Feature Textures Extraction of Macroscopic Image of Jatiwood (Tectona Grandy) Based on Gray Level Co-occurrence Matrix

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Abstract—The features texture in the textured images could be extracted by using grey level co-occurrence matrix (GLCM). GLCM was a such kind of good descriptor for textured images, which has two variables in observation window such as angle and distance of pixels. This research observed the results of features texture for four different observation angle in the window of GLCM such as 0°, 45°, 90° and 135°. The object in this research was the textured image of macroscopic jati wood (Tectona grandy), a such kind of good wood from Indonesian forest. The extracted texture features were contrast, correlation, energy and homogeneity. The results showed that contrast had a biggest value in direction of 45°, the other features correlation, energy and homogeneity had the biggest value both in direction of 0°.

Keywords: feature, GLCM, gray level, texture, window

1. Introduction

This paper assessed the possibility to invent the novel method of extracting the features texture of macroscopic image of Jatiwood (Tectona Grandy) based on grey level co-occurrence matrix (GLCM). Knowing about the features texture of Jatiwood is very important to prevent the illegal logging of this wood, therefore this paper is first step to do pattern recognition of Jatiwood. In the previous research of features texture extraction, we worked on Synthetic Aperture Radar (SAR) image of certain area of West Jakarta. These features were contrast, correlation, energy and homogeneity. We extracted four areas such as housing area, grass area, tree area and water area. In other research we worked on L Band Multi polarization SAR Image [1]. In these researchs, the features were extracted by using one variables in observation angle, it was 0°. The objective of this research was to have the four feature texture, as mentioned before, for the four direction or four observation angle such as 0°, 45°, 90° and 135°. The object of this research was the Macroscopic image of Jatiwood (Tectona Grandy).

The GLCM is extensively used in a couple of research domain and has been assessed and improved continuously [2]. Pacifici et al. [3] specifically calculated different dimension observation window and certain direction to extract multi-scale texture features from very high-resolution panchromatic imagery. Mukherjee et al. [4] used GLCM as a pre processor, the results of GLCM, in this case the features of textured images were processed by employing a BP-MLP (backpropagation-multilayer perceptrons). GLCM and BP-MLP is a classifier to classify two types of medicinal plants. Li et al. [5] employed the GLCM to extract texture features from the first two principal components and performed a principal component analysis of the image. The texture features as a results of GLCM were considered as a new band, and combined these features with the original image band formed a new image, and finally was employed for supervised classification. Huang et al. [6] used the texture features extracted from the GLCM, they formally proposed the dynamic observation windows algorithm, in this algorithm the the
dimension of observation window was varied. The objective of this research is to classify remote sensing imagery by combining the grey scale and texture features. Rao et al. [7] identified the phase transition temperature of the crystal. The liquid crystal texture was extracted using the GLCM, and only four features are selected and employed in these research such as contrast, energy, uniformity, and correlation. Tengetal.[8] extracted five samples Quick Bird data based on GLCM, specifically, to quantitatively calculate six statistical texture features. In this research these features were obtained by computing the average values in four directions and one pixel of pair-wise distance. The paper discussed had a focus on dimension of the observation window, certain observation direction, and one pixel distance. Recently, researchers have shown an increased interest in GLCM in domain image recognition, image segmentation, image retrieval, image classification, and texture analysis methods [9]. One of the greatest challenges of GLCM is the modification aspect of GLCM such as in direction of observation window, the aspect of the difference in certain direction and pixels distance to all features. These paper assessed the second one, the difference of direction to four features such as contrast, correlation, energy and homogeneity employed in L Band multi polarization SAR images.

2. Texture Analysis
2.1. Gray Level Co-occurrence Matrix

Analysis on the characteristic textured SAR image can be done with the structural approach or statistical approaches. Texture can be said to be a descriptor that can provide information about the regularity, roughness and smoothness. Structural approach can be performed on images that have certain structural components. Examples for the image tile floor has rectangular structural component. SAR images do not have a structural component, we could so use a statistical approach. Tomita described a statistical approach is divided into three levels such as:

a. The first level: by calculating the average, maximum and minimum.

b. The second level: by counting Grey Level Co-occurrence Matrix (GLCM), Semi-variogram, or Autoregresi.

c. The third level: by counting the cover or run length interval.

Naddler also described three levels statistic such as:

a. Imaged-based: characteristic obtained directly from the image.

b. Model-based: characteristics obtained by creating a model of texture.

c. Transform based: transform image to another domain which included based transform is a Fourier transform, Wavelet, and CLCM

Analysis using Grey Level Co-occurrence Matrix will produce some texture characteristics of the image such as energy, entropy, correlation, dissimilarity, inverse different moment, inertia, cluster shade, cluster Prominence, homogeneity [5],[6], but not all characteristics could be used, in some studies using only the four features such as contrast, correlation, energy and homogeneity. GLCM is a method that is widely used for texture analysis in the SAR image.

Here for the example suppose we have 5 x 5 pixels image depicted on Figure 1. There are four degrees of grey level from 0, 5, 8, and 10.

|   | 5 | 8 | 0 | 10 |
|---|---|---|---|----|
| 5 | 8 | 0 | 10 | 5  |
| 5 | 8 | 0 | 10 | 8  |
| 8 | 10| 0 | 0  | 8  |
| 5 | 10| 0 | 8  | 5  |
| 8 | 8 | 5 | 0  | 10 |

**Figure 1.** 5 x 5 pixels image.

If the distance pixels are selected one to the right and the direction angle co-occurrence 0° then the matrix can be formed as follows:

1. Determine the degrees of grey, sorted from minimum to maximum in the example was from 0 to 10, in the form one dimension vector was [0,5,8,10].
2. Form m x n framework matrix where m = n was the number of degrees of greylevel, elements of the frame matrix F is \( f_{i,j} \), where \( f_{i,j} \) was the number of occurrences with a degree of grey level. Framework matrix is shown in Figure 2.

\[
\begin{array}{cccc}
0 & 5 & 8 & 10 \\
0 & 1 & 0 & 2 \\
5 & 1 & 0 & 2 \\
8 & 2 & 2 & 1 \\
10 & 2 & 1 & 1 \\
\end{array}
\]

**Figure 2.** Framework matrix

In the first row \( f_{i,j} \) or \( a_{i,j} \) were the number of pixels 0 followed by 0, 0 followed by 5, 0 followed by 8 and 0