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Image Retrieval using Modified Multi Texton and Rotation Invariant Local Binary Pattern

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Abstract*— Image retrieval is a standard method used to search a digital image in large image databases. *One of the most critical things in image retrieval is the feature extraction process. Several techniques can be used in the image feature extraction process, one of which is Multi Texton Histogram (MTH). MTH is usually carried out with two main processes, namely color quantization, and texture orientation. Improvement of MTH method performance can be made by adding texton. In our experiment, we test the method by using rotated images. In this paper, we develop the use of an invariant method for rotation, namely the Local Binary Pattern Rotation Invariant (LBPROT) method to improve image retrieval precision. The results of combining these two methods produce features of each image. The features produced by each image are compared using a distance matrix. A query image that has the smallest distance matrix value is an image that has the same class as the compared database image. Based on our experiments on typical images, the use of Modified MTH and LBPROT can improve image retrieval performance by increasing the percentage of precision and recall by 3.63% and 0.62%. However, The Modified MTH is better when compared to the merging of the Modified MTH and LBPROT on 45 °, 135 °, 225 °, and 315 ° angle rotations with precision values by 24% -27%. Meanwhile, our testing result using rotated images, the combination of Modified MTH and LBPROT produces an increase in precision at angles rotation of 90 °, 180 °, and 270 ° by 2% -3%.

Keywords*— *image retrieval, multi texton histogram, local binary pattern, rotation invariant.

I. Introduction

An image contains some information like brightness, contrast, contour, color, shape, and texture. We use some digital image processing to gain information from an image[1]. Image retrieval is one of the digital image processing applications. There are three approaches to retrieve an image: text-based, content-based, and semantic-based. The text-based approach needs a text descriptor, where it will manually annotate the whole images on the database. Another approach needs visual content to retrieve. These contents can be extracted into a numerical value called features. There are three main categories of features: color[2], texture[3], and shape[4]. Various features will be stored as indexes of the image. Retrieval images can be done by calculating the similarity of the query images, and their similarity will rank it. So, one of the essential things in content-based image retrieval is extraction features.

MTH is one of the extraction features methods that can be used on image retrieval that combining color and texture. MTH does not need image segmentation and easy to implement. Furthermore, MTH is faster than Texton Co-occurrence Matrices (TCM), and Edge Orientation Autocorrelogram (EOAC) [5]. A combination of MTH and another method can increase precision and recall. When combining MTH and Gray Level Co-occurrence Matrix (GLCM) to retrieve an image, it can gain precision and recall consecutive 3.10% and 0.37%[6]. Even it can increase some precision and recall; it did not test on the rotated image.

In another research, Local Binary Pattern Rotation Invariant (LBPROT) was used to image retrieval on rotated images. They used batik and songket dataset, and get 100% recall. It is shown that features from LBPROT robust to retrieve a rotated image[7]. So in this paper, we are trying to adopt some technique that used by [6] by adding some texton on MTH and combine it with invariant Rotated Local Binary Pattern (LBPROT) to outperform the rotated image of image retrieval. The next section presents the related work. Meanwhile, in section III, we will discuss the features extraction approach, then in section IV, we explain our experimental result. Our conclusions will be stated in our last section.

II. Related Work

The use of MTH for image retrieval was implemented by various researchers [6], [8]–[11]. The result showed that MTH has an outstanding achievement for it. Qazy and Farid [8], modified MTH by localized image into nine equals district block. Then, the feature will be extracted for each block using MTH. Ramadevi [9], modified the shape features of MTH, and it can outperform Color Look Up Table and Micro Structure Descriptor. Minarno [6], proposed enhancement of MTH by adding two shapes of MTH descriptor and combined the features with a global texture feature called Micro Structure Co-occurrence Descriptor (MTCD). The result showed that MTCD was outperformed MTH. Even MTH shows high performance on image retrieval, but all of the previous works are not rotation invariant.

