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Image Retrieval Using Normalized Histogram Distance in HSV Color Model

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Abstract – *Color is one of features that used in image retrieval systems. Pixel color distribution in an image can be represented by a color histogram. Similarity degree between images determined by calculate the distance of histogram. Images with smaller value of histogram distance should be considered more similar than the images that have greater distance value. For color images, histogram distance is calculated for each color component. In this research HSV color model is used. Each color component is quantized into 128, 64 and 64 levels respectively. H color component has more number of levels than the other, because it has biggest influence for human eye's perception to colors. A number of pixels in images are very diverse, so the histogram should be normalized in order to be invariant to the image size. Normalization is done by divide the number of pixels for each level with total number of pixels in the image. Image retrieval results are ranked based on histogram distance value.*

Keywords: image retrieval, histogram, HSV

1 Introduction

The need for efficient management of data which includes text data, voice, image and video increasing along with the development of information technology and the extent of utilization of computer technology in various fields of life. One of the aspects in the data management systems is Information Retrieval (IR). The main purpose of the IR is to find back the document that contains information relevant to the query given by the user.

This paper focused on retrieval of image documents. Relevance of content in an image document is relatively more complex than in a text document because of influence of human's perceptions on an image. To simplify this, only objective descriptors are used in Content-Based Image Retrieval (CBIR) Systems. Low level features of an image such as color, texture or shape generally used as objective descriptor. [5].

Digital image document composed of elements called pixels. Image size is generally expressed by its pixels number. Image with size 640 x 480 pixels, has 640 pixels length and 480 pixels wide. Determining the features of an image efficiently needed in the process of image similarity search, because the image document consists of hundreds, thousands even millions pixels.

Human perception of an image tends to be dominated by the color composition. We often distinguish an image with the others by its color composition. This assumption is the basic idea for Image Retrieval Systems that use color composition as features that represent an image. Histogram of color pixels in the image can be used as a representative of image color composition.

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2 Theoretical Background

2.1 Image Retrieval Systems

Image Retrieval Systems at the beginning of the development around the end of the 1970s, use the text for image annotation. First, image documents are annotated with text and then retrieval process conduct on general Database Management System (DBMS). This method has some weaknesses, for example, if the image collection has a very large number, it is not efficient because the process is done manually and the information provided in the image is subjective, depends on our perception. To overcome these problems, in the early 1990s CBIR (Content-Based Image Retrieval) began developed. CBIR retrieves image based on the visual content of image, such as color, texture or shape[3] [4]. In general CBIR system can be expressed in the diagram in Figure 1.

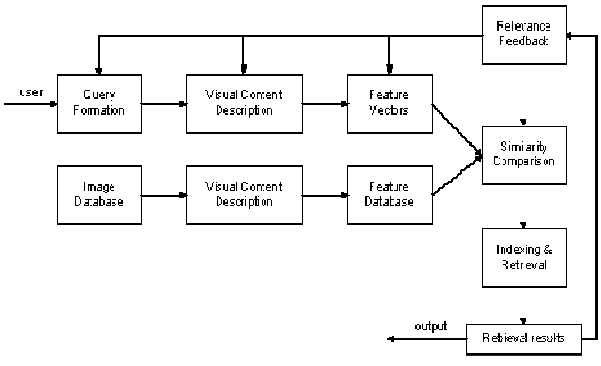

Figure 1. Content-Based Image Retrieval Diagram

Visual content of the image in database extracted, and described as a feature vector and then stored in feature database. To retrieve an image, user provides input to the system that is an image to be searched. This process is called Query By Example (QBE). System extracts features from sample image as feature vectors and then comparing its similarity with feature vectors in the database. In measuring similarity process, indexing schema can be use to speed up process. Next process is retrieving and ranking image documents based on its similarity value that has calculate in previous process. Nowadays, retrieval systems have also involved feedback from the user whether image retrieval results relevant or not. Relevance feedback used as reference to modify retrieval process to get more accurate result. [3]

2.2 Histogram

Color is one of the features that can be used in image retrieval system. Color can be represented in the form of a histogram. Color histogram represents the distribution of the number of pixels for each intensity colors in the image. To define the histogram, each color quantized into some discrete level. For each level the number of pixels is calculated according to the value [1] as shown Figure 2.

