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Application of content based image retrieval in digital image search system

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ABSTRACT

Multimedia data is growing rapidly in the current digital era, one of which is digital image data. The increasing need for a large number of digital image datasets makes the constraints faced eventually drain a lot of time and cause the process of image description to be inconsistent. Therefore, a method is needed in processing the data, especially in searching digital image data in large image dataset to find image data that are relevant to the query image. One of the proposed methods for searching information based on image content is content based image retrieval (CBIR). The main advantage of the CBIR method is automatic retrieval process, compared to traditional keyword. This research was conducted on a combination of the HSV color histogram methods and the discrete wavelet transform to extract color features and textures features, while the chi-square distance technique was used to compare the test images with images into a database. The results have showed that the digital image search system with color and texture features have a precision value of 37.5%-100%, with an average precision value of 80.71%, while the percentage accuracy is 93.7%-100% with an average accuracy is 98.03%.

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1. INTRODUCTION

The world today has many uses for many digital devices to obtain images. Nowadays, it becomes easy to store huge amount of images by using image processing techniques. Digital image is one of the most widely created multimedia data and is used in various needs in the modern era. Meanwhile, the need to find useful information in digital image datasets is needed at this time. In managing data a better system in need, especially in searching for digital image data, so the need to find image files on a computer that has a large image database can be met. The textual image search method using keywords given to each image data can spend a lot of time and cause the image description process to be inconsistent. The rapid access to these masses collections of images and retrieve similar images of a given image (Query) from this huge collection of images presents major challenges and requires efficient algorithms.

This research proposes the method that was emerged later to use the features contained in a digital image to index image datasets, this method is better known as content based image retrieval (CBIR) [1]. The CBIR method is used to index digital image datasets based on image color and texture features. Some research studies on CBIR have been used based on leaf color features [2], color and texture features [3-5]. Using gradient vector flow snake (GVFS) method and the CBIR technique in implementing an application search [6]. Not only that, the CBIR has been applied using the pyramid histogram of oriented gradients (PHOG) approach in extracting shape [7].

The research presented in this area is focused to reduce the semantic gap between the image feature representation and human visual understanding. In CBIR and image classification-based models, high-level image visuals are represented in the form of feature vectors that consists of numerical values [8]. In this study, we design the interface of a digital image search system. The purpose of this study is to display relevant images in image datasets based on searching by the query image using CBIR method based on color and texture features.

In previous studies related to feature extraction in CBIR, among others, Insan Taufik *et. al* [9] in their research have implemented HSV color detection for features color extraction in images. Based on this research, it is stated that the HSV model can represent a point in the RGB color model, which re-arranges RGB geometry in an effort to perceptual more relevant than cartesian coordinate representations. User control through color sample and color tolerance as the reference filter so that the right color can be obtained. HSV color detection is quite effective for detecting colors in natural color images and tends to be more stable in changes in light. But in this study, the application uses the extraction of texture and color features. The method applied is a discrete wavelet transform for extracting texture features, and HSV color histograms for extracting color features. By using these two feature extractions, it is expected to produce better CBIR techniques and can assist in the process of retrieval images that are more accurate and relevant to the user.

2. LITERATURE STUDY

CBIR is the automatic retrieval of digital images from large databases. The CBIR systems identify the images by automatically extracted syntactical features. This technique makes use of the inherent visual contents of an image to perform a query [10]. Figure 1 shows a typical CBIR system automatically extract visual attributes (colour and texture) of each image in the database based on its pixel values and stores in a different database within the system called feature database.

In this process, the users usually formulate a request image and presents it to the system. The system automatically extracts the visual attributes of the query image in the same mode as it does for each database image, and then identifies images from within the database whose feature vectors match those of the query image, and sorts the best similar objects according to their similarity value. During operation, the system processes less compact feature vectors rather than the large size image data thus giving CBIR its cheap, fast and efficient advantage over text-based retrieval.

