Image Retrieval using Multi Texton Co-occurrence Descriptor and Discrete Wavelet Transform

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***Abstract*—This paper describes an efficient algorithm for Content-Based Image Retrieval (CBIR) based on Multi Texton Co-Occurrence Descriptor (MTCD) and Haar (Wavelet) namely MTCD-H. The problems from the previous research were the computational speed and the low value of precision. The data that was used consisted of 10000 Corel images and 300 batik images. MTCD used the RGB colour feature, the Sobel edge detection, and global feature using Gray Level Co-Occurrence Descriptor (GLCM). Wavelet was considered an approach that could increase the precision value as well as reduce the features. This paper combined the MTCD with Haar for the image extraction process in order to increase the computational speed and the precision value. The contribution of this paper was aiming for extracting the Wavelet feature on a grayscale image before extracting the feature using GLCM. The results showed an increase of precision value pointed at 3.36 for batik images and 5.11 for the Corel images. In addition, the computational speed for batik images was performed 84.35s faster as for the Corel images 2988 faster. Based on the specified results, it could be concluded that the MTCD-H were effective in reducing the computational speed as well as increase the precision.**

Keywords: Batik, Image Retrieval, Haar, MTCD, MTCD-H, Texton, Wavelet

I. INTRODUCTION

The studies of image retrieval were initiated since the 1970s when the utilization of text was not optimal since every image needed a label. The problems occurred when a huge number of images were requiring a label from the human. The manual labelling process was considered inefficient and subjective. On the early of the 1990s to the present, the studies of image retrieval have captivated the enthusiasm of a lot of researchers which mainly investigated the combination of colour features, textures, and the shapes on individual or group of images [1].

The feature extraction commonly produced a huge amount of features causing the decreasing of accuracy value. Therefore, there should a method for reducing insignificant features for achieving the only relevant features and giving an optimal solution without reducing the accuracy value [2].

Research [3] related to image retrieval with Batik dataset used level 2 Deubecheuss Wavelet and invariant movement. This research was deployed for analysing 7 types of pattern and 225 images. The research results used 5 Batik patterns including *lereng*, *parang*, *kawung*, *nitik*, and *truntum* utilizing 20 test data on each pattern which produced a similarity percentage around 80%-85%. In term of the others 2 Batik pattern including *mendung* and *ceplok,* used 10 test data on each pattern which produced a similarity percentage around 30%-40%. The other research which utilized Batik images dataset combined Wavelet transformation method with Canberra distance [4]. Based on this research, the Wavelet transformation was the combination of Discrete Wavelet Transform and Rotated Wavelet Filter. This research produced average accuracy pointed at 70%. The researchers in [5] utilized Corel image dataset using Radial Mean Local Binary Pattern (RMLBP) which was implemented for extracting the texture features from grayscale images. In addition to the implementation of RMLBP method, the researchers also applied the Particle Swarm Optimization (PSO) for features weighting. The proposed method was performed for analysing 5k and 10k Corel images resulting the increase of features extraction process speed.

Another related research in term of image retrieval used Color Difference Histogram (CDH) in 300 Batik images dataset which has 50 classes and 6 images on each class. This research combined the CDH and Gray Level Co-Occurrence Matrix (GLCM) for defining the global features. The research result concluded that the GLCM could increase 3.5% higher than utilizing the CDH alone indicating the combination of GLCM and CDH considered effective [6]. Research related to texton has already performed for analysing 400 images. The results showed that the proposed method could significantly increase the precision value rather than using the GLCM and colour correlograms (CCG) methods [7]. Another research which used the texton method proposed the multi-texton histogram (MTH) which based on the theory of Julesz's textons. The experiment was performed in 15000 Corel images divided into 2 main datasets including 5000 and 10000 data. The research result indicated that the proposed method was better in term of colour, texture, and shape features. The precision value produced form the MTH was pointed at 49.98 and the recall at 6.00 for the 5000 Corel datasets while for the 10000 Corel datasets the precision depicted at 40.87 and the recall at 4.91 [8]. On the other research [9], related to CDH, the proposed method has some characteristics including the calculation process of differentiation of perceptual colour between 2 dots including the colour and the edge orientation. This method experimented on Corel images dataset divided into 2 categories including the 5000 having 50 classes and the 10000 Corel data consisting of 100 classes. The research result from the proposed method increased the precision and recall up to 7.39% and 0.89% respectively compared to the MTH [9].

