Journal on Advanced Research in Electrical Engineering, Vol. 6, No.1, Apr. 2022

Extraction of Timber Features using GLCM, Color Moment and Isotropic Undecimated Wavelet Transform (IUWT)

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***Abstract*—Feature extraction can be used to know the characteristic of timber's texture. Characteristic of timber's texture can be used to help researcher to identify DNA of timbers which can be detected illegal logging in Indonesia. In this research the proposed method is combination GLCM, Color Moment, and Isotropic Undecimated Wavelet Transform (IUWT). The result of the proposed method has a good accuracy.**

Keywords*—*color moment, feature extraction. GLCM, Isotropic Undecimated Wavelet Transform (IUWT),

I. Introduction

The problem of illegal logging in Indonesia can be solved with a technology. The technology can detect the DNA of timbers. The function of DNA can be used for Doublehelix to legality verification system. Doublehelix creates an open-source nation and an international legality verification. Although Indonesia does not have a legality verification system [1].

Three are three services of Doublehelix for detecting legality: 1) population genetic, 2) DNA finger printing, 3) DNA barcoding. The extraction feature can be added to population genetic because the test helps it determine whether the timber is harvested from the declared county, the timber comes from a natural forest or the timber comes from a plantation. The fact that a new timber verification technology has apparently failed to solve this problem. This research combines extraction methods for extraction timber to know the DNA of the timbers and can be added to DNA barcoding data [1].

There are some methods for extraction timbers with GLCM: 1) Classification wood texture with GLCM and SVM. The result of this proposed method is 90.5% [2], 2) Extraction feature using GLCM, LBG, and KPE. The accuracy of this method is 89.10% [3].

In this research, the researcher combines GLCM with color moment and isotropic undecimated wavelet transform to improve the GLCM method. The function of color moment is used to analyze color timbers in spatial dimension. The function of isotropic undecimated wavelet transform is used to analyze texture in signal dimension.

The first method is GLCM. It is one of the oldest techniques used for texture analysis. The important parameters in GLCM are distance and direction [4]. GLCM can improve classification accuracy because window in GLCM can affect the validity of the characteristic of texture.[5]

The second method is color moment. The function of color moment is for color detecting in different image with the similar color[6]. Color moment is simple and effective in representing color features [7].

The third method is Isotropic Undecimated Wavelet Transform (IUWT). It is very powerful with redundant wavelet transform in image and has a good spatial resolution in high frequencies with a difficult texture analysis [10].

In this research, the function of IUWT is not for segmentation but extraction texture with the calculation of the average pixels of IUWT. The contribution of this proposed method can be seen in Fig.10.

II. Methods

The first step was using 400 datasets consist of 100 types of teak, 100 types of mahogany, 100 type of mindi, and 100 types of sengon. The example of dataset can be seen in Fig. 2, Fig. 3, and Fig. 4.

Fig. 1. Teak

Fig. 2. Mahogan

Fig. 3. Mindi

Fig. 4. Sengon

A. GLCM

In this research, the function of GLCM is to calculate the selected pair of distance and angle in timbers texture d and angle ϴ relative frequencies of pair of each pixel. GLCM angles are 0^o, 45^o, 90^o, and 135^o [4].

The similarities of GLCM are the ability to make a good detection patterns and surface in timbers. The research shows that GLCM combined with color input can provide a better classification results [11]. The input for GLCM is not grey but H, S, and V.

There are several steps in GLCM: 1) Changing the images to H, S, V for input in GLCM; 2) The process of co-occurrent matrix can be seen in the Table I, Table II, and Table III; 3) Statistic extraction is used to calculate contrast, dissimilarity, and energy; 4) The result of the calculation of contrast, dissimilarity, and energy.