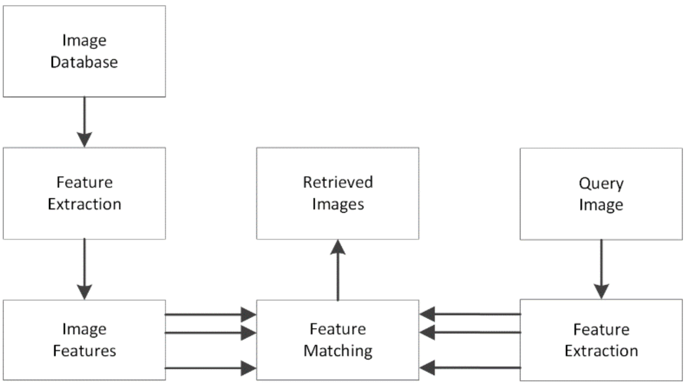


Figure 1. Process involved in content based image retrieval

3. RESEARCH METHOD

3.1. Feature extraction

3.1.1. Color histogram

A color histogram [11] is a representation of the color distribution in the image. For digital images, the color histogram represents the number of pixels that have colors in each group, with a certain color range that includes the color space of the image. In a CBIR system, a color histogram is an effective approach to implement an image retrieval system [12].

Based on the applied method, at this stage, we use the HSV color space because the hue and saturation are close to the reported human visual system [13-15]. The image is divided into fields H, S, V, and each field is quantized, by determining the value of the quantization level. Maximum H, S, and V are obtained to make the final histogram and subsequently normalized [16]. The image in the RGB color space can easily be transformed to HSV color space using [17].

$$H = arccos \frac{\frac{1}{2} 2R-G-B}{\sqrt{(R-G)^2-(G-B)(R-B)}} \quad (1)$$

$$S = \frac{\max R,G,B - \min R,G,B}{\max R,G,B} \quad (2)$$

$$V = \max R, G, B \quad (3)$$

3.1.2. Discrete wavelet transforms

Wavelets are a little wave that is concentrated in frequency around a certain point. Fourier transforms deal only with the frequency component in a signal while temporal details are not available [12]. Wavelet transform has a wide application in the image processing system. In this study, applying discrete wavelet transform 2-D method, we see that in the decomposition process that the 2-D discrete wavelet transformation is done by processing rows and columns separately which can be illustrated by the following Figure 2:

Discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of wavelet scales and translations that are obeying some defined rules or this transform decomposes the signal into a mutually orthogonal set of wavelets [18]. DWT has stronger resistance than LWT, DWT is based on transforming Fourier which has more intensive changes to better images and is able to produce watermarks with higher NCC [19].

In this study, the wavelet decomposition of grayscale image regions into four sub-images (LL, HL, LH and HH) [3] called wavelet or DWT sub-bands. Every sub-band is the result of a transformation that has a quarter of the original size of aimage before changing. On the low frequency Sub-band LL produces the images that are similar to the converted images. So it's also called the approximation coefficient. Whereas, LH, HL and HH are coefficient of detail because it displays a very smooth image containing an image [20]. Calculating the mean and variation of four sub-images correspondings to each region and concatenating them. Two vectors will be obtained which describe texture information of image. Both of these vectors are normalized to get the texture feature histogram [21].

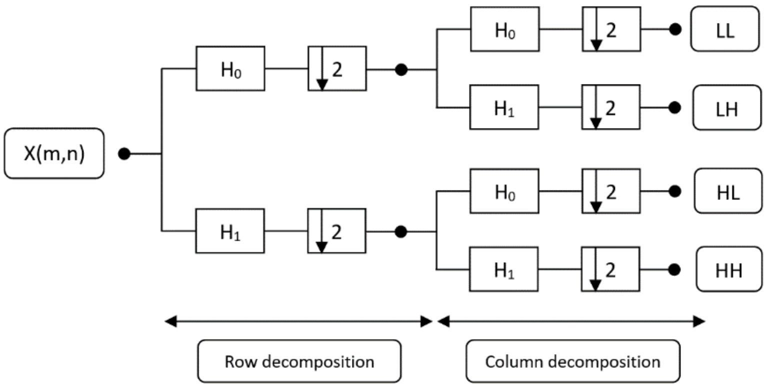


Figure 2. Level 1 2D wavelet transform

3.2. Similarities measurement

This research uses distance based technique to take CBIR. The measurement of the histogram vector feature distance used for the image matching method is Chi-square distance which was used successfully in face image analysis [22]. The results of these experiments indicate that this metric is more accurate than the Euclidean distance in the histogram feature [23].

