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Image Retrieval Using Features in Spatial and Frequency Domains Based on Block-Division

Kazuhiro KOBAYASHI
Kogakuin University, Faculty of Engineering
Department of information and Communication Engineering
Tokyo, Japan
cm14011@ns.kogakuin.ac.jp

Qiu CHEN
Kogakuin University, Faculty of Engineering
Department of information and Communication Engineering
Tokyo, Japan
chen@cc.kogakuin.ac.jp

Abstract— **In recent years, the demand for image retrieval is increasing due to the development of the information society. There are mainly two categories of image retrieval approaches: TBIR and CBIR. The local binary pattern (LBP) texture method has been reported as a highly robust approach in CBIR studies. In our previous paper [9], we have proposed a novel image retrieval algorithm to improve retrieval accuracy, which using both features obtained from spatial and frequency domains. We added the DCT features as frequency characteristics. In this paper, we propose a block division method in order to improve the retrieval accuracy by adding geometric information. We divide the image area into separate regions relating to the image blocks. Retrieval results with different blocks are first obtained separately and then combined by weighted. Corel database is used for the evaluation of our proposed algorithm. Experimental results show a significantly higher retrieval accuracy compared with previous research.**

Keywords— Image Retrieval, DCT, LBP, Histogram Feature

I. INTRODUCTION

In recent years, the spread and development of computer and digital camera, generation and collection of digital images in personal storage and WWW is increasing rapidly. In this situation, there is a growing interest in the image retrieve an image that the user is required. As a method of image retrieval, First, as a method of utilizing the text query has been previously assigned to the meta data of the query image TBIR (Text-Based Image Retrieval), Second, and the image itself query utilizing the color and texture of the image there is a method for CBIR (Content-Based Image Retrieval). TBIR is widely used, and the speed of processing is also faster. Examples of TBIR, include the image retrieval engine such as Google and is used by many users today. However, for TBIR that the text query, the burden on the people by the amount of massively growing image, such as the recent years occur. Because, since it is necessary to artificially indexed such as words and sentences to the metadata in the image in the database beforehand. Although the index, search results may differ from the ideal image because Index grant index and users demand are there may be a possibility that the difference is caused by the sense of personal. Therefore, Researchers of CBIR is working hard to study towards a better search methods that Image on the Internet, video databases and other information sources.

When searching an image, first calculates the feature from the image, then comparing the feature value of the image on the query image and the database, and extracts the images by the rate of matching features. The features of the image, there is characterized derived from features and spatial domain obtained from the frequency domain. Feature of the former frequency domain, and that many methods utilizing the Gabor filter [1] used in the MPEG-7 [2], rely on them derivation algorithm of the DFT (Discrete Fourier Transform) [3]. Features obtained from spatial domain of the latter, a feature quantity based on the color and texture of the image, which is represented by the color histogram [4], color correlogram [5], descriptors such as a color moment [6]. In this study, DCT (the Discrete Cosine Transform) [7] is used for the feature of frequency domain, the features of spatial domain using a LBP (Local Binary Pattern) [8]. DCT is used converted to a standard format such as JPEG or MPEG for reasons that it has a characteristic that can increase the compression rate and the hardware implementation is easy fast algorithm. LBP is frequently utilized by simple method which is calculated based on the texture image. Study conducted block based image retrieval using the LBP was done by Takala et al. [9]. Moreover, there is a possibility that suggests an improvement in the success rate by using the features which are obtained from the frequency domain. In our previous paper, we have proposed a novel image retrieval algorithm to improve retrieval accuracy, which using both features obtained from spatial and frequency domains. In addition, we verify the accuracy of image retrieval using block division method. The purpose of this study is to perform block based image retrieval using the features which are obtained from the two methods described above, to examine or consider the results.

