COMPARATIVE ANALYSIS OF IMAGE SEARCH ALGORITHM USING AVERAGE RGB, LOCAL COLOR HISTOGRAM, GLOBAL COLOR HISTOGRAM AND COLOR MOMENT HSV

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Dedicated to…

My precious mother and father.

My beloved husband and children.

My brothers and sisters.

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ABSTRACT

Image retrieval forms a major problem when a large database is considered. Content Base Image Retrieval (CBIR) makes use of the available visual features of the image and helps in retrieving similar image as that of the query image. In the CBIR method, each image stored in the database has its features extracted and compared to the features of the query image. Thus, it involves two processes, feature extraction and feature matching. In this thesis, four techniques have been used, which are the Average of Red, Green and Blue Color Channels (Average RGB), Local Color Histogram (LCH), Global Color Histogram (GCH) and Color Moment of Hue, Saturation and Brightness Value (HSV) to retrieve relevant images based on colour. These techniques are applied on the collection of three images chosen randomly from each class of Wang images database. The performance of each technique has been individually evaluated, in terms of Execution Time, Precision, Recall, Accuracy, Redundancy Factor and Fall Rate. The results were then analysed and compared. The comparison was shown in bar graphs that the Average RGB technique has the best performance, where it obtained high accuracy. As a conclusion to the report, this comparative study contributes to the image searching field, by measuring the performance for several CBIR techniques using more commonly used parameters.

ABSTRAK

Perolehan imej merupakan satu masalah utama apabila memperkatakan tentang pengkalan data yang besar . Perolehan Data Berasaskan Kandungan (CBIR) menggunakan ciri-ciri visual yang sedia ada pada imej, dan membantu perolehan imej yang sama seperti imej yang dikehendaki. Dalam kaedah CBIR, setiap imej disimpan di pangkalan data, ciri-ciri imej diesktrak dan dibandingkan dengan ciri-ciri imej yang dikehendaki. Secara umumnya, ia melibatkan dua proses, iaitu Purata merah, hijau dan biru (Purata RGB), Histogram Warna Setempat (LCH), Histogram Warna Umum (GCH) dan Momen Warna pada Warna, Tepu dan Nilai Kecerahan (HSV), untk memperoleh imej yang berkaitan berdasarkan kepada warna. Teknik-teknik ini diaplikasikan kepada koleksi tiga imej yang dipilih secara rawak pada setiap kelas pangkalan data Wang. Prestasi setiap teknik telah dinilai dari aspek Masa Perlaksanaan, Ketepatan, Panggilan Semula, Ketepatan, Faktor Pertindihan dan Kadar Kejatuhan, kemudian keputusan telah dianalisis dan dibandingkan. Perbandingan yang dipaparkan pada graf bar menunjukkan teknik Purata RGB menghasilkan prestasi yang terbaik, yang telah menunjukkan ketepatan yang tinggi. Kesimpulan dari laporan ini, kajian perbandingan menyumbang kepada bidang pencarian imej, dengan mengukur prestasi untuk beberapa teknik CBIR menggunakan parameter yang menjadi kebiasaan.

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LIST OF SYMBOLS AND ABBREVIATIONS

CBIR	- Content Base Image Retrieval
Average RGB	- Average, Red, Blue and Green channel
GCH	- Global Color Histogram
LCH	- Local Color Histogram
HSV	- Color Moment (Hue, Saturation and brightness value)
V	- Relevant
NV	- Non Relevant
R	- Retrieved
I	- Image
DB	- Database

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CHAPTER 1

INTRODUCTION

1.1 Background

In the last few years, the rapid growth of the Internet has enormously increased the number of image collections available. The accumulation of these image collections is attracting more and more users in various professional fields (Rui Y *et al*., 1999). Traditional methods are used to locate the desired images by matching keywords that are assigned to each image manually. However, as a result of the large number of images in collections, manual processing has become impractical. Since users are unlikely to foresee all the query keywords that will be used in a matching process, it is impractical to assign keywords to every image, which makes the effectiveness of the classic image retrieval very limited.