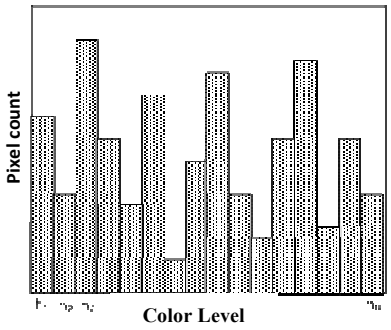

Figure 2. Color Histogram

Horizontal axis represent color levels of the pixels in image and vertical axis express pixel numbers in each appropriate color level.

2.3 Histogram Distance

Color composition similarity of images can be determined by its color histogram. Level of similarity between two images measured with its histogram distance. If $G = \{g_1, g_2, \ldots, g_N\}$ and $H = \{h_1, h_2, \ldots, h_N\}$ are the color histogram from two images, where g_i and h_i is the number of pixels at level i and N is the number of levels for each histogram, then distance (d) between two histogram can be expressed in Manhattan metric as in Equation (1).

$$d = \sum_{i=1}^{N} \left| g_i - h_i \right| \quad (1)$$

Image with smaller distance value is considered has more similar color compared with image that has greater distance value.

2.4 HSV Color Model

HSV model is a color model that focuses on human's eye perception to the color. HSV color model represents color as three components, Hue (H) , Sturation (S) and Value (V). Hue is an attribute of human perception and can be described as red, green, blue, purple, and yellow as primary hues or any intermediate combinations of the primary hues. The colorfulness of a color is described by the saturation component. Saturation is thus a measure of colorfulness or whiteness in the color perceived. The Value essentially provides a measure of the brightness of colors. This gives a measure of how much light is reflected from the object or how much light is emitted from a region[1]

Image processing hardware, in general, apply the RGB color model with the consideration of the ease in technical color displaying. Color conversion is needed to bridge the two models so the color can processed and displayed correctly. Color conversion from RGB to HSV steps are as follows: *r,* g, *b* values are first obtained by normalizing each pixel such that :

$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}, b = \frac{B}{R+G+B}$$

Accordingly, the H , S , and V values can be computed as

$$V = \max(r,g,b) \quad (2)$$

$$S = \begin{cases} 0 & \text{if } V = 0 \\ V - \dfrac{\min(,r,g,b)}{V} & \text{if } V > 0 \end{cases} \quad (3)$$

$$H = \begin{cases} 0 & \text{if } S = 0 \\ \dfrac{60*(g-b)}{S*V} & \text{if } V = \text{r} \\ 60*\left[2 + \dfrac{(b-r)}{S*V}\right] & \text{if } V = \text{g} \\ 60*\left[4 + \dfrac{(r-g)}{S*V}\right] & \text{if } V = \text{b} \end{cases} \quad (4)$$

$$H = H + 360 \text{ if } H < 0 \quad (5)$$

3 System Description

In this research, CBIR system was built to search color image document. This system uses QBE model, user gives an image as input, and then system will search similar image in image database.
Similarity value is determined based on the distance between histogram in the HSV color model. The search results will be displayed in ascending order based on histogram distance value. Retrieval for similar image process depicted in Figure 3

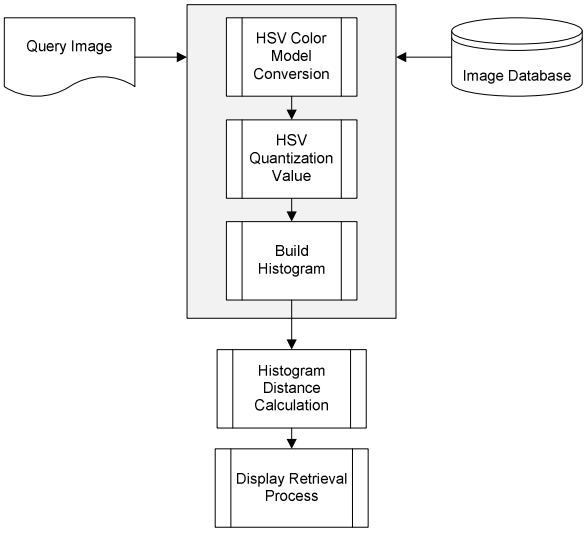

Figure 3. Image retrieval process

Query image and image in the database are converted from RGB color model to the HSV color model using Equation (2) to (5). H component has a range 0° – 360°, S component $\in [0,1]$ and S component $\in$ [0,1]. To simplify calculation process, each component should be quantized into some predefined discrete values. This simplification also leads to faster retrieval process without degrading fidelity significantly.