TABLE I. ANGLE OF DIRECTION

135	90	45
180		0
225	270	315

TABLE II. THE INTENSITY OF IMAGE

0	0	1	2
0	1	1	1
1	2	2	1
2	2	1	1

TABLE III. CO-OCCURENT MATRIX 1

i/j	0	1	2
0	[0,0]	[0,1]	[0,2]
1	[1,0]	[1,1]	[1,2]
2	[2,0]	[2,1]	[2,2]

TABLE IV. CALCULATION OF PIXEL IN 0 DEGREE

0	0	1	2
0	1	2	0
1	0	3	2
2	0	2	2

Table I, Table II, and Table III are the step of co-occurrent matrix in GLCM. The steps for co-occurrent matrix can be described as follows in step 1, 2, 3, and 4:

1) The first Process was intensity calculation in 0 degree can be seen in Table III. This research is using 0 degree for direction because 0 direction more compatible with timbers dataset.
2) Normalization process transposes the value of table III.
3) The next normalization process is dividing each pixel with the amount of all element pixels in step 2.
4) Last process is calculating with statistical calculation. The statistical calculations are contrast, dissimilarity, and energy.

The formulas used in this research are contrast, dissimilarity, and energy. The formulas can be seen in equation (4), (5), and (6) [6] [9].

Contrast $= \sum_{i,j=0}^{N-1} Pi,j(i-j)^2$ (4)

Dissimilarity $= \sum_{i,j=0}^{N-1} Pi,j\,|i-j|$ (5)

Energy $= \sqrt{\sum_{i,j=0}^{N-1} Pi,j^2}$ (6)

Information:
P i, j = Value of each pixel
N = Sum all of pixels
i, j = Rows and columns

B. Color Moment

Color moment is mainly used for color indexing in similarities of two images. Color moments are scaling and rotation in invariant image with the similarities image. The advantages of the color moment is its robustness under changing lighting conditions[6].

Color moment can be used to measure the difference of color in an image[12]. In this research, the researchers used 4 results on the color moment those were standard deviation, skewness and d (the difference between the two images). This formulas can be seen in equation 1, equation 2, equation 3, and equation 4 [13].

The function of the formulas are: 1) Mean can be understood as the average color value in image; 2) Standard deviation is the square root of the variance of the distribution; 3) Skewness is for the measurement of the degree asymmetry in the distribution; 4) Different pairs of distribution or d is a similarity function of two images[13].

$$E_i = \sum_{n}^{j=1} \frac{1}{n} Pij \quad (1)$$

Information:

E = Average of each image
N =Sum of all pixels
P i, j =Value of each pixel.

$$\sigma_i = \sqrt{\frac{1}{n} \sum_{n}^{j=1} (pij - Ei)^2} \quad (2)$$

Information:

σi = Standard deviation
Pij =Value of each pixel
Ei =Average of all pixels

$$S_i = \frac{1}{N}\sqrt[3]{\sum_{N}^{j=1}(Pij - Ei)^3} \quad (3)$$

Information:

S_i = Skewness
Pij = Value of each pixel
Ei = Average of all pixels

$$d = \sum_{i=1}^{r} W1|E_i^1 - E_i^2| + W2|\sigma_i^1 - \sigma i_i^2| \quad (4)$$

Information:

W1 = Maximum value of average in all images
W2 = Maximum value of standard deviation
D = The similarities between of two pictures

C. *Isotropic Undecimated wavelet transform (IUWT).*

The IUWT method is usually for astronomical data which has a big different data with less isotropic like in timbers texture. The conditions IUWT can be seen below [15]:

1) The filter used must be symmetrical. The example of the filter size ($\overline{h}[k] = \overline{h[k]}$) and g[k] = g[k].
2) For on two dimensions or higher dimension h, g, Ψ, ϕ should be close to isotropic.

The IUWT's step can be seen in [15] and [16]. In this research, the function IUWT was not for segmentation but extraction. The calculation IUWT used for extraction took the average value of IUWT process with input in level 3. The result of Level 3 was better than the result of other levels. The differences result of level in IUWT can be seen in Fig. 6, Fig. 7, Fig. 8, and Fig. 9.

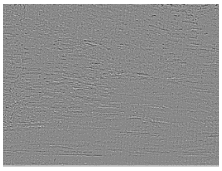
Fig. 6. Level 1

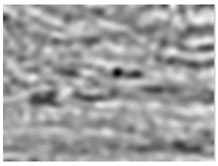
Fig. 7. Level 2

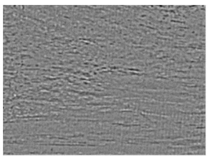
Fig. 8. Level 3

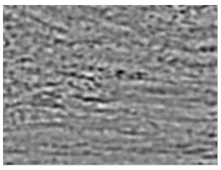
Fig. 9. Level 4

D. *Multi layer Perseptron (MLP)*

In this research, MLP was used because it produced better result than SVM. The process of MLP is a feed forward neural network which is trained with Back propagation algorithm. The performance of statistical classifier can be approximated in optimal manner during difficult problem. Thus, the author combined the extraction feature of timbers with MLP Classification [17].