An image retrieval system is a system, which allows us to browse, search and retrieve the images. Content Based Image Retrieval (CBIR) is the process of retrieving the desired query image from a huge number of databases based on the contents of the image. Colour, texture, shape and local features are some of the general techniques used for retrieving a particular image from the images in the database. CBIR systems works with all the images and the search is based on the comparison of features with the query image. The main components of CBIR are the features, which includes the Geometric shape, colours and the texture of the image. The colour feature is one of the most widely used visual features in the image retrieval. It is relatively robust to background complication and independent of the image size and orientation. In the image retrieval, the colour histogram is the most commonly used colour feature representation. Statistically, it denotes the joint

probability of the intensities of the three colour channels (Gaurav Jaswal *et al*., 2012).

Biomedicine, Military, Education, Web Image Classification and Searching are some of the areas where the CBIR technique finds its prime importance. Some of the examples for the current CBIR are VIPER (Visual Information Processing for Enhanced Retrieval) and QBIC (Query by Image Content and Visual seek) ,which is a web tool for searching images and videos. CBIR mainly decreases the heavy workload and overcomes the problem of heavy subjectivity (Ms. K. Arthi *et al*., 2013).

1.2 Motivation

Human vision is the most advanced of all our senses, and as such he gathers a majority of information from the real world by visual sense. The twentieth century has witnessed unparalleled growth in the number, availability and importance of images in all walks of life. As the diversity and size of digital image collections have grown exponentially, an efficient image retrieval is becoming increasingly important. Large image databases are difficult to browse with traditional text searches because the task of user based annotation has become very time consuming, as the text often fails to convey the rich structure of images. A content-based retrieval system solves this problem where the retrieval is based on the automating matching of the feature of the query image with that of the image database through some image-image similarity evaluation. Therefore, images will be indexed based to their own visual content, such as colour, texture, shape or any other feature or a combination of set of visual features. In this paper, our research is limited to the colour feature of the image. There are several techniques available for the colour feature extraction like colour histogram, colour layout, clustering and colour correlogram etc.

Color Histogram is one of the widely used technique for the colour feature extraction in colour-based image retrieval. Color Histogram is a method for describing the colour content of the image, constructed by counting the number of pixel of each colour. There are two traditional techniques for the colour-based image retrieval: Global Color Histograms (GCH) that represent images with single

histograms and Local Color Histograms (LCH) that divide images into fixed blocks and obtain its colour histogram for each block. Global Color Histograms do not capture the content of images adequately, whereas Local Color Histograms contain more information and also enable the colour distances among regions between images to be compared (Gaurav Jaswal *et al*., 2012).

The Color Moment of the Hue, Saturation and brightness Value (HSV) is used as feature vectors for the image retrieval to overcome the quantization effects of the color histogram. Since any colour distribution can be characterized by its moments and most information is concentrated on the low order moments, only the first moment (mean), the second moment (variance) and the third moment (skew-ness) are taken as the feature vectors. With a very reasonable size of the feature vector, the computation is not expensive (S. Deb *et al*., 2004). Color Moments differentiate images based on their features of colour. However, the basic concept behind Color Moment is in the assumption that the distribution of color in an image can be interpreted as a probability distribution.

The advantage is that, its skew-ness can be used as a measure of the degree of asymmetry in the distribution.

1.3 Problem Statement

There is an increasing demand for searching the digital images accurately and efficiently, which are distributed randomly in the World Wide Web. Existing image search engines, such as Google and Yahoo image search, are both based only on relevant text. But the synonymy and polysemy of the relevant texts lead to the serious limitation. To solve these problems, the visual features are extracted and used in Content Based Image Retrieval (CBIR) (Matei Dobrescu et al., 2010). Average of Red, Green and blue color channels (Average RGB), Local Color Histogram (LCH), Global Color Histogram (GCH) and Color Moment of Hue, Saturation and brightness Value (HSV) are some of the techniques that have been used in CBIR method to extract the visual features for query image. The results of each technique are used for comparison; the significance of this comparison is to find out which one of these techniques gives more accurate and efficient results.