The use of a rotated image as a data test on image retrieval was performed [7], [12]–[14]. The use of a rotated image as a data test on image retrieval was performed [7], [12]–[14]. The invariant rotated Local Binary Pattern (LBP)

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was used on different datasets and showed that this method outperformed another method which is using rotated images as a dataset; e.g., Outex-12, Outex-10, and UIUC dataset [12]; Broadtz, Outex, and PSU [13]; Batik, and Brodatz [14]; and songket dataset [7]. So, in this research, we develop a combination method for image retrieval, which is rotation invariant.

III. Features Extraction

A. *Modified Multi Texton Histogram*

1) *Edge Orientation Quantization*

One of the essential things to create a human visual perception of an image is edge orientation, which is on how to get gradients of image color was described by Zenzo [15]. Sobel Operator is used to detecting horizontal and vertical orientation. Using Eq. 1 and 2, find the horizontal and vertical gradient, then the magnitude of the image will find using Eq. 3.

$$|a| = \sqrt{(R_x)^2 + (G_x)^2 + (B_x)^2} \quad (1)$$

$$|b| = \sqrt{(R_y)^2 + (G_y)^2 + (B_y)^2} \quad (2)$$

$$a.b = R_x.R_y + G_x.G_y + B_x.B_y \quad (3)$$

The edge orientation is obtained by quantifying the result of Eq. 5 into 18 bins. So from this step, we got an edge orientation map that contains a value from 0 to 17.

$$\cos(\overline{a,b}) = \frac{a.b}{|a||b|} \quad (4)$$

$$\theta = \arccos[\cos(\overline{a,b})] = \arccos\left[\frac{a.b}{|a|\,|b|}\right] \quad (5)$$

2) *Color Quantization*

It is widespread to use color for gathering information that is used to retrieve an image. The common way to used color as a feature is by its histogram. In our research, we use RGB color space. Each component of RGB will quantify into 64 bins, which each component of RGB will quantify into 4 bins. The final form of this step is a color quantization map using Eq. (6) and (7)[16].

$$QR = \left[R \times \frac{bins\ R}{\max(R)}\right], QG = \left[G \times \frac{bins\ G}{\max(G)}\right], QB = \left[B \times \frac{bins\ B}{\max(B)}\right] \quad (6)$$

$$QC = (bins\ G \times bins\ B \times QR) + (bins\ B \times QG) + QB \quad (7)$$

3) *Texton Detection*

The next step after gain both edge orientation and color quantization maps is texton detection. The original MTH that is found by Liu used 4 textons to create a histogram as a feature in MTH. Then, Minarno, in his study, adds two additional textons, so there are six textons in total. The result shows that with that two additional textons can increase the performance of MTH because using these two additional textons can prevent the loss of information that contains in vertical right and horizontal bottom of occurrence pixels. Fig. 1 show the texton that used in this study, which is T1-T4 is the original Texton of MTH, while T5 and T6 are additional.

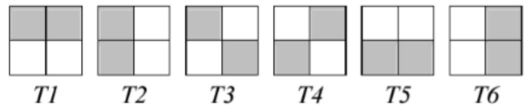


Fig. 1. Six textons of modified MTH.

Texton works as a mask on both maps of the previous process. Each texton is convoluted on both of the maps. Texton will convoluted from left to right, top to bottom, and move by 2x2 pixels. If there is the same value of the pixel detected by the texton mask, the value will be held. Otherwise, the value will change into zero. At the end of this process, each texton will produce its map based on each detected texton. Both edges oriented and color quantization maps will have six different texton detection, and the final form is created by combining all six of the texton detection for each map. So now, maps of edge orientation and color quantization based on six texton detection has been created, from this form the next steps is to create a histogram of edge orientation and color quantization as shown in Fig. 2 and Fig. 3. Next, combine these two histograms by concatenated and called modified MTH features.

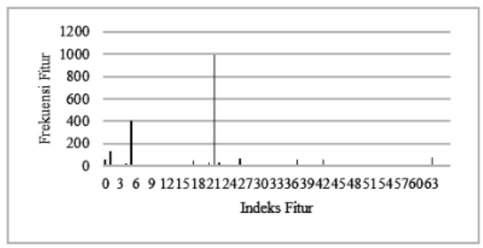


Fig. 2. Color Histogram.