II. PROPOSED ALGORITHM

In our previous paper, we proposed an efficient image retrieval algorithm using combined histogram-based features which contain both spatial and frequency domain information of an image, are utilized as a very effective image feature [10]. The flow chart of proposed algorithm is illustrated as Fig. 1. Generates pixel block in DCT to scan the image. After converting the pixels block is quantized using a low-frequency region. DCT histogram is generated using bin obtained for

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each block. LBP was calculated by three operators in the same way as previous research. LBP histograms were obtained by summing the histogram obtained from three operators. To compare the image search after registering the 2 features. Furthermore, for adding the geometric information of the image to improve the retrieval accuracy, a block division method is proposed in this paper. We divide the image area into separate regions relating to the image blocks. Retrieval results with different blocks are first obtained separately and then combined by weighted.

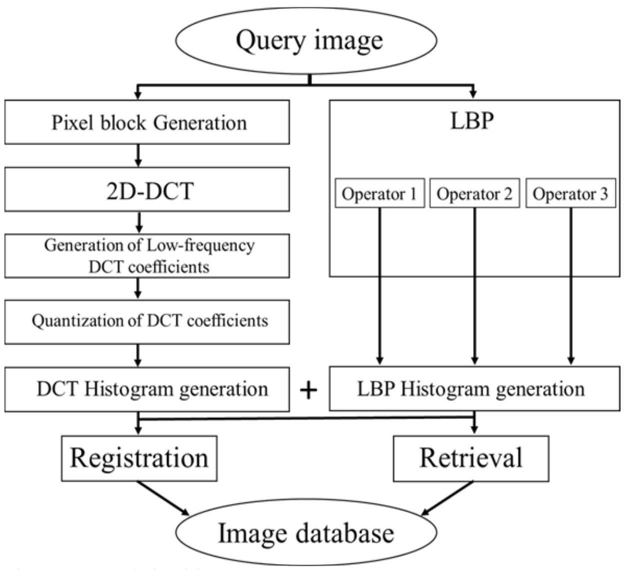

Fig. 1. Proposed algorithm

A. *Discrete Cosine Transform (DCT)*

DCT used in image is extended to two-dimensional DCT, represented by the transformation equation as the following eq. 1 [6].

$$F(u,v)=\frac{2}{N}C(u)(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}f(x,y)\cos\frac{(2x+1)u\pi}{2N}\cos\frac{(2y+1)v\pi}{2N} \quad (1)$$

$$f(x,y)=\frac{2}{N}\sum_{u=0}^{N-1}\sum_{v=0}^{N-1}C(u)C(v)F(u,v)\cos\frac{(2x+1)u\pi}{2N}\cos\frac{(2y+1)v\pi}{2N} \quad (2)$$

$$\text{Where, } C(k)=\frac{1}{\sqrt{2}}(k=0), C(k)=1(k\neq 0) \quad (3)$$

When applying the DCT, The method is often used to perform the DCT while overlapping the small block instead of performing the DCT for the whole image data. Pixel block of 8×8 after conversion by the eq. 1 is represented by the DCT coefficients. After conversion, as shown in Fig. 2. The block is divided into a high-frequency component part and low frequency component parts.

	0 (Low)	1	2	3	4	5	6	7 (High)
0 (Low)	DC	AC01	AC02	AC03	23	-6	-14	19
1	AC10	AC11	AC12	AC13	10	20	13	10
2	AC20	AC21	AC22	AC23	8	1	-20	-5
3	AC30	AC31	AC32	AC33	-9	-7	6	7
4	-9	2	5	9	-10	9	9	17
5	7	1	-10	8	4	8	1	1
6	0	0	-5	4	-7	1	-1	-7
7 (High)	-5	-8	8	3	2	-4	-8	0

Fig. 2. Generation of Low-Frequency DCT coefficients

We will use the features of low-frequency portion shown in Fig. 2, and we calculated number of six low frequency component. These figures are expressed as the following eq. 4 using the values of Fig. 2.

$$\left.\begin{aligned} a[0] &= AC01 \\ a[1] &= AC11 \\ a[2] &= AC10 \\ a[3] &= (AC02+AC03+AC12+AC13)/4 \\ a[4] &= (AC22+AC23+AC32+AC33)/4 \\ a[3] &= (AC20+AC21+AC30+AC31)/4 \end{aligned}\right\} \quad (4)$$

After calculating the six features of low-frequency, then performs the quantization of the DCT coefficients. When DCT coefficient is 0 or more, assigns 1 low frequency feature vectors. When the DCT coefficients is less than 0, assigns 0 to the low-frequency feature vectors. Thus calculates the feature of each block overlapping, we will continue to generate DCT histogram as in Fig. 3.