The other research related to image retrieval using GLCM experimented on Batik images datasets consisting of 1088 images divided into 7 distinct groups was directed to identify the pattern on Batik images automatically [20-22]. There existed 6 texture descriptor that utilized during the experiment including the maximum probability, correlation, contrast, uniformity, homogeneity, and entropy. The feature extraction process was matched using the Canberra distance. The best retrieval value was pointed at 92.1% [10].

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There was previous research concerning about the Multi Texton Co-Occurrence Descriptor (MTCD). This method was the development of MTH added with 2 new textons. MTCD extracted the colour, texture, and shape features concurrently, then calculated the representation of the image globally using GLCM. The experimented data consists of 300 Batik images and 15000 Corel images as datasets. The similarity of images was calculated using the Canberra distance while the MTCD was tested using the precision and recall values. The experiment showed that the addition of 2 new textons could increase the precision value up to 2.86% for Batik, 3.40% for 5000 Corel datasets, and 3.06% for the 10000 Corel datasets[1].

The other researchers used the Wavelet method on Batik images dataset [11]. The goals of the research were directed to resolve the noise problems such as the unbalanced brightness, the fold on the image, the different size of the base pattern, and the low contrast. Apart from using Wavelet, the authors also implemented the GLCM method. The Wavelet method was utilized for decomposing the real images then the GLCM method was used to extract the texture features. This research resulted the maximum value at 72%. Concerned to the Wavelet method, the authors in [12] utilized the combination of Wavelet and Color Vocabulary Trees on 1000 Corel images datasets. This research produced the average value of precision at 50.3% [12].

Based on the previous research MTCD could increase the precision value for both Batik and Corel images datasets. The combination of Wavelet method also could rise the precision and recall values. The problems from the former researches were related to the computational speed because the datasets that were used during the experiment consisted of 10000 Corel and 300 Batik images which required a number of steps regarding the feature extraction including the colour, edge, and angle. The goals of this paper were directed to combine the MTCD and Wavelet method in order to accelerate the computational speed as well as increase the precision value. The difference from the former works was the addition of Wavelet before the GLCM process.

II. MTCD AND WAVELET

A. *Multi Texton Co-Occurrence Descriptor*

The features utilized in the experiment consisted of 3 main features for detecting or extracting the feature from images including the colour, edge, and angle. The following lost is the explanation of each feature.

1. *Colour Feature*

Colour is the spatial information which is useful for object detection and taking an image. Colour histogram was commonly used as a feature for extracting an image. On this research, the authors used the RGB colour space. The RGB colour space was quantified into m bins. For example, if 4 bins are used, then the component value of R, G, and B respectively are 0 and 63 [1].

2. *Edge Feature*

This process was utilized for detecting the edge part of an image directing to detect the detailed part of the image. On this research, the edge detection method that was performed was the Sobel operator.

Sobel is considered as a way to avoid the gradient which is calculated on the interpolation point from the involved by smoothing the digital images [13]. Fig. 1 below illustrated the Sobel Matrix in 3x3 pixels.

$$\begin{bmatrix} a_0 & a_1 & a_2 \\ a_7 & (x,y) & a_3 \\ a_6 & a_5 & a_4 \end{bmatrix}$$

Fig. 1 Sobel Matrix in 3x3 pixel

3. *Gray Level Co-occurrence Matrix Corner Feature*

The texture feature of the image could be extracted using several statistic steps on GLCM. The common statistical measurement in GLCM includes the Angular Second Moment, Entropy, Contrast, dan Correlation [11]. Fig. 2 below illustrated the GLCM features extraction.