1.4 Objectives

Based on the research background and the related issues, the objectives of this research have been formulated as follow:

(i) To apply the four techniques of CBIR method, Average of Red, Green and Blue color channels (Average RGB), Local Color Histogram (LCH), Global Color Histogram (GCH) and Color Moment of Hue, Saturation and brightness Value (HSV) on several groups of images.

(ii) To evaluate the performance of the Above Mentioned CBIR techniques in the retrieval of similar images from the database by measuring the Execution Time, Precision, Recall, Accuracy, Redundancy and Fall Rate.

(iii) To provide a comparative analysis based on the result obtained in (ii).

1.5 Scope Of Work

The research will start using experimental images from the WANG images database and will apply the image retrieval techniques by the RGB, LCH, GCH and HSV performance evaluation of the four techniques on the experimental images and finally will discuss the detailed comparison of the result.

1.6 Report Outlines

In this project, The work has been divided into five chapters starting from the introduction and ending with the conclusion.

Chapter One introduces the general information about the project and it discusses the objectives and motivation of the proposed project. General introduction to image retrieval were discussed. The problem statement has been defined properly.

Chapter Two introduces the content-based image retrieval method. Many algorithms are discussed in this chapter and several works have been reviewed and used in this chapter as literature review for the whole project. Furthermore, the limitations of the previous methods were introduced.

Chapters Three introduces several image retrieval techniques and an explanation on their mathematical representations. An image measurement is

discussed as well in this chapter and it's used here to evaluate the Content-Based Image Retrieval techniques in retrieving similar images.

Chapter Four evaluates the performance of each technique using several parameters. The results are compared and finally, a discussion is provided on the results.

Chapter Five presents the conclusion and future work.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Content Base Image Retrieval (CBIR) is defined as a process to find similar picture or pictures in the image database when a query image is given. In CBIR, the retrieval of an image is based on the similarities in their contents, i.e., textures, colours, shapes etc., which are considered the lower level features of an image. These conventional approaches for image retrieval are based on the computation of the similarity between the users query and images. Also each image stored in the database has its features extracted and compared to the features of the query image. Thus, it involves two processes, which are feature extraction and feature matching.

Feature extraction involves the image features to a distinguishable extent, where the Average of Red, Green and Blue color channels (Average RGB), Local Color Histogram (LCH), Global Color Histogram (GCH) and Color Moment of Hue, Saturation and brightness Value (HSV) are used to extract features from the test image. Feature matching, on the other hand, involves matching the extracted features to yield results that exhibit visual similarities.

Feature vectors are calculated for the given image. The Euclidean distance is used as the default implementation for comparing two feature vectors. If the distance between feature vectors of the query image and images in the database is small enough, the corresponding image in the database is to be considered as a match to the query. The search is usually based on the similarity rather than on the exact match and the retrieval results are then ranked accordingly to a similarity index. Figure 1 shows the block diagram of a basic CBIR system.

The basic steps for CBIR method illustrated from Figure 3.1.