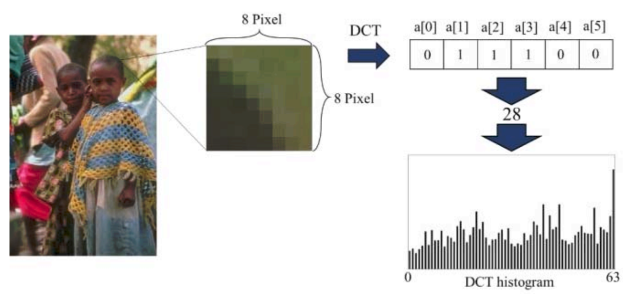

Fig. 3. DCT histogram generation

B. *Local Binary Patterns (LBP)*

The original LBP algorithm is proposed by Ojara et al. for local feature extraction of image [7]. The operator labels the pixels of an image by thresholding the 3×3-neighbourhood of each pixel with the center value and considering the result as a binary number. The feature of this approach is that it can be extracted local features of an image, it is hardly affected by illumination changes, it calculates the cost is low, and various applications thereof can be expected in the derived algorithm. An example of binarizing the vicinity of LBP is shown in Fig. 4.

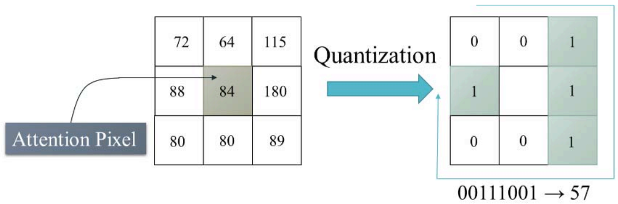

Fig. 4. The original LBP

Original LBP is possible to obtain the features of the binary number of 8 bits for LBP, to obtain the features of 0 to 255 and convert to decimal. LBP has that has been extended not limit the number of sample points instead of LBP to take neighboring pixels as described above as a sample point. Three different LBP operators as in Fig. 5 as an example the LBP of this approach is given [10].

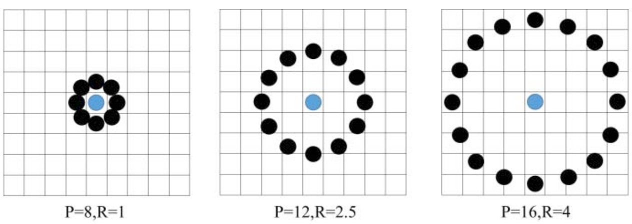

Fig. 5. Circularly symmetric neighbor sets

Sample points in order to not apply the exact pixel locations are arranged in a circle, using the bilinear interpolation in the calculation in this approach. The value taken by the LBP increases exponentially as the number of sampling points is increased. We can deal with research methods for this event that Uniform Pattern [10]. This method is intended to be reduced without damage to said frequency of feature vectors by attention 1 and 0 transition in binary value of LBP. As an example, if it takes eight interpolation points, we get the frequency of 58 instead of the frequency of 256, or, we get the frequency of 59 the rest of the pattern is stored in one frequency. An example of Uniform Pattern is shown in Fig. 6.

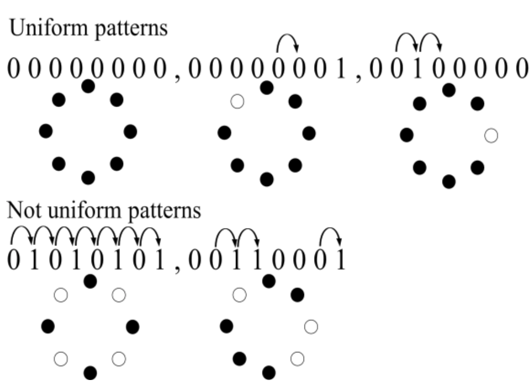

Fig. 6. Uniform Pattern

It is possible to extend the LBP by combining operators with different radii. When using N number of operators, the distance between the query and the model is expressed by the following eq. 5.

$$L_N = \sum_{n=1}^{N} (Q^n, M^n) \qquad (5)$$

LBP scans the whole image like DCT, too. It is to continue to overlap the pixel block of the calculation range of LBP in the image. That the sum of the radius of different circular LBP operator respectively are generated as LBP histogram as in Fig. 7.