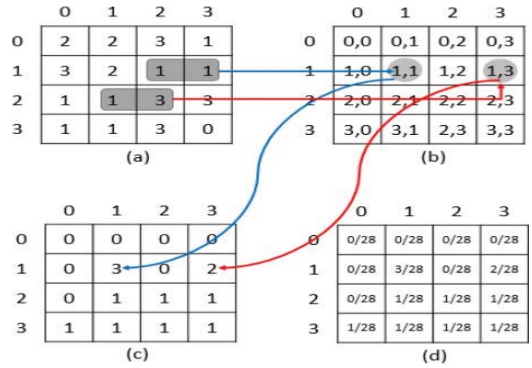

Fig. 2 GLCM Matrix (a) Real image, (b) GLCM index, (c) Co-occurrence Matrix, (d) Probability value

a. *Angular Second Moment*

Angular Second Moment (ASM) also known as energy. The energy calculates the uniformity of texture. If an image is fully homogeneous, its energy value will be high [14]. The equation of ASM is described below:

$$ASM = \sum_{i,j=0}^{L-1} p^2(i,j,d,\theta) \tag{1}$$

b. *Entropy*

Entropy is inversely correlated with energy, as measured by the diversity or randomness of an image [7]. Entropy equation is described below:

$$Ent = \sum_{i,j=0}^{L-1} P(i,j,d,\theta).\,logP(i,j,d,\theta) \tag{2}$$

c. *Contrast*

Sum of Square Variance is another name of Contrast. It defers the calculation of the intensity contrast linking pixel and its neighbor over the whole image. [8]. The Equation of contrast is described below:

$$Cont = \sum_{ij=0}^{L-1} (i-j)^2.\,P(i,j,d,\theta) \tag{3}$$

d. *Correlation*

Correlation measures the linear dependence between the two pixels [8]. Correlation equation is described below:

$$Corr = \sum_{i,j=0}^{L-1} \frac{(i-\mu_x)(i-\mu_y)P(i,j,d,\theta)}{\sigma_x\sigma_y} \tag{4}$$

Where:

$\mu_x = \sum_{i,j=0}^{L-1} i.\,P(i,j,d,\theta)$

$\mu_y = \sum_{i,j=0}^{L-1} j.\,P(i,j,d,\theta)$

$\sigma_x = \sum_{i,j=0}^{L-1} (i-\sigma_x)^2.\,P(i,j,d,\theta)$

$\sigma_y = \sum_{i,j=0}^{L-1} (i-\sigma_y)^2.\,P(i,j,d,\theta)$

4. *Texton Detection*

The method used in the detection of texton is MTCD. MTCD is the development of the MTH method. The difference lies in the addition of 2 textons so that in the MTCD method the number of textons is 6. The new textons are horizontal bottom and vertical right. The purpose of this addition is to prevent loss of information when pixels occur simultaneously at the horizontal bottom and vertical right [1]. Both Fig. 3 and Fig. 4 below describe the textons mapping in MTH and MTCD respectively.

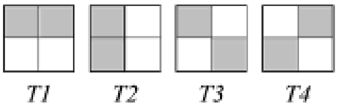

Fig. 3 MTH textons

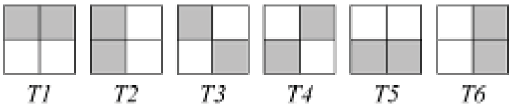

Fig. 4 MTCD textons

B. Wavelet

The Wavelet transformation from digital images extracts the information from several spatial orientations that are useful for analyzing image content, texture discrimination, and fractal analysis [15]. The same wavelet function used for decomposition and reconstruction. The level 1 decomposition and reconstruction process uses the wavelet function [16]. Fig. 5 below illustrated the DWT.

