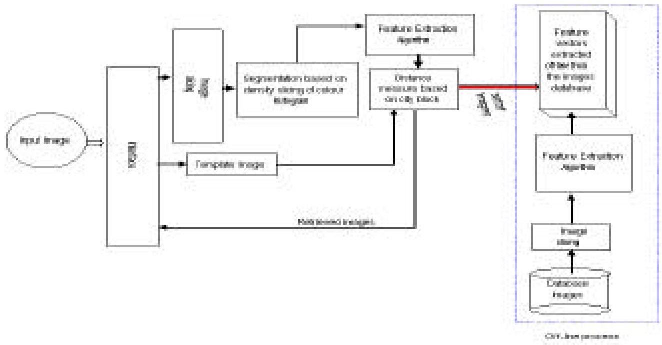

Figure 1. System overview.

8. System Evaluation

Using precision and recall to measure the accuracy of retrieval system still the most prominent technique. Suppose a data set dB and a query q are given. So, the data set can be divided into two sets: The relevant for the query q, $R(q)$ and its complement, the set of irrelevant images $\overline{R}(q)$. Suppose that the query q is given to a data set and that it returns a set of images A(q) as the answer. Then, the precision of the answer is the fraction of the returned images that is indeed relevant for the query [11].

$$Precision = \frac{|A(q) \cap R(q)|}{|A(q)|} \quad (4)$$

And the recall is the fraction of relevant images that is returned by query:

$$Recall = \frac{|A(q) \cap R(q)|}{|R(q)|} \quad (5)$$

9. Experimental Setup and Results

Our master database consists of 10,000 unconstrained images of various sizes collected from different sources. From the master database we choose randomly a set of 2000 images for testing, these images represent animals, humans in various activities, landscape, space, trees, cars, flags, and others. Additionally, any class of images does not dominate the database. Our benchmarks are based on 10 query images is given in Figure 2.

For each image used in the query there is a unique correct answer, identified manually. Table 2 shows the number of relevant images in the database for each query image.

Table 2. Number of relevant images for each query in the database.

Image	No. of Relevant Images in the Database
2	38
5	49
6	54
8	30
4	39
10	117
7	70
327	30
1950	24
1817	64

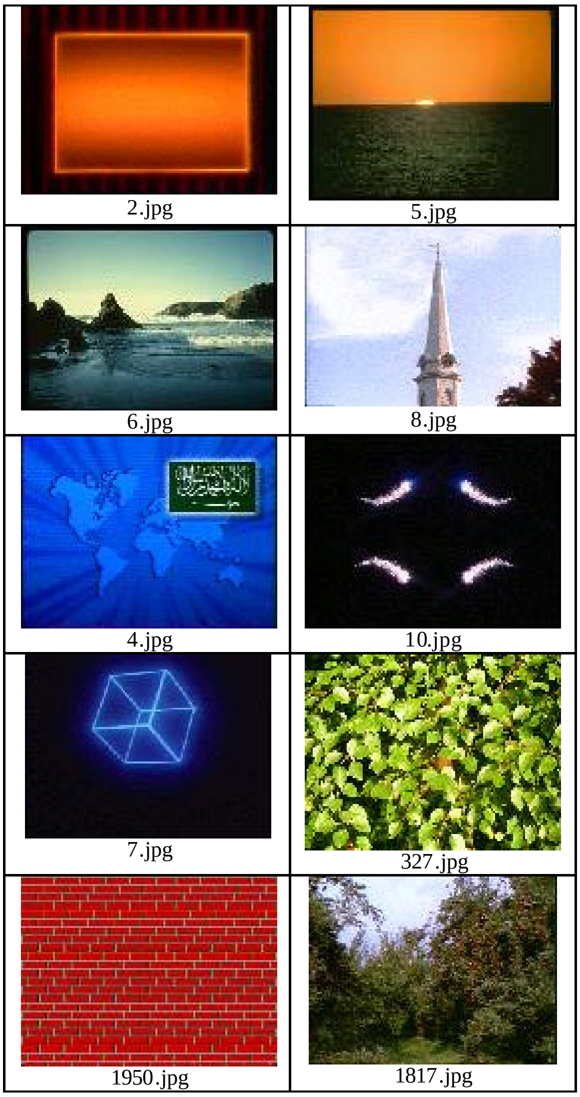

Figure 2. Query images.

