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Malaysia Travel Destination Images Search Engine Using Geometric Moment Invariants

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Abstract

Content-based image retrieval (CBIR) is an alternative way to achieve effective image retrieval results that fulfill the user's requirement when he/she search for image information from the Web. In this paper, we present a Malaysia's travel destination images retrieval prototype application using moment geometry. In this prototype the effectiveness and the accuracy of the image retrieval process will be determine through features extraction by using moment geometry. The keywords from user will be used to match with the image database to search for the related images. The result from the text-based retrieval will be shown to user. The user will choose one of the images that he or she wanted. The selected image will proceed for the edge detection process using *Sobel* operator. Features extracted from the edge detection process will be used for the matching process to retrieve related and relevant images. Edge detection using the *Sobel* operator and moment geometry invariants algorithm were implemented into this prototype while precision and recall metrics are used to evaluate the effectiveness and the accuracy of this image retrieval prototype.

***Keywords**: features extraction, geometric moment invariants, edge detection, Sobel, image search engine*

1. Introduction

The introduction of the usage of image into HTML since 1993 has made image become one of the most important communication media [1]. The increment of the usage of images increases the demand on images search on the internet. There are two categories in image search, which are text-based image retrieval and content-based image retrieval. Content-based image retrieval is much more complex and rigid compare to text-based image retrieval but it will have better results because images are retrieving based on the element from the image itself which is unique.

Geometric moment invariants has been widely applied by many researches to extract features from images for process such as invariant pattern recognition, object classification and image reconstruction [2]. A set of moment computer from a digital image, generally represents global characteristics of the image shape and provides a lot of information about different types of geometrical features of the image. The main advantage with geometry moments is that image coordinate transformation can be easily expressed and analyzed in terms of the corresponding transformations in the moment space [6].

In this paper we propose a combination of edge detection using Sobel operator and feature extraction using geometric moment invariants for Malaysia travel destination images search engine. The edge detection process is to identify the edges for the objects in an image and create a new image file which contains the edge information of the selected image. A particular image chosen by the user will be process by the Sobel operator to produce a new edge image. The geometric moment invariants will be applied into this new edge image to generate the moment values for the retrieval task.

The remainder of this paper is as follows: The geometry moment invariant is discussed in Section (2). The edge detection process using sobel operator is described in Section (3). Section (4) discuses image retrieval process using moment invariant. The experiments and results are described in Section (5). Finally, the conclusion is discussed in Section (6).

2. Geometry Moment Invariants

Feature extraction is a process of extracting the necessary image area from a given input image. In a feature extraction process, data from an image will be scan through and algorithm calculation will be applied to generate related values for matching purpose, pattern recognition or reconstruction. To develop the feature extraction process for this prototype geometric moment invariants is implemented.

Functions of geometric moments which are invariant with respect to image-plane transformations are used in object identification and pattern recognition applications. The fundamental theorem of moment invariants was first formulated by Hu [7] based on the theory of algebraic invariants, to derive functions of moments which are invariant with respect to affine transformations of images.

Geometric moments, which are also, know as Cartesian moments or regular moments are the simplest among moment functions, with the kernel function defined as a product of the pixel coordinates. Functions of geometric moments that are invariant with respect to image plane transformations have found many applications in object identification and object pose estimation [4].

Geometrical moments are defined with the basis set $\{x^p, y^q\}$. The $(p+q)^{th}$ order two-dimensional geometric moments are donated by m_{pq} , and can be expressed as $p, q = 0, 1, 2, \ldots$

$$\mu_{pq} = \int\int_{\delta} (x - x_0)^p (y - y_0)^q f(x, y)dxdy \; ; \qquad (1)$$

where δ is the region of the pixel space in which the image intensity function $f(x, y)$ is defined.