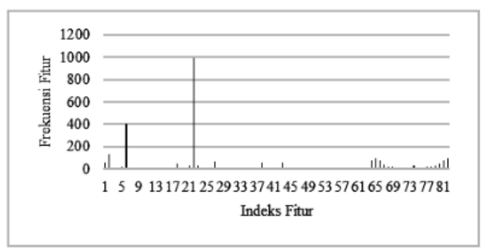


Fig. 3. Edge Orientation histogram.

B. *Local Binary Pattern Rotated Invariant*

The original Local Binary Pattern (LBP) is getting by calculated the difference between the value of the center pixel and its neighborhood using Eq. (8) and (9) [12].

$$LBP_{P,R} = \sum_{p=0}^{P-1} s(g_p - g_c)2^P \quad (8)$$

Where

$$s(g_p - g_c) = \begin{cases} 1, & g_p \geq g_c \\ 0, & g_p < g_c \end{cases} \quad (9)$$

P is the number of neighborhoods, R is the radius between the center and its neighborhood, g_c is the value of the center, g_p is the value of the p neighbor pixels. In Eq. (9), s is the thresholding function of LBP; s will be 1 if g_p is higher than g_c, and otherwise will be 0. After that, we can obtain the binary value by the thresholding process. If the number of neighbors is 8 pixels, the length of the feature would be 256.

Local Binary Pattern Rotated Invariant (LBPROT) fixed the weakness of LBP to detecting the rotated image. The idea of LBPROT is to simplifying the various values of LBP, e.g., when some different values of LBP as 10000010, 00101000, and 00000101 are obtained, these values will be shifted bit by bit until the minimum value of LBP is produced. Eq. 10 can be used to find the minimum value of LBP.

$$LBP_{P,R}^{ri} = \min\{ROR(LBP_{P,R}, i) \mid i = 0,1,\dots,P-1\} \quad (10)$$

IV. Result and Discussion

A. Datasets

Several data are commonly used for image retrievals such as OUTex, Brodatz, Vistex, batik, and Corel. This paper use 10k Corel datasets that can be obtained on http://www.ci.gxnu.edu.cn/cbir/Dataset.aspx. The Corel dataset contains 10000 images on it, which consists of 100 categories with 128x187 pixels of jpg image. Some examples of the categories we use are Bus, F1, Stained Glass, Stamps, Lion, Wolf, Horse, Mountain, Butterfly, Tiger, Elephant, Roses, Fractal, Tennis player, and Bonsai. The example of Corel dataset is shown in Fig 4. In this study, 70% of data is set as data training, while 30% as data testing or query image. Besides, we rotate 100 images with different orientations to test the robustness of our methods.

Fig. 4. Example of Corel Dataset.

B. Distance metric

As the proses before, the features will be represented as an M-dimensional feature vector $T_i = [T_1, T_2, \dots, T_m]$ will be stored in the database. Let Q as a data test or query image, Q will contain the feature vector of the query image. To calculate the distance can be provided using L1 Distance as Eq. (11).

$$D(T,Q) = \sum_{i=0}^{M-1} \frac{|T_i - Q_i|}{1 + T_i + Q_i} \quad (11)$$

The similar image will be decided base on the smallest value of Eq. (9) and will be assigned as the same class of image. The use of the distance is because of its simplicity and not much computational cost, so that it will be suitable for large image datasets.

C. Performance Evaluation

Precision and recall were used to evaluate the performance, as shown as Eq. (12) and Eq. (13).

$$Precission = \frac{I_N}{N} \times 100\% \quad (12)$$

$$Recall = \frac{I_N}{M} \times 100\% \quad (13)$$

Where I_N is the number of relevant images retrieval, N is the number of retrieval images, M is the total image on the database, which is on the same categories as a query image.

D. Retrieval Performance

To evaluate the performance of the methods, we set the number of retrieval images to 12. Next, precision and recall are used to show the performance. There are two scenarios that we use in this study, first is image retrieval by using the normal images, and the second is by using some rotated images. The rotated image will be rotated as 45º, 90º, 135º, 180º, 225º, 270º, dan 315º. All of the scenarios are used all of the combination methods such as modified MTH, LBPROT, and the combination of modified MTH dan LBPROT.