The calculation of the MLP can be seen in [18]. Each input (x) is weighted with w, and the activation function v(t) depends on the input (x), weight(W), and bias (b). The equation can be seen in equation 4 [18].

$$V(t)=W*x+b \quad (4)$$

Backpropagation is generally found in the method of neural network training which leads to the increasing of error in weighting. The formula of weight can be seen in equation 5 [17].

$$W(k+1)=W(k)+\alpha\frac{\partial E(k)}{\partial W(k)}\mu\Delta W(k) \quad (5)$$

Where W(k) denotes weight at k iteration, α is the learning rate which leads to high computational burden, E(k) is the difference between the expected output and the NN output or error, ΔW denotes the weighted difference between the k and k-1 iteration, μ denotes the momentum constant [17].

The step of proposed method can be seen in Fig. 10. The proposed method produces seven features: 1) The GLCM values are three features: contrast, dissimilarity, and energy in H, S, and V, 2) Color Moment produces three features. The features are E, σ_i, and d. 3) Isotropic Undecimated Wavelet Transform (IUWT) produces one feature that is the average of pixel. The last process is classification with MLP.

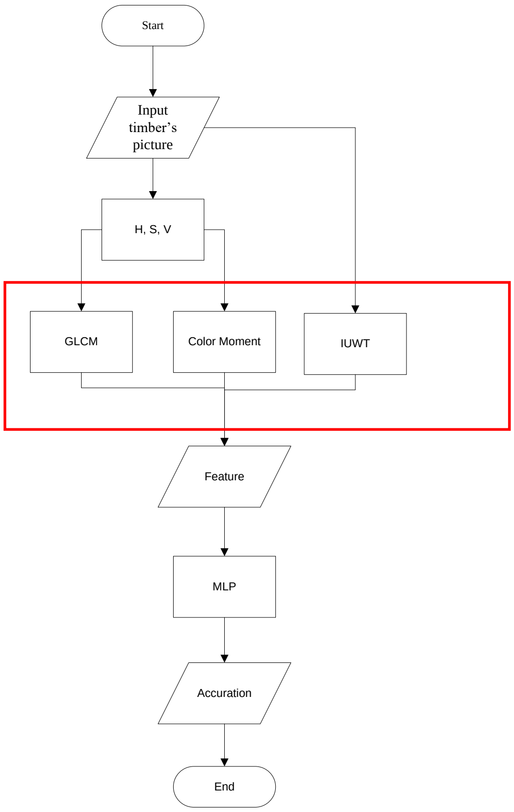

Fig. 10 Flowchart Proposed Method

III. RESULTS AND DISCUSSION

The proposed method in Table V shows a better classification than the extraction without proposed method because of the combination extraction in spatial dimension (GLCM, color moment) and the extraction in signal dimension (Isotropic Undecimated Wavelet Transform). However, the accuracy of GLCM from the proposed method has the same value as in [2] because the proposed method doesn’t have a pre-processing process and a different characteristic of texture in dataset.

TABLE V. CLASSIFICATION WITH MLP

	Proposed Method	GLCM	Color Moment	IUWT
Acc.	90.5	79	56.75	31.25
Error	9.5	21	43.25	68.75

The example of the value extraction timbers texture can be seen in Table VI, Table VII, Table VIII, Table IX and Table X. The extraction in Table VI, Table VII, Table VIII, Table IX and Table X is not significantly different. But if the value of extraction is combined in one combination, that value will be significant different.