The first-order functions $m_{10} m_{01}$ provide the intensity moment about the x-axis and y-axis of the image respectively. The intensity moment (x_0, y_0) is given by

$$x_0 = m_{10} / m_{00} \quad y_0 = m_{01} / m_{00} \qquad (2)$$

The moments computed with respect to the intensity moment are called central moments and are defined as $p, q = 0, 1, 2, \ldots$

$$\mu_{pq} = \iint_{\delta} (x - x_0)^p (y - y_0)^q f(x, y)dxdy \; ; \qquad (3)$$

Central normalized moment value η_{pq} is used for the image scaling with the formula:

$$\gamma = (p+q+2)/2, \quad \eta_{pq} = \mu_{pq} / (\mu_{00})^{\gamma/2}, \; p+q \le 3 \qquad (4)$$

Geometric moment values, φ_1 to φ_7 will be compute with respect to translation, scale and rotation invariants with formula:

$$\varphi_1 = \eta_{20} + \eta_{02}$$

$$\varphi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}{}^2$$

$$\varphi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$$

$$\varphi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2$$

$$\varphi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})\left[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2\right] +$$

$$(3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})\left[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right]$$

$$\varphi_6 = (\eta_{20} - \eta_{02})\left[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$$

$$\varphi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})\left[(\eta_{30} + \eta_{12})^2 + 3(\eta_{30} + \eta_{03})^2 +\right]$$
$$(\eta_{30} - 3\eta_{12})(\eta_{12} + \eta_{03})\left[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right] \qquad (5)$$

3. Edge Detection Using Sobel Operator

Edge detection is an important first stage in the determination of the oriental of objects in images [5]. Edges correspond to local intensity discontinuities of an image. Edge detection can be used for region segmentation, feature extraction and object or boundary description. How ever, edge detection is usually sensitive to noise and the structure of edge detectors is often heavily influenced by the type of noise that is expected [6].

Sobel operator is applied in this prototype for the edge detection process to produce a new image with the edge information. This new image file will contribute to the geometry moment invariants computation for the moment values. The Sobel operator uses the convolution concept where there will be two 3 x 3 convolution kernels will be used. One of the kernels will be use to detect the brightness changes in the horizontal direction (G*x*) and another one to detect the brightness changes in the vertical (G*y*) direction as shown in Fig. 1.

-1	0	+1
-2	0	+2
-1	0	+1

Mask for G*x*

+1	+2	+1
0	0	0
-1	-2	-1

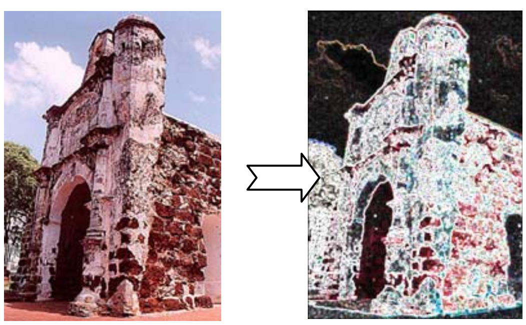
Mask for G*y*

Figure 1. Sobel operators

The gradient magnitude can be calculated from the following equation:

$$|G| = \sqrt{Gx^2 + Gy^2} \text{ or } |G| = \sqrt{Gx^2 + Gy^2} \qquad (6)$$

The new |G| value is the new pixel color value for the new edge image. A new edge image will be creating once all the |G| value for the entire coordinate is collected. The example of input image before and after edge detection process is shown in Fig. 2.



The Original Image The Sobel Edge Image

Figure 2. The input before edge detection and the output after edge detection

4. Image Retrieval Process

This image retrieval prototype is divided into four main modules, which are the keyword search module, the edge detection module, the feature extraction module and lastly the retrieve module. The flow of the module is shown in Fig. 3.

Figure 3 shows about how the image retrieval process can be performed. Keywords will be requiring from users to start the keyword search. Frequent keywords that will enter by the user are saved inside the database so that related image will be retrieve and display to the users. Results from this keyword search will be shown and users will be requiring choosing an image for the coming edge detection and featuring extraction process for related images retrieving.

The edge detection module is the process that uses the Sobel operator to detect the edges of the objects in the image selected by users. Two kernels which are the G*x* and G*y* shown in the Fig. 1 will be used to generate the convolution process to process the new pixel value to form a new image file with all the edge information. The new pixel value is form by adding up the G*x* and G*y* value for each coordinates in the selected image. The new created image is in a .BMP file format.

Before starting the feature extraction process, header information of the new .BMP edge image file will be scanned to retrieve some data such as height and width of the image. These data will be used for the feature extraction process to produce the moment value that will contribute to the retrieve process. During the feature extraction process, the geometric moment invariants algorithm will be applied to detect the edges in the edge image the compute the moment value, the moment intensity value, the central value lastly the normalized central moment value. These values will then used to generate the seven (7) moment geometric values for the retrieve process.