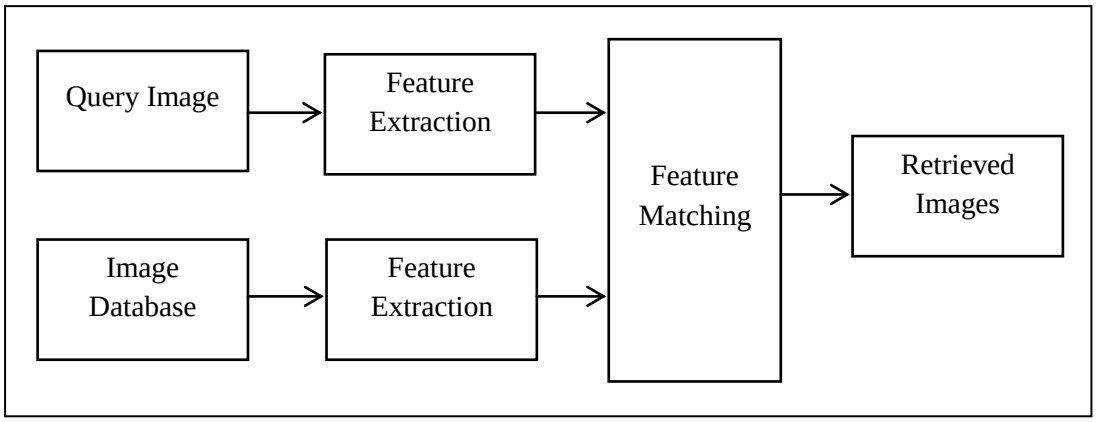

Figure 3.1: Block Diagram of a Basic CBIR

3.2 The Steps for Comparative Analysis Study

In this study four techniques will be applied one by one, using query image, three images from each class of the WANG database. The four techniques are the Average of Red, Green and Blue color channels (Average RGB), Local Color Histogram (LCH), Global Color Histogram (GCH) and Color Moment of Hue, Saturation and Brightness Value (HSV). These four techniques will be evaluated using the parameters, such as Time, Precision, Recall, Accuracy, Redundancy Factor and Fall Rate. Finaly the results will be compared and discussed.

The goal is to evaluate these techniques and compare the result to find the best one, in terms of measuring the factors that are mentioned earlier, especially the accuracy. According to this, using the appropriate technique for the image retrieval process is to produce the best results. Figure 3.2 shows the steps for the comparative analysis Study.