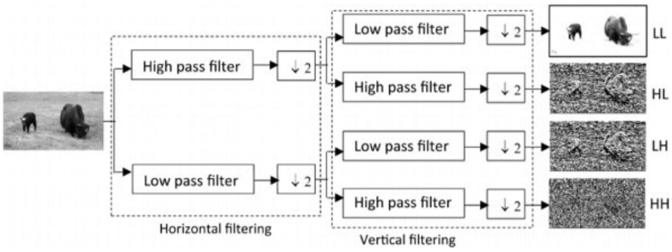

Fig. 5 Discrete Wavelet Transform (DWT)

The basic concept of Wavelet is explained in the decomposition of 1-D signals. Wavelet breaks down the f (x) signal into sub-band signals, using a scaling and translation function known as a Mother Wavelet. Mother Wavelet is used to produce other window functions [11].

$$\psi_{a,b}(x) = \frac{1}{\sqrt{|a|}}\psi(\frac{x-a}{b}) \quad (5)$$

Where a and b are scaling factors and translation parameters, related to window location [17]. The image consists of 2-D signals, including rows and columns. In order to analyze the 2-D signal, 2-D Discrete Wavelet Transform (DWT) is needed. 2-D DWT can be computed using 2-D Wavelet filters followed by 2-D sampling operations [11]. In this paper, the Wavelet methods that are used include Haar, Daubechies, Coiflet, and Biorthogonal. By the end of the research, the authors compared each of the Wavelet methods results by calculating the average precision for investigating the best approach.

III. RESULTS AND DISCUSSION

A. Data

The data used in this paper were the images of Batik and Corel. The image data was obtained from the previous research. Batik images consisted of 300 images with 50 classes and each class has 6 images, while Corel images consisted of 10000 images with 100 classes and each class has 100 images. The illustration of datasets is described in Fig. 6 and Fig. 7.