Furthermore, for this stage calculation, the distance between query image and database image. This distance is a bin-to-bin histogram comparison, which considers the difference of bins as well and their sizes [24]. Images are then sorted in ascending order from the distance calculation result. Chi-square distance is given by the following (4):

$$\chi^2(X,Y) = \sum_i \frac{(x_i-y_i)^2}{x_i+y_i} \quad (4)$$

where x and y are two histogram data and i indicates bin index in these histograms.

3.3. Proposed research

The overall working flow is shown in Figure 3 and our proposed research has the following steps: a) The first step is to prepare a database image in the *form* of image data that has been prepared for research; b) The *database* image will go through the pre-processing stage, which is the process of resizing and converting the database image; c) Extract color and texture features from the inserted database image, and then save it in CSV file format; d) Enter the query image used for searching; e) Extract color and texture features from the query image; f) Calculate the *chi-squared* distance between the query image and the database image and sort them from the smallest score to the largest; g) Displays the image of search results sorted on the system interface.

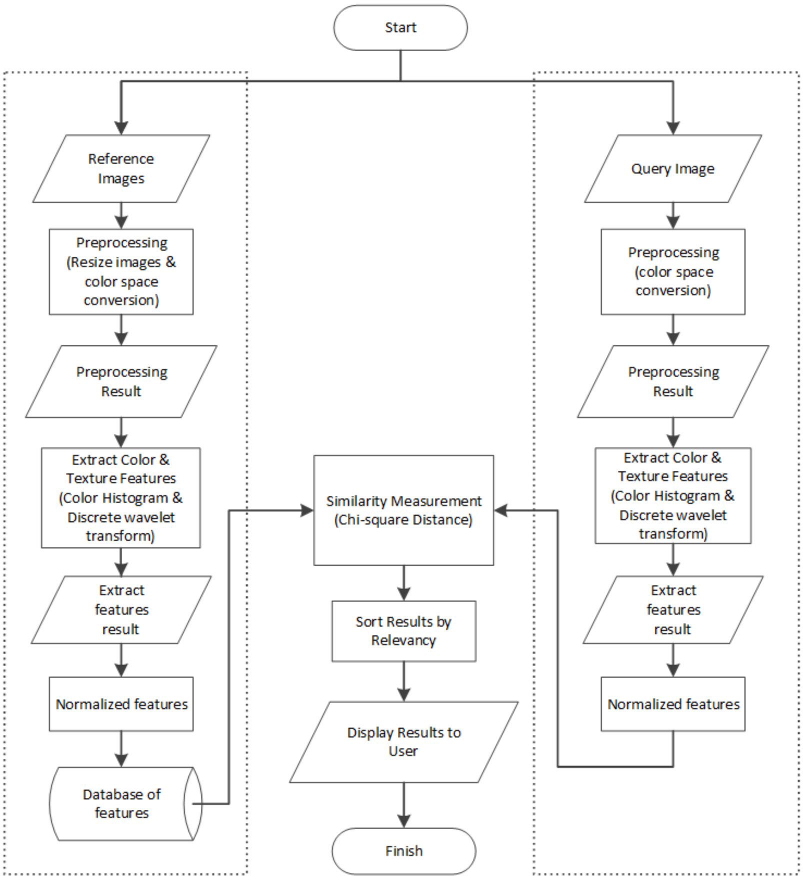


Figure 3. The flow diagram of proposed research

4. RESULTS AND DISCUSSION

4.1. Datasets and performance measurement

In this study uses the INRIA Holidays dataset. Here, 200 images containing 20 image categories are taken from INRIA Holidays database for our experimental analysis. The image categories are boat, temples, mountains, flowers, fruits and houses. Where each category having 10 images. An important task used to determine the accuracy of the system takes a performance. Accuracy calculations can be obtained using *precision* and *recall*. *Precision* is used to extract an image [25]. The evaluation formula used is shown in the following (5).