Histogram that used in this system is in normalized form. Normalized means that pixels number in the histogram invariant to the total pixel in image or image size, so retrieval can be done in various image sizes. Histogram distance value between query image and image in database calculated with Equation (1). This value determine similarity degree between query image and image in database. Retrieval process results are sorted by its histogram distance value, from smallest to the largest.

3.1 HSV Value Quantization

In this research each component of HSV color value quantized into 128, 64 and 64 level. H component has more number of levels because it has more influence to perception of the human eye than the other color component [2] . Quantization of value for each color component (q) is calculated using Equation (6)

$$q = \left\lfloor \frac{v}{v_{\max} - v_{\min}} (q_{\max} - q_{\min}) \right\rfloor \quad (6)$$

v is the value to be quantized. $v_{\max}$, $v_{\min}$ are initial maximum and minimum value, $q_{\max}$, $q_{\min}$ are maximum and minimum target value. In this research target value range used are [0, 127] for H component, [0, 63] for S and V components.

3.2 Histogram Normalization

Number of pixels the image is very diverse, then the histogram should be normalized so the value of histogram distance invariant to the size of the image. Normalization is done by divide the number of pixels for each level with the total number of pixels in the image (N) Each level color of normalized histogram has value minimum = 0 and maximum = 1. Normalization of each histogram level (h_i) expressed in Equation (7) where $\overline{h_i}$ is normalized value.

$$\overline{h_i} = \frac{h_i}{N} \quad (7)$$

3.3 Distance Measurement

The distance between the query image histogram with the image in the collection is calculated for each component of the HSV color components using formula in Equation (1). Total distance between two histograms defined as total sum of difference between each level color in each color component histogram, as expressed in Equation (8)

$$D = d_Y + d_I + d_Q \quad (8)$$

D has a range of values [0,3], because for each color component on normalized histogram has differencan value in range[0,1].

4 Experiment and Results

4.1 Experiment

Experiment carried out by develop a computer program using Delphi programming language that can retrieve image based on color composition similarity. Program can calculate histogram distance between image and then displaying retrieval result in a ascending order based on its distance value.

Input image or query image selected by user. Query image selected from file in the computer in specified location. Location of image collection to be searched by program also determined by user. After finished retrieval

process, results will be displayed with information such as file name and the value of distance. To test the program, experiments conducted on several queries in image collection of flowers and misc images[6].

4.2 Results

Similarity search results of the experiment on the collection of images shows that the image has a color distribution similarity with the query image has a small value of the distance and will appear at the beginning or occupy high ranking.

Greater value distance reflects greater difference color distribution of image. Image that exact same, has distance value equals to 0 . Correlation between distance value and similarity of images tends to be subjective, depends on someone perception to the image. Results of this experiment explore the distribution of color similarity, not an object or texture or even semantic of an image. Example of search results can be seen in Figure 4 and Figure 5. Image on left-top side is query image and results are in the list on right side.