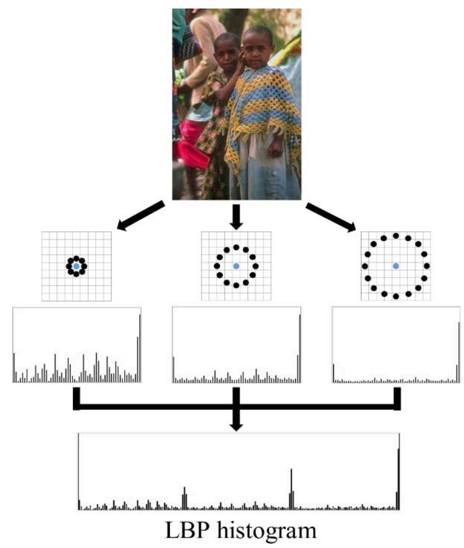

Fig. 7. LBP Histogram

III. Retrieval Metric

A. Dissimilarity

A distance function is needed for comparing images through their features. Most of the LBP researches got a favored a nonparametric log-likelihood statistics as suggested by Ojala et al. [10]. However, the relative L_1 measure similar to those proposed by Huang, et al. [5]. When it is compared with the likelihood with other Statistics available, relative L_1 measure is one third of the time requested by the log-likelihood. Relative L_1 measure is used this reason in Takala et al. LBP research. We also use this difference in this study. DCT feature also can use this difference as well. The dissimilarity measure is given in Eq. 6:

$$L_1^{relative}(x_1, x_2) = \sum_{n=1}^{N} (Q^n, M^n) \qquad (6)$$

where x_1 and x_2 represent the feature histograms to be compared and subscript we is the corresponding bin.

B. Block-Based CBIR

Blocking of images can be obtained more local features. It compares each block of the query image and all the blocks in the model image. The minimum distance of each block of the query image is a feature of the image.

$$D = \sum_{i=0}^{N-1} min_j(D_{i,j}) \quad (7)$$

Where N is the total amount of query image blocks and D_{ij} the distance (relative L_1) between the ith query and jth model block histograms. An example of the approach in operation is shown in Fig. 8.

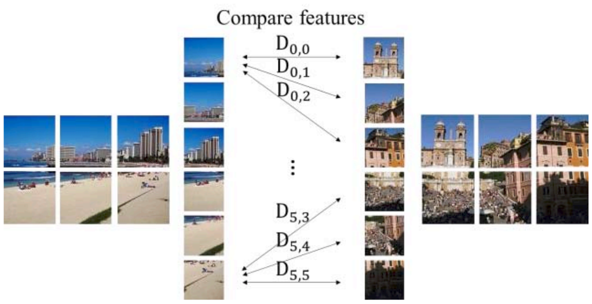

Fig. 8. Block-Based CBIR

C. Weighting of Features

When adding DCT features and LBP feature, put the weight on both features. It measures the accuracy due to a change in weight. Expression is shown below:

$$F = \frac{w_1(D_{DCT}) + w_2(D_{LBP})}{w_1 + w_2} \quad (8)$$

where, D_{dct} and D_{lbp} are the minimum distance between the images. w_1 and w_2 are the weight of each feature.

IV. Experimental Results and Discussions

A. Image Database

Image retrieval methods are tested on a database consisting of Wang database [11] Corel images of sizes 384×256 and 256×384. There are 10 categories of 100 images each making up 1000 images in total. Africa people, beach, horse, mountain, dishes are chosen as a category used by an experiment. Some example images are shown in Fig. 9.