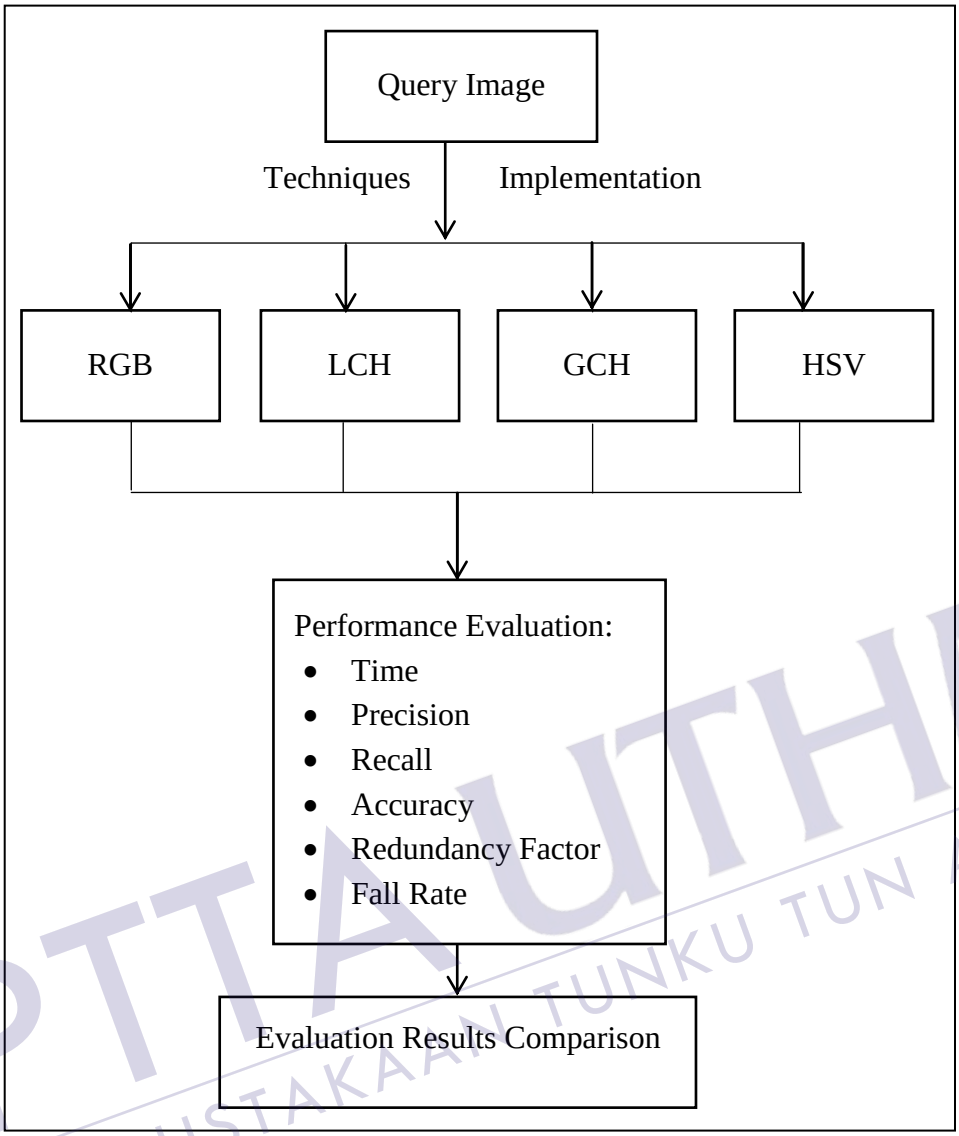

Figure 3.2: The Steps for Comparative Analysis Study

3.2.1 Average RGB

Average RGB is to compute the average values in R, G and B channel of each pixel in an image and used as the descriptor of an image for comparison purpose. The following are 3 equations for computing the average R, G, B component of an image I:

$$r = \sum_{x=1,y=1}^{x=w,y=h} \frac{R\big(I(x,y)\big)}{w \times h} \qquad (3.1)$$

$$g = \sum_{x=1,y=1}^{x=w,y=h} \frac{G\big(I(x,y)\big)}{w \times h} \tag{3.2}$$

$$b = \sum_{x=1,y=1}^{x=w,y=h} \frac{B\big(I(x,y)\big)}{w \times h} \tag{3.3}$$

Here is the equation for distance measure of image I_a and I_b, where the weighted Euclidean distance is used. The distance between two exact images will be 0 and the distance between to most dissimilar images (black and white) will be 1 depending on the range of RGB is from 0-1 or 0-255.

$$d\big(I_{a,}I_b\big) = \sqrt{\frac{(r_{a-}r_b)^2 + (g_a - g_b)^2 + (b_{a-}b_b)^2}{3}} \tag{3.4}$$

Notation:

I : an image.
w : width of image I.
h : height of image I.
I(x,y) : the pixel of image I at row y, column x.
R(p), G(p), B(p) : the red, green and Blue color component of pixel p.
r_a, g_a, b_a : the average red, green and Blue component of image I_a.
$d(I_a,I_b)$: the distance measure between image I_a and I_b.

3.2.2 Local Color Histogram (LCD)

Colour histograms are frequently used to compare images. Examples of their use in multimedia applications include scene break detection and identifying for the ease of explanation; let's assume that all images are scaled to contain the same number of pixels M. The colour space of the image discretized such that there are *n* distinct (discretized) colours. A colour histogram H is a vector (h_1, h_2, ..., h_n), in which each bucket h_j contains the number of pixels of colour *j* in the image. Typically images are represented in the RGB colour space and a few of the most

significant bits are used from each colour channel. The 2 most significant bits of each colour channel used, for a total of n = 64 buckets in the histogram. For a given image I, the colour histogram H_I is a compact summary of the image. A database of images can be queried to find the most similar image to I and can return the image I' with the most similar colour histogram $H_{I'}$. Typically colour histograms are compared using the sum of squared differences (L_2-distance) or the sum of absolute value of differences (L_1-distance). So the most similar image to I would be the image I' minimizing the L_2-distance or L_1-distance. Note that we are assuming that weighted evenly across different colour buckets for simplicity.