Table 1 shows the result of the first scenario. Both Modified MTH and a combination of Modified MTH and LBPROT outperform LBPROT. This result occurs because the feature of LBPROT was extracted only from a grayscale image, compared to modified MTH, it has more information gathered than LBPROT. Because modified MTH extracted feature from color and edge orientation, some additional of LBPROT features on modified MTH can increase the performance up to 3,63% for precision and 0,62 % for recall.

TABLE I. Result of Normal Image Data

Method	Performance	
	Precision	***Recall***
Modified MTH	34.70%	5.95%
LBPROT	14.54%	2.49%
Modified MTH + LBPROT	**38.33%**	**6.57%**

In the second scenario, on the rotated image query, based on Tabel 2, and Table 3 LBPROT still cannot beat the other

TABLE II. AVERAGE OF PRECISION ON ROTATED IMAGE

Method	Degree of rotation						
	45°	90°	135°	180°	225°	270°	315°
Modified MTH	**27.42%**	37.67%	**26.50%**	38.25%	**27.25%**	37.92%	**24.92%**
LBPROT	2.33%	13.58%	2.67%	13.58%	2.25%	13.50%	2.67%
Mod. MTH + LBPROT	16.00%	**39.83%**	15.25%	**40.33%**	15.75%	**39.67%**	14.58%

TABLE III. AVERAGE OF RECALL ON ROTATED IMAGE

Method	Degree of rotation						
	45°	90°	135°	180°	225°	270°	315°
Modified MTH	**4.70%**	6.46%	**4.54%**	6.56%	**4.67%**	6.50%	**4.27%**
LBPROT	0.40%	2.33%	0.47%	2.33%	0.40%	2.31%	0.47%
Mod. MTH + LBPROT	2.74%	**6.83%**	2.61%	**6.91%**	2.70%	**6.80%**	2.50%

method. Modified MTH shows its robustness on 45, 135, 225, and 315 degrees of rotation, while the combination of modified MTH and LBPROT show its strength on 90, 180, and 270 degrees of rotation. This result is affected by the rotation image of 45 degrees, and its multiplies have black padding on it, as shown in Fig. 5. Even so, the combination of modified MTH and LBPROT shows the robustness of handling the rotated image.

The overall results of this study show that the value of precision is small. This result can happen because some of the images on different categories of Corel datasets have similar visuals. For example. On Fig. 6, image (a) is located in different categories compare to (b), even it's a different category of an image, but both of the images have a similar color and similar texture.

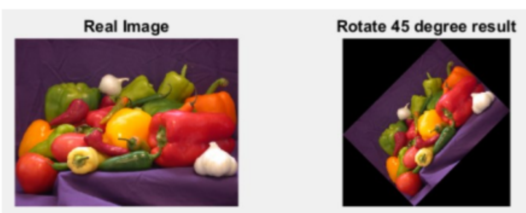
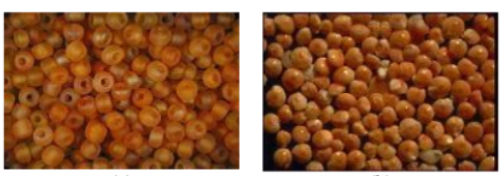


Fig. 5. Image Rotated by 45 degrees.



(a) (b)

Fig. 6. Similar image on different categories dataset, (a) in categories 16, (b) in categories 61.

V. CONCLUSIONS

This study is presenting an image retrieval on the rotated image using a combination of modified MTH and LBPROT. The combination has excellent performance and outperforms the others. The combination increases the precision until 3.63% and 0.62% of recall on the typical image Corel dataset. Using the rotated image as a data test, both modified MTH and combination of modified MTH and LBPROT give a good result. The average result of modified MTH showing its best on rotated image query, but the difference is less than 1%. Overall, the combination of modified MTH and LBPROT shows other its superiority. Future work in this method is to combine any invariant rotation methods to gain the performance of image retrieval.

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