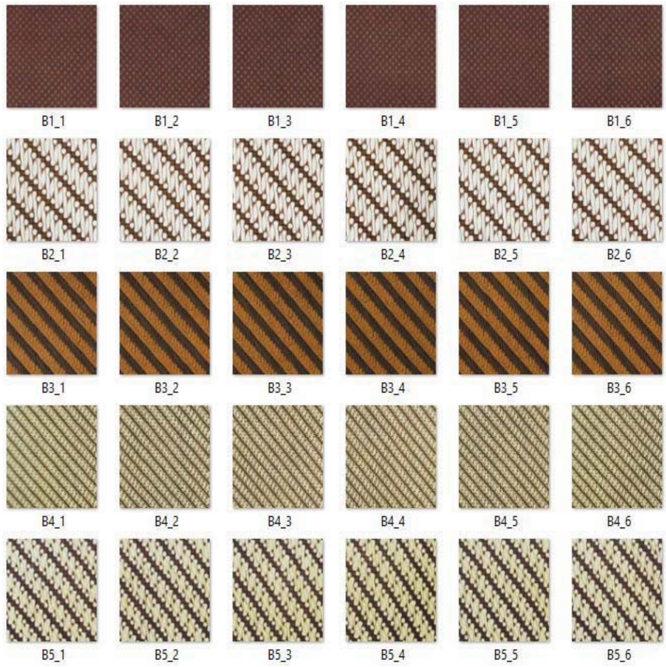

Fig. 6 Batik images

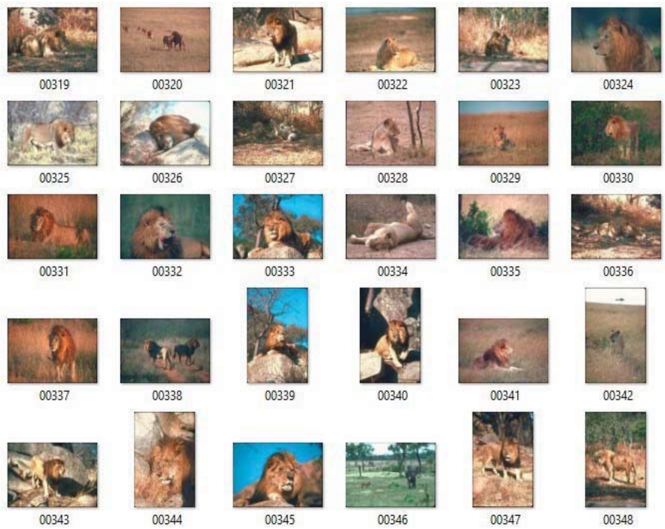

Fig. 7 Corel images

B. Indexing

Indexing was carried out according to the feature extraction used in this research, including colour, edge and angle. Fig. 8 and Fig. 9 shows example of batik and corel histogram respectively.

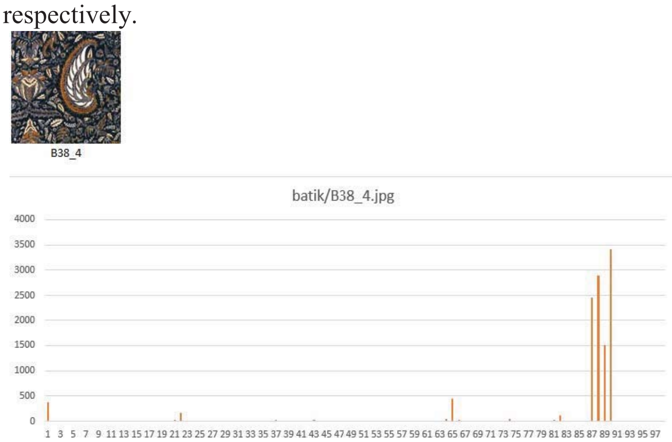

Fig. 8 Example of the result from Batik image's indexing process

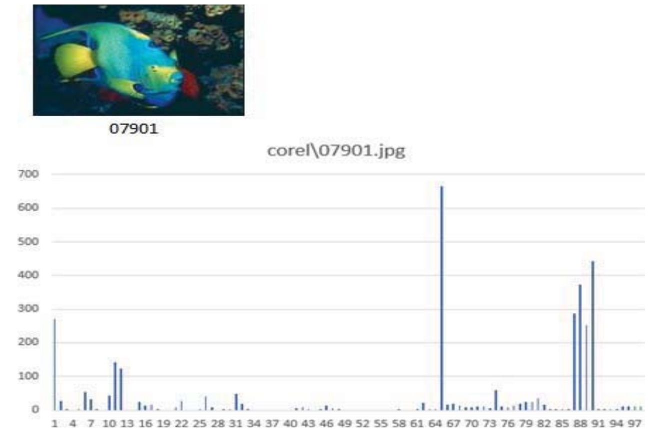

Fig. 9 Example of the result from Corel image's indexing process

C. Measure

The similarity between the image which is being looked for and the image in the dataset is measured by using the modified Canberra distance [9].

$$D(T, Q) = \sum_{i=1}^{M} \frac{|Tt - Qt|}{|Ti + \mu T| + |Qi + \mu Q|} \qquad (6)$$

Explanation:
$\mu T = \sum_{i=1}^{M} \frac{Ti}{M}$, $\mu Q = \sum_{i=1}^{m} \frac{Qi}{M}$ and M is the sum of all relevant data in the dataset [18].