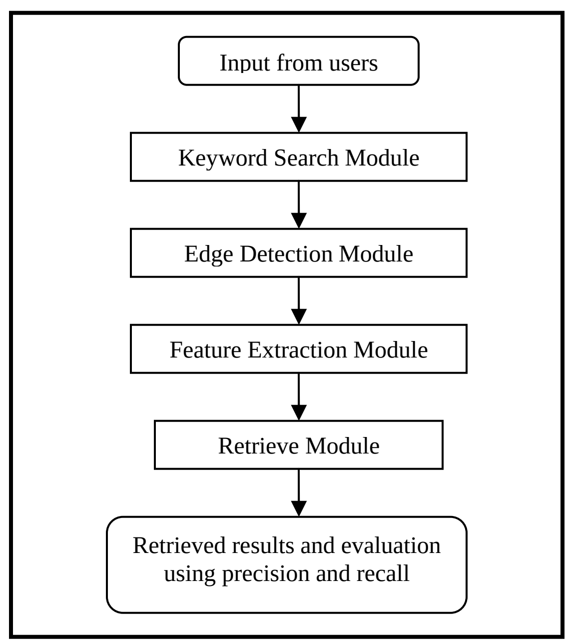


Figure 3. Flow chart of image retrieval process

The generated moment geometric values will be use to retrieve the related images by calculating the Euclidean Distance value for the selected image and all images in the database. The Euclidean Distance value is to calculate the distance between the selected image and the entire images in the database.

Euclidean Distance

$$E_d = \sqrt{\sum (V1_i - V2_i)^2}$$

E_d = Euclidean Distance value
$V1$ = the selected image
$V2$ = image from the database
$_i$ = represents the

A threshold value will be set for each retrieve process so that only images with its Euclidean Distance value that are equal or less then the threshold value are retrieved as result. The effectiveness of images retrieving process for each search with different threshold value will be measured by using the precision and the recall criteria.

Precision and recall are defined as follows:-

Percentage of precision

$$\text{Precision} = \frac{\text{Retrieved related images}}{\text{Total retrieved images}} \times 100\%$$

Percentage of recall

$$\text{Recall} = \frac{\text{Retrieved related images}}{\text{Total related images}} \times 100\%$$

5. Experiments and Result

After implementations, a testing for the performance of precision and recall is held by using different threshold values. Threshold values 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 were applied into this testing to observe the performance of the prototype as shown in Tables 1, 2, and 3, respectively, as shown in Appendix section. Six images from six different travel destinations in Malaysia are chosen as the sample images for this testing. The six destination includes A Famosa, Kek Lok Si, KLCC Twin Tower, KL Tower, Jambatan PulauPinang and Taman Negara. The retrieval results basedon precsion, recall on deffeient images are sown in Figs. 4, 5, and 6, respectively.

Figure 4 shows that the total retrieve images increases when the threshold values are increase. The threshold value will be used to compare the Euclidean Distance value of each image and those images will the value equal or lesser then the threshold value will be retrieved. More images are success retrieved by the prototype with the bigger threshold. At the last few threshold the increase in the retrieve image are lesser compare to the result using the first few threshold.

Figure 5 shows the performance of the precision. The precision of this prototype does not show a satisfactory level because the precision percentage for most of the search does not reach more then 50 percent. There are obvious changes on the precision value on the first few threshold but later then there is not much changes on the precision percentage. It shows a stable performance at the last few threshold searches.

Figure 6 shows the recall performance of the prototype.
At the last few threshold searches, the percentage of the recall value is more then 60 percent, which means most of the related images in the database has been successfully retrieved by the prototype. The recall percentage increases while the threshold values increase but the increment of the recall is more obvious at the first few thresholds compare to the last few values.