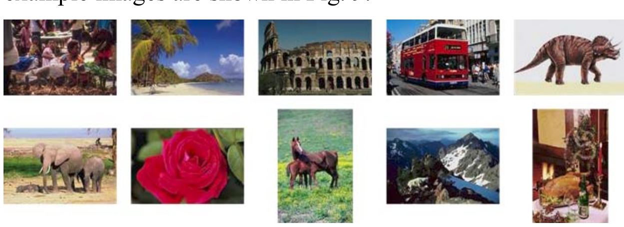

Fig. 9. Image examples from the Wang database

B. Experimental Methods

We calculate the quantity of characteristic of all the images to use in an experiment first. First, we calculate the quantity of characteristic of all the images to use in an experiment. We use Extended LBP having 3 radiuses unlike 8 interpolation point for spatial domain. It is the same as Takala et al. method, which is chosen for comparison. Frequency of each of the LBP has the Uniform pattern is reduced to 59, Extended LBP the frequency of 177 is calculated. Radius of each of the LBP operator was set in the prior research and same 2.4 and 5.4 for comparison. Further, DCT features frequency domain because it has a frequency of 64, the frequency of 241 per one image is calculated one after another. We based feature calculated, to compare the feature of the query image and the database images. Enter a single query image we want to calculate the distance compared to the feature of all of the database image. Comparison of 250 is performed per piece of the query image. Query images are made comparison of 42,500 times of an image since there 250. Retrieves the some images of the smaller distance from database image, it is confirmed whether the same category. In previous research, 6 block division (128 * 128 sized blocks) and 8 block division (96 * 96 sized blocks) were used. In addition, we experimented two block division, four blocks divided, and 12 block division. 8 division was further expanded experiment block range.

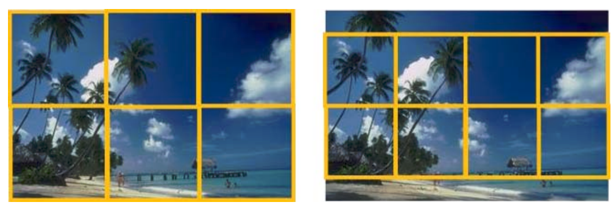

Fig.10. Block Division of Previous Research

Fig. 11. Added Block Division

C. Experimental Results

The results of the experiments are shown in Table 1. The evaluation measures used are precision, recall and F-measure. The table shows the results which using only DCT and LBP for comparison. In Takala et al. experiments, since the interpolation points are three different radii which using eight LBP operators [9], and experiments are conducted using the same LBP for comparison. Table shows the results of each block division and global features. Only result in the LBP, the results of the 3 operators had higher search precision and recall than 1 operator. Further compared with the result that using only DCT and LBP, the results with both methods improve the precision and recall are obtained. Results of the block division than the results of the full image was a high accuracy. In 10 images retrieval, the highest result was the weighted features of both the 4 division, F-measure was 26.7 (precision rate was 80.2% and recall rate was 16.0%). In 25 images retrieval, the highest result was the weighted features of both the expanded 8 division, F-measure was 47.0 (precision rate was 70.6% and recall rate was 35.3%). In 50 images retrieval, the highest result was the weighted features of both the 6 division and 12 division, F-measure was 59.5.

TABLE I FULL IMAGE

Method	Number of Images (%)		
	10 images	*25 images*	*50 images*
DCT	60.0/12.0/20.0	52.4/26.2/34.9	43.2/43.2/43.2
$LBP_{8,1}^{u2}$	73.3/14.7/24.4	64.0/32.0/42.7	51.5/51.5/51.5
$LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	76.6/15.3/25.5	66.3/33.2/44.2	53.5/53.5/53.5
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	77.7/15.5/25.9	66.4/33.2/44.3	53.9/53.9/53.9
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$weight	78.0/15.6/26.0	66.9/33.4/44.6	54.1/54.1/54.1

TABLE II 2 BLOCKS DIVISION

Method	Number of Images (%)		
	10 images	*25 images*	*50 images*
DCT	64.9/13.0/21.6	56.8/28.4/37.9	46.6/46.6/46.6
$LBP_{8,1}^{u2}$	76.8/15.4/25.5	68.3/34.2/45.6	57.0/57.0/57.0
$LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	78.0/15.6/26.0	70.1/35.1/46.8	58.5/58.5/58.5
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	77.8/15.6/25.9	69.5/34.7/46.3	58.2/58.2/58.2
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$weight	78.5/15.7/26.2	70.5/35.3/47.0	58.8/58.8/58.8