D. Performance Measurement

Precision and recall were used to measure the accuracy of image retrieval process with relevance to requests and datasets [19].

$$Precision(N) = \frac{I_N}{N} \qquad (7)$$

$$Recall(N) = \frac{I_N}{M} \qquad (8)$$

Where:
I_N: The size of the image taken
N: The size of relevant images
M: The size of all relevant data in datasets

E. The Experiment

In the experiment, the comparison between the MTCD method and the combination method of MTCD and Wavelet was performed. The Wavelet methods consisted of 4 types including Haar, Daubechies, Coiflet, and Biorthogonal. The comparison in this research was carried out on four aspects including Precision, Recall, as well as Indexing time and Retrieval time with the number of Retrieval 4, 5, 6, 8 for Batik images and 12 Corel images. The distribution of training data and test data were divided into 70:30, 60:40, and 50:50. Fig. 10, Fig. 11, and Table 1 – Table 4 are examples of Retrieval results and the comparison tables.

The experiment was conducted by using Google's Colab. The purpose of using Google's Colab was to simplify research development.

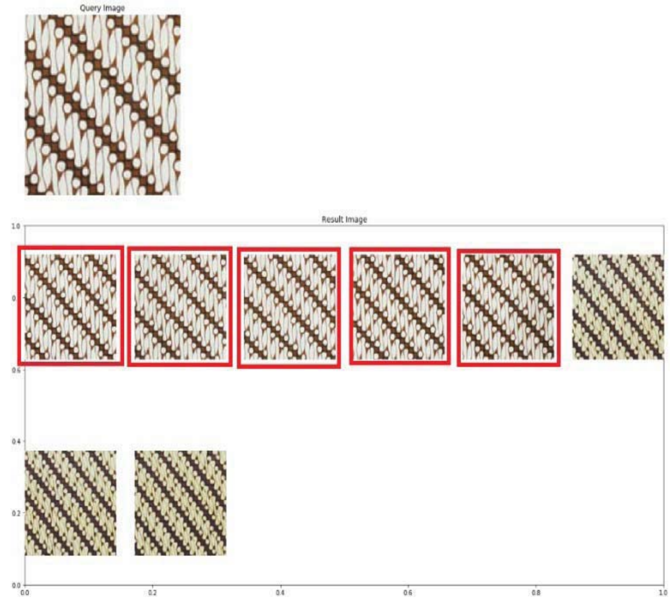

Fig. 10 Example of the result from Batik image retrieval

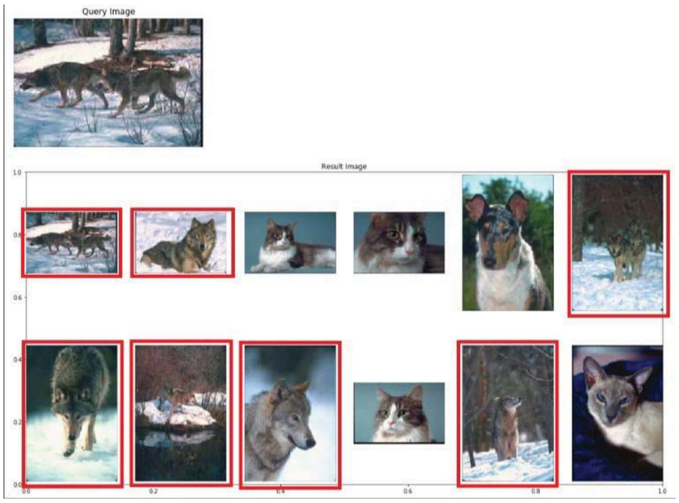

Fig. 11 Example of the result from Corel image retrieval

TABLE 1. WAVELET EXPERIMENT'S RESULTS

Data	*Performance*	*Haar*	*Daubechies*	*Coiflet*	*Biorthogonal*
Batik	Precision	93.75	93.75	89.58	89.58
	Recall	89.72	89.72	86.63	86.63
Corel	Precision	49.08	49.08	44.72	41.66
	Recall	5.40	5.40	5.32	4.28

TABLE 2. CLASSIFICATION ACCURACY (%) FOR BATIK DATASETS

Performance	*70:30*	*60:40*	*50:50*
Precision	93.75	92.97	91.57
Recall	89.72	88.63	88.32