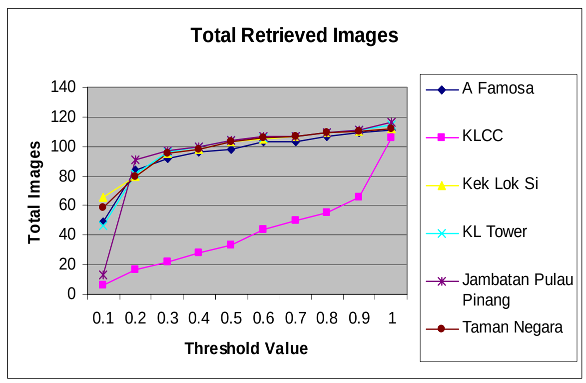


Figure 4 Total retrieved images by different threshold value

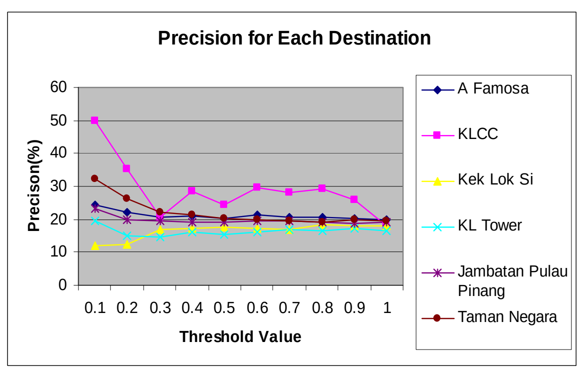


Figure 5. Percentages of precision

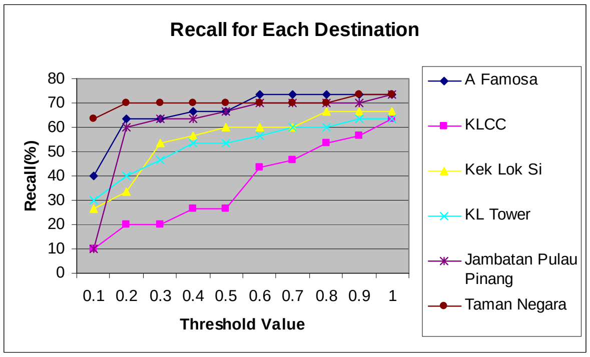


Figure 6. Percentages of precision

From the experiments, there are increments of total retrieved images when the threshold value increases. The performance of the recall of this system show a better result compare to the performance of the precision. According to the results of the precision, there are related images retrieved from each search but these related images only consists a small value among the total retrieved image. The performance of the recall shows that the majority of the related images in the database have been successfully retrieved although the precision is low.

6. Conclusion

Nowadays search engine plays a very important role in daily lives and is does not limited with the usage of media only. Images have become a very important media for users to search for and its effectiveness and accuracy has become very important. The geometric moment invariant is very effective in generating useful moment geometric values for retrieving related images from the database. From the results of the testing the performance of recall shows a very prominent result where most of the related images are retrieved successfully. The image selected by users and the threshold value plays a very important role to decide the result of that particular search. There is the interactive ness between the user and the prototype. For future enhancement is suggested that more images are used as sample data to increase the precision and recall for the prototype.

7. References

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8. Appendix

Table 1. Total retrieved images for each threshold value

Destination \ Threshold Value	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
A Famosa	49	84	92	96	98	103	103	107	109	111
KLCC	6	17	22	28	33	44	50	55	66	106
Kek Lok Si	66	80	95	98	103	105	107	109	110	112
KL Tower	46	81	96	100	104	106	107	109	111	115
Jambatan Pulau Pinang	13	91	97	100	104	107	107	109	111	116
Taman Negara	59	80	95	98	103	106	107	109	110	112

Table 2. Precision for each threshold value

Destination \ Threshold Value	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
A Famosa	24.29	22.169	20.652	20.833	20.408	21.359	20.56	20.56	20.183	19.819
KLCC	50	35.294	20.723	28.571	24.242	29.545	28	29.091	25.758	17.925
Kek Lok Si	12.121	12.5	16.842	17.368	17.478	17.143	16.822	18.349	18.182	17.857
KL Tower	19.565	14.815	14.583	16	15.345	16.038	16.822	16.514	17.117	16.521
Jambatan Pulau Pinang	23.077	19.78	19.588	19	19.23	19.626	19.626	19.266	18.918	18.966
Taman Negara	32.203	26.25	22.105	21.429	20.388	19.811	19.626	19.266	20	19.643

Table 3. Recall for each threshold value

Destination \ Threshold Value	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
A Famosa	40	63.333	63.333	66.667	66.668	73.333	73.333	73.333	73.333	73.333
KLCC	10	20	20	26.667	26.667	43.333	46.667	53.333	56.667	63.333
Kek Lok Si	26.667	33.333	53.333	56.667	60	60	60	66.667	66.667	66.667
KL Tower	30	40	46.667	53.333	53.333	56.667	60	60	63.333	63.333
Jambatan Pulau Pinang	10	60	63.333	63.333	66.667	70	70	70	70	73.333
Taman Negara	63.333	70	70	70	70	70	70	70	73.333	73.333