L_1-distance

$$|H_I - H_{I'}| = \sum_{j=1}^{n} |H_I[j] - H_{I'}[j]| \quad (3.5)$$

L_2-distance

$$\|H_I - H_{I'}\| = \sum_{j=1}^{n} (H_I[j] - H_{I'}[j])^2 \quad (3.6)$$

Divides an image into 16 equal sections, as shown in Figure 3.4:

H_0	**H_1**	**H_2**	**H3**
H_4	**H_5**	**H_6**	**H_7**
H_8	**H_9**	**H_{10}**	**H_{11}**
H_{12}	**H_{13}**	**H_{14}**	**H_{15}**

Figure 3.4: LCH Image Division

For each section of the image, uses 1 vector, $H_k(h_1, h_2, ..., h_n)$, to represent that section of the image. So, there are 16 vectors, H_k, to describe an image.

Default vector comparing method: In DISCOVIR, by default, measuring the distance of 2 images as follow:

$$H_I - H_{I'} = \sqrt{\frac{\sum_{j=1}^{n}(H_I[j] - H_{I'}[j])^2}{n}} \quad (3.8)$$

Notation:

M : number of pixels that an image has, which has been assumed, for the ease of explanation.

H(h_1, h_2, ..., h_n) : a vector, in which each component h_j is the number of pixels of colour *j* in the image.

n : number of distinct(discretized) colour.

I : an image.

H_I : the colour histogram of image I.

3.2.3 Global Color Histogram (GCH)

Using 1 vector, H(h_1, h_2, ..., h_n) to describe an image. As shown in Figure 3.3.

H (h_1,h_2,h_3,……..h_n)

Figure 3.3: GCH image describing vector

$$h_j = \frac{\text{(Number of pixels of colour } j \text{ in the image)}}{\text{(Total number of pixels in the image)}} \quad (3.7)$$

3.2.4 Color Moment HSV

The three colour moments can be defined as:

Moment 1– Mean:

$$E_i = \sum_{N}^{j=1} \frac{1}{N} P_{ij} \quad (3.9)$$

Mean can be understood as the average colour value in the image.

Moment 2 – Standard Deviation:

$$\sigma_{i=}\sqrt{\left(\frac{1}{N}\sum_{N}^{j=1}\left(P_{ij}-E_i\right)^2\right)} \qquad (3.10)$$

The standard deviation is the square root of the variance of the distribution.

Momet 3 – Skew-ness:

$$S_{i=}\sqrt[3]{\left(\frac{1}{N}\sum_{N}^{j=1}\left(P_{ij}-E_i\right)^3\right)} \qquad (3.11)$$

Skew-ness can be understood as a measure of the degree of asymmetry in the distribution.

A function of the similarity between two image distributions is defined as the sum of the weighted differences between the moments of the two distributions. Formally this is:

$$d_{mom}(\mathrm{H},\mathrm{I}) = \sum_{i=1}^{r} w_{i1}\left|E_i^1 - E_i^2\right| + w_{i2}\left|\sigma_i^1 - \sigma_i^2\right| + w_{i3}\left|S_i^1 - S_i^2\right| \qquad (3.12)$$

Notation:

(H, I): Are the two image distributions being compared.

i : Is the current channel index (e.g. 1 = H, 2 = S, 3 = V).

r : Is the number of channels (e.g. 3).

E_i^1, E_i^2 Are the first moments (Mean) of the two image distributions.

σ_i^1, σ_i^2 Are the second moments (Standard Deviation) of the two image distributions.

S_i^1, S_i^2: Are the third moments (Skew-ness) of the two image distributions.

w_i: Are the weights for each moment.

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