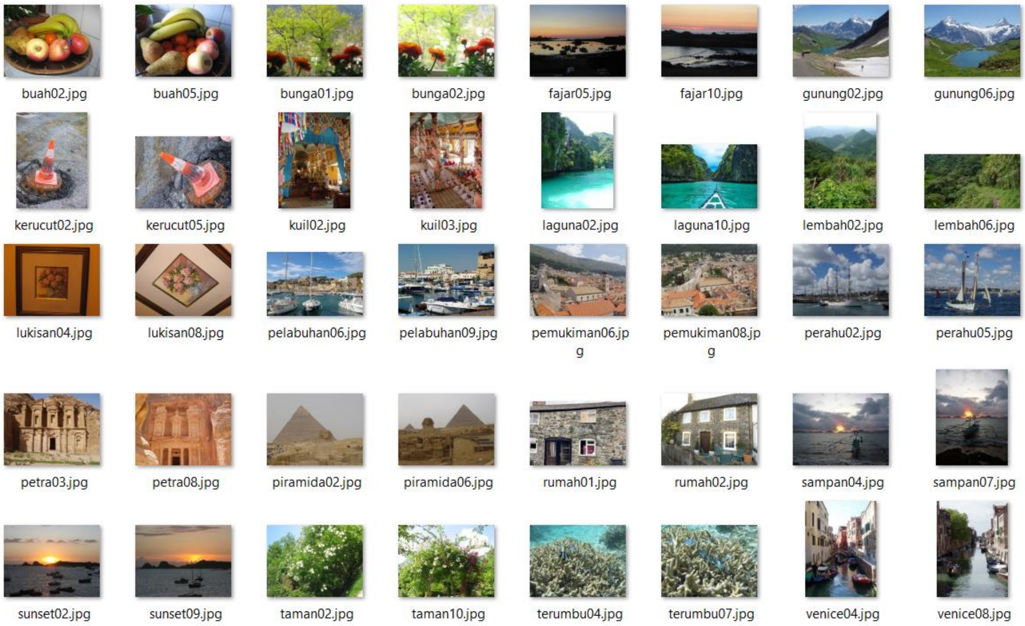
$$Precision = \frac{Number\ of\ relevant\ retrieved\ images}{Total\ number\ of\ relevant\ images} \quad (5)$$

Recall is used to extract all suitable images from the image database [25]. The evaluation formula used is shown in the following (6).

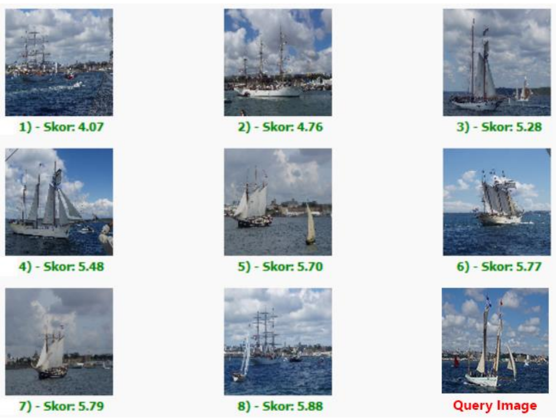
$$Recall = \frac{Number\ of\ relevant\ retrieved\ images}{Total\ number\ of\ relevant\ images\ in\ database} \quad (6)$$

4.2. Experimental results

Our proposed method using color and texture based on feature extraction technique applied on 200 images of INRIA image database. In the evaluation stage, as shown in Figure 4(a) that two pictures are taken randomly from each category and computed the *precision* and *recall* for each of them. Then in Figure 4(b) shows the results of the average *precision* and average *recall* for each measured category.



(a)



(b)

Figure 4. INRIA image database, (a) Snapshot of the data set, (b) Retrieved result with an input test image

In this study, a digital image search system using the CBIR method will be tested in three stages. In Table 1 shows the CBIR system experiment using texture features and Table 2 shows the CBIR system experiment using color features, while in Table 3, the CBIR system uses combined color and texture features.