TABLE 3. CLASSIFICATION ACCURACY (%) FOR COREL DATASETS

Performance	*70:30*	*60:40*	*50:50*
Precision	49.08	45.07	43.68
Recall	5.40	4.53	4.25

TABLE 4. THE COMPARISON BETWEEN MTCD AND PROPOSED METHOD MTCDH

Data	*Retrieval*	*Performance*	*MTCD*	*MTCD-H*
Batik	Avg 4, 5, 6, 8	Precision	90.39	93.75
		Recall	87.56	89.72
Corel	12	Precision	43.97	49.08
		Recall	5.28	5.40

TABLE 5. THE COMPARISON OF INDEXING AND RETRIEVAL SPEED IN SECOND

Data	*Dataset*	*Time*	*MTCD*	*MTCD-H*
Batik	300	Indexing	116.64	84.35
		Retrieval	0.53	0.40
Corel	10.000	Indexing	3273	2988
		Retrieval	2.67	6.05

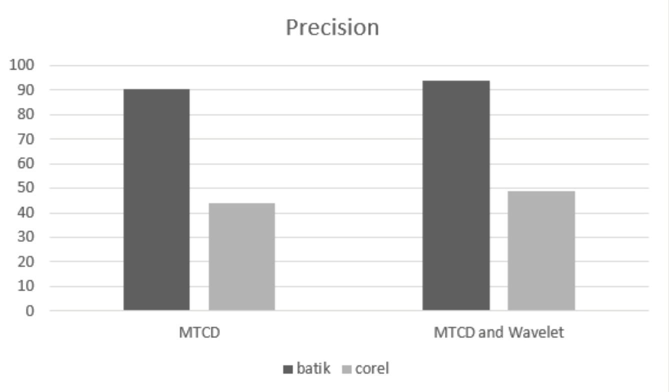

Fig.12 The graph of precision value between MTCD and MTCD-H (Haar Wavelet)

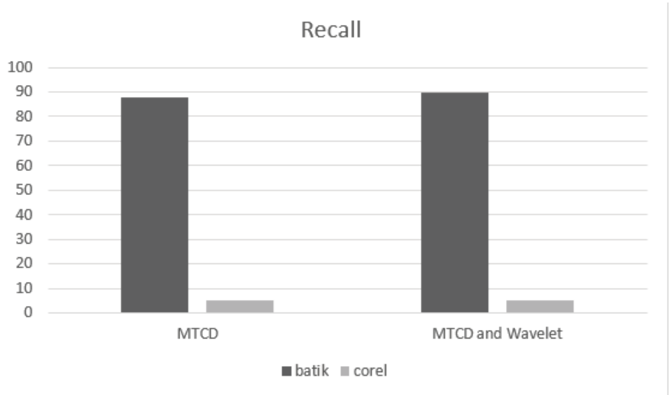

Fig. 13 The graph of recall value MTCD and MTCD-H (Haar Wavelet)

The experimental results obtained that the Batik data precision value was 93.75 which increased by 3.36 after the Wavelet method was added to the MTCD method, while for the precision of the Corel data was pointed at 49.08 which also increased 5.11. Fig. 12 and Fig. 13 shows graph of precision and recall value between MTCD versus MTCD-H. In term of the computational speed, the results showed that the speed of computation needed 84.35 seconds faster for the Batik image and 2988 seconds faster for the Corel image after the Wavelet method was added to the MTCD. MTCD-H is faster because the image size becomes smaller then original image so computing becomes faster.

IV. CONCLUSION

Based on the research of image retrieval feature selection using the MTCD and Wavelet method, it can be concluded that the best results from the experiment of the combination of both methods succeeded for increasing the average value of precision by 3.36 in Batik images and 5.11 in Corel images. In addition, the computation speed was also becoming faster by 84.35 seconds for Batik images and 2988 for Corel images. Haar wavelet method is the most effective method in this research because it can increase the value of precision compared to other Wavelet methods.

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