TABLE VI. THE EXAMPLE OF THE EXTRACTION TIMBER TEXTURES WITH GLCM EXTRACTION IN H DIMENSION

Timber Type	Contrast	Dissimilarity	Energy
Teak	15534.12	13413.62	15788.58
Teak	16969.13	11308.18	16234.21
Teak	15364.78	13506.51	16502.24
Mahogany	14971.71	15351.23	14281.73
Mahogany	15910.91	13880.29	13965.17
Mahogany	14810.57	14916.47	14095.04
Mindi	14972.42	16345.59	13943.56
Mindi	14898.42	14772.86	15129.39
Mindi	14937.44	16096.19	15272.09
Sengon	21093.48	15417.66	14904.71
Sengon	13383.33	19070.07	14838.21
Sengon	1.463.389.091	14776.66	14670.44

TABLE VII. THE EXAMPLE OF THE EXTRACTION TIMBERS TEXTURE WITH GLCM EXTRACTION IN S DIMENSION

Timber Type	Contrast	Dissimilarity	Energy
Teak	101.93	94.43	103.22
Teak	106.97	85.91	104.76
Teak	101.07	94.47	105.39
Mahogany	100.55	101.39	98.14
Mahogany	102.17	96.24	95.45
Mahogany	99.56	99.66	96.96
Mindi	100.06	105.38	96.47
Mindi	99.80	99.45	100.50
Mindi	99.90	104.03	101.14
Sengon	90.93	98.69	99.26
Sengon	94.96	114.94	99.73
Sengon	99.05	99.22	99.19

TABLE VIII. THE EXAMPLE OF THE EXTRACTION TIMBERS TEXTURE WITH GLCM EXTRACTION IN V DIMENSION

Timber Type	Contrast	Dissimilarity	Energy
Teak	1.34	1.37	1.33
Teak	1.37	1.49	1.33
Teak	1.55	1.42	1.37
Mahogany	1.35	1.32	1.34
Mahogany	1.39	1.34	1.37
Mahogany	1.46	1.32	1.35
Mindi	1.32	1.46	1.35
Mindi	1.31	1.33	1.34
Mindi	1.31	1.35	1.34
Sengon	2.20	2.14	1.38
Sengon	2.52	2.12	1.37
Sengon	1.32	1.32	1.33

TABLE IX. THE EXAMPLE OF THE EXTRACTION TIMBERS TEXTURE WITH IUWT IN LEVEL 3

Timber Type	Level 3
Teak	0.50
Teak	0.52
Teak	0.51
Mahogany	0.59
Mahogany	0.41
Mahogany	0.69
Mindi	0.49
Mindi	0.49
Mindi	0.53
Sengon	0.52
Sengon	0.54
Sengon	0.50

TABLE X. THE EXAMPLE OF THE EXTRACTION TIMBERS TEXTURE WITH COLOR MOMENT

Timbes Type	Energy	Std	Skewness	d
Teak	1.02	1.04	0.01	1.43
Teak	0.98	1.13	0.14	1.19
Teak	1.00	1.11	0.10	1.27
Mahoni	1.05	1.05	0.01	1.48
Mahoni	1.08	1.09	0.01	1.53
Mahoni	1.12	1.14	0.02	1.56
Mindi	1.19	1.13	-0.06	1.71
Mindi	1.23	1.12	-0.09	1.78
Mindi	1.23	1.10	-0.13	1.86
Sengon	1.09	1.09	-0.01	1.51
Sengon	1.17	1.13	-0.05	1.68
Sengon	1.15	1.15	-0.03	1.58

IV. CONCLUSION

According to Table V, the proposed method results in a better accuracy compared to the method without it because the proposed method combines spatial dimension (GLCM, color moment) with signal dimension (Isotropic Undecimated wavelet Transform). The function of GLCM in proposed method is to extract the texture and the color since the input of GLCM is in hsv dimension. The researcher added the color moment for a better timber color analysis.

The function of color moment is to analyze the similarity of the timber color. The last combination is with the isotropic undecimated wavelet transform. The function of the isotropic undecimated wavelet transform is to analyze the texture in timber with signal dimension.

The proposed method has the same accuracy as in [2] because the proposed method doesn't have a pre-processing process and a different characteristic of dataset and quality.

ACKNOWLEDGMENT

According to Table V, the proposed method results in a better accuracy compared to the method without it because the proposed method combines spatial dimension and signal dimension for extraction timbers. However, the proposed method has the same accuracy as in [2] because the proposed method doesn't have a pre-processing process and a different characteristic of dataset.

This research can be improved by adding pre-processing process like sharpening and to extraction timber texture with another extraction method in spatial dimension and signal dimension.

The quality of the extraction can be improved by choosing dataset with the same age because the age of timbers can affect its color and texture.

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