TABLE III 4 BLOCKS DIVISON

Method	Number of Images (%)		
	10 images	*25 images*	*50 images*
DCT	65.7/13.2/22.0	58.0/29.0/38.7	48.3/48.3/48.3
$LBP_{8,1}^{u2}$	77.2/15.5/25.9	68.7/34.4/45.8	57.4/57.4/57.4
$LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	79.4/15.9/26.5	70.5/35.2/47.0	58.5/58.5/58.5
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	79.4/15.9/26.5	70.1/35.1/46.8	58.5/58.5/58.5
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$weight	80.2/16.0/26.7	70.1/35.5/47.3	58.9/58.9/58.9

TABLE IV 6 BLOCKS DIVISION

Method	Number of Images (%)		
	10 images	*25 images*	*50 images*
DCT	66.0/13.2/22.0	58.2/29.1/38.8	48.1/48.1/48.1
$LBP_{8,1}^{u2}$	76.4/15.3/25.5	68.1/34.1/45.4	57.5/57.5/57.5
$LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	77.8/15.6/25.9	69.6/34.8/46.4	58.9/58.9/58.9
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	78.4/15.7/26.1	69.4/34.7/46.3	59.2/59.2/59.2
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$weight	79.0/15.8/26.3	69.9/35.0/46.6	59.5/59.5/59.5

TABLE V 8 BLOCKS DIVISION

Method	Number of Images (%)		
	10 images	*25 images*	*50 images*
DCT	63.0/12.6/21.0	55.9/28.0/37.3	57.9/57.9/57.9
$LBP_{8,1}^{u2}$	76.4/15.3/25.5	68.7/34.3/45.8	47.1/47.1/47.1
$LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	76.7/15.3/25.6	68.4/34.2/46.6	58.1/58.1/58.1
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	77.0/15.4/25.7	68.5/34.2/45.7	58.1/58.1/58.1
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$weight	77.5/15.5/25.8	68.9/34.5/45.9	58.4/58.4/58.4

TABLE VI EXPANDED 8 BLOCKS DIVISION

Method	Number of Images (%)		
	10 images	*25 images*	*50 images*
DCT	66.4/13.3/22.1	58.1/29.0/38.7	49.0/49.0/49.0
$LBP_{8,1}^{u2}$	77.9/15.6/26.0	69.4/34.7/46.3	57.5/57.5/57.5
$LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	78.2/15.6/26.1	70.0/35.0/46.7	58.3/58.3/58.3
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	79.0/15.8/26.3	70.1/35.0/46.7	58.4/58.4/58.4
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$weight	79.6/15.9/26.5	70.6/35.3/47.0	58.8/58.8/58.8

TABLE VII 12 BLOCKS DIVISION

Method	Number of Images (%)		
	10 images	*25 images*	*50 images*
DCT	64.6/12.9/21.5	58.2/29.1/38.8	48.1/48.1/48.1
$LBP_{8,1}^{u2}$	78.3/15.7/26.1	68.1/34.1/45.4	57.5/57.5/57.5
$LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	77.8/15.6/25.9	69.6/34.8/46.4	58.9/58.9/58.9
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$	78.4/15.7/26.1	69.4/34.7/46.3	59.2/59.2/59.2
$DCT+LBP_{8,1}^{u2}+{}_{8,2.4}^{u2}+{}_{8,5.4}^{u2}$weight	79.4/15.8/26.3	69.9/35.0/46.6	59.5/59.5/59.5

V. CONCLUSIONS

In this paper, we proposed a robust block based image retrieval algorithm using the features in both spatial domain and frequency domain. The image retrieval algorithm is combined with DCT and conventional LBP approach, which can obtain more image features. The image retrieval accuracy increases by adding geometric information using proposed block division method. However, in Takala et al. experiments are also performed technique for searching a portion of an image overlapping. That approach it is necessary to perform experiments to confirm the retrieval accuracy. Also, there is a technique that has been extended to the LBP, it might be able to improve the image retrieval accuracy by incorporating them.

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