Since judging the similarity is subjective and affected by human perspective of similarity and to remove any perceptual biases of the examiner we used two tools to reduce this effect, these are random sampling and large database size. A large database size ensures that a particular class of images does not affect the method being used and enable to test the scalability of the method.

The result of the query is presented to the user through a "result window". The following Figure shows the retrieval result of image No.4. In the result window the images ranked in decreasing order of similarity from left to right, and from top to bottom. The image query shown in the upper left corner of the result window. Because of the space limitation in this paper we were not able to present all results, while the table showing the precision and recall for our approach and the original colour pair approach will follow.

Figure 3. Result window for image query number 4.

The following table shows the average precision and the average recall for the proposed approach as well as the original colour-pair technique. For both methods we considered the image to be retrieved if the similarity between the query and the database image more than or equal to 0.5. For the proposed technique we followed our ranking technique presented in section 6 of this paper, while for the original colour pair technique, the ranking is based on sorting the distance matrix in ascending order.

Table 3 shows that the original colour-pair retrieval technique has an average Recall value of 0.42 and average Precision of 0.4, while, the average Recall value for the proposed technique is 0.75 and average Precision value is 0.83.

Table 3. Recall and precision of retrieval experiment.

	Proposed Technique		**Original Colour-pair Technique**	
Image Query	**Recall**	**Precision**	**Recall**	**Precision**
2	0.66	0.85	0.50	0.40
5	0.74	0.82	0.15	0.60
6	0.72	0.88	0.40	0.45
8	0.83	0.86	0.33	0.42
4	0.82	0.87	0.25	0.30
10	0.69	0.88	0.30	0.55
7	0.63	0.83	0.46	0.50
327	0.63	0.78	0.60	0.30
1950	0.92	0.77	0.66	0.29
1817	0.89	0.75	0.55	0.28
Average	0.75	0.83	0.42	0.41

This shows that the new technique add significant improvement over the original technique (33% Recall and 42% Precision).

The analysis of the results indicates that the new technique is able to overcome the drawbacks of the original colour-pair technique. The most significant improvement is to consider the spatial similarity between images by slicing the image to sub areas, this had a major impact on enhancing the retrieval accuracy. The second improvement is to remove the unwanted colour-pairs through utilizing density-slicing technique, which contribute to reduce the computational complexity too. Furthermore, the new ranking technique proves it is efficiency in arranging the retrieved images in the correct manner. Finally, the system we created allows the user to deal with a friendly user interface through utilizing QBE (query by example) technique and Template images.

10. Conclusion

There are many approaches for retrieving and classifying image in a huge image database. Most recent research is concerned with retrieving by content not by keywords and many researchers considered CBIR as the most recent and promising approach. We proposed a new approach to retrieve images from the database. Our approach utilized density slicing of colour histogram of sliced images combined with the colour pair technique. The testing of the new approach shows that it is able to overcome many limitations of the original colour-pair technique and to add some significant improvement in enhancing the accuracy of retrieving relevant images from the database. Spatial similarity is one of the most important features we considered in applying this system through slicing the image to subareas. Moreover, to overcome the speed problem and decrease the computational complexity we proposed to use the density slicing to the colour histogram. Using template images in which the related information saved in advance in the database gives the user ability to search based on cues provided through the interface.

As a future enhancement to the system, we need to explore the best ways to deploy *relevance feedback*, through utilizing some tools to the user in order to refine the searching and to help the system to increase the retrieving accuracy.

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