In testing, by using the CBIR method based on the texture features in Table 1, the *maximum* efficiency of the results has yielded a *precision* level of 83% for the 'mountain' and 'sunset' image categories with an average *precision* of 40%, *recall* of 32%, and accuracy of 94%, while the results experiments based on the color features in Table 2 maximum results can reach 100% in several image categories such as 'boat', 'cone', 'temple' with an average *precision* and *recall* of 73% and accuracy of 97%. From the test results shown in Table 3, it can be seen that based on the combination of color and texture features, we have provided a maximum efficiency of 100% results in more categories of images compared to CBIR method testing based on color and texture features separately. We have obtained an average value of *Precision* 80.71%, *Recall* 80%, and Accuracy 98.03%. Simulation results show that schemes with color features are better than schemes with texture features. Schemes with combined color and texture features provide the best results. This approach achieves better performance for picture taking than schemes by using separate color and texture features.

Table 1. The performance of CBIR based on texture feature

Query Image	Precision (%)	Recall (%)	Accuracy (%)
Sunrise	50	50	95
Mountain	83.3	62.5	97.5
Lagoon	28.5	25	93.1
Valley	0	0	91.8
Harbor	40	25	94.3
Boat	37.5	37.5	93.7
Petra	33.3	12.5	94.3
Pyramid	66.6	50	96.2
House	14.2	12.5	91.8
Coral	80	50	96.8
Fruit	42.8	37.5	94.3
Flower	50	50	95
Cone	25	12.5	93.7
Temple	28.5	25	93.1
Paint	14.2	12.5	91.8
Settlement	16.6	12.5	92.5
Canoe	50	50	95
Sunset	83.3	62.5	97.5
Garden	33.3	25	93.7
Venice	42.8	37.5	94.3
Average	40.99	32.5	94.27

Table 2. The performance of CBIR based on color feature

Query Image	Precision (%)	Recall (%)	Accuracy (%)
Sunrise	75	75	97.5
Mountain	87.5	87.5	98.7
Lagoon	62.5	62.5	96.2
Valley	37.5	37.5	93.7
Harbor	87.5	87.5	98.7
Boat	100	100	100
Petra	37.5	37.5	93.7
Pyramid	87.5	87.5	98.7
House	75	75	97.5
Coral	87.5	87.5	98.7
Fruit	37.5	37.5	93.7
Flower	37.5	37.5	93.7
Cone	100	100	100
Temple	100	100	100
Paint	87.5	87.5	98.7
Settlement	87.5	87.5	98.7
Canoe	87.5	87.5	98.7
Sunset	75	75	97.5
Garden	87.5	87.5	98.7
Venice	25	25	92.5
Average	73.12	73.12	97.28

Table 3. The performance of CBIR based on color and texture features

Query Image	*Precision* (%)	*Recall* (%)	*Accuracy* (%)
Sunrise	87.5	87.5	98.7
Mountain	87.5	87.5	98.7
Lagoon	62.5	62.5	96.2
Valley	42.8	37.5	94.3
Harbor	87.5	87.5	98.7
Boat	100	100	100
Petra	37.5	37.5	93.7
Pyramid	100	100	100
House	87.5	87.5	98.7
Coral	100	100	100
Fruit	71.4	62.5	96.8
Flower	75	75	97.5
Cone	100	100	100
Temple	100	100	100
Paint	87.5	87.5	98.7
Settlement	87.5	87.5	98.7
Canoe	87.5	87.5	98.7
Sunset	75	75	97.5
Garden	87.5	87.5	98.7
Venice	50	50	95
Average	80.71	80	98.03

5. CONCLUSION

In this paper, discrete wavelet transforms are added to features extraction and chi-squared distance for similarity measurement from previous studies to make research results more accurate. Based on the research obtained results, it can be concluded that the CBIR method has been successfully applied to digital image search systems for image feature extraction with the dataset used by 200 images. Image retrieval is simulated 20 times with different queries. The queries used in the simulation are taken randomly. Evaluations of color and texture that are based on image capture performance are measured with *precision*, *memory*, and *accuracy*, which generally show that performance using color features is better than texture features.

Combining two or more features provides better results than a single feature. Color features and textures that are more precisely used to form feature vectors and similarities that can be matched with *chi-squared* distances.

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