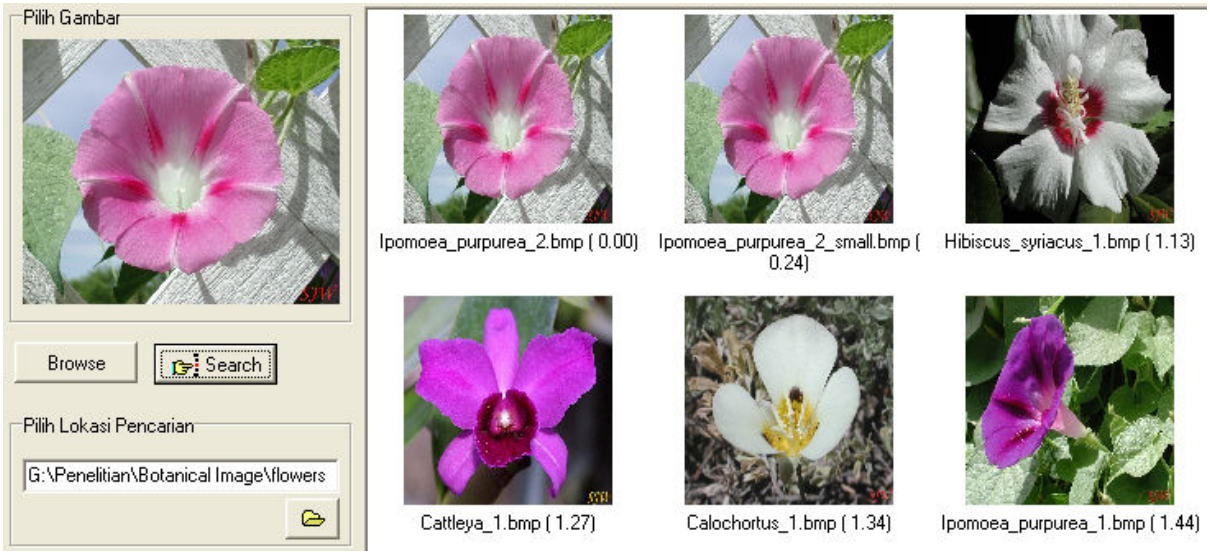

Figure 4. Retrieval result on flower images collection

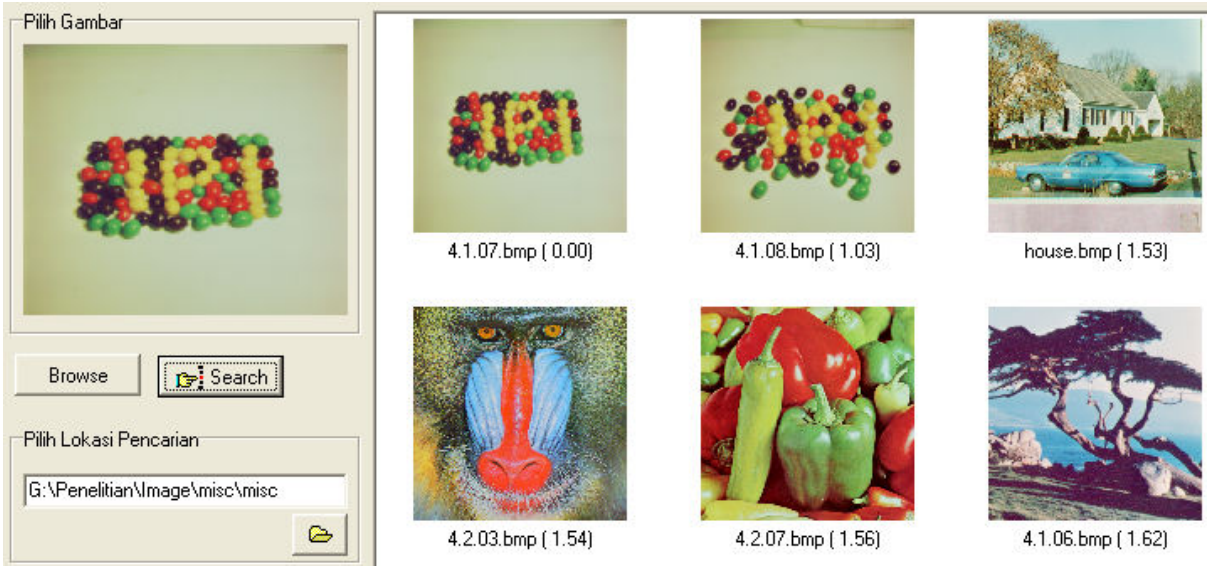

Figure 5. Retrieval result on misc images collection

5 CONCLUSIONS

Retrieval system that has been build can find the similarity between images based on its histogram distance value. This proved with the results of experiments that have been made show that images which has a similarity color distribution belong to top rank, and the exact same image, is in first rank and has a distance equal to zero.

Program that has been made did not used index scheme and index data structure. So, for development and sustainability of this research, author suggest to create index scheme and data structure to speedup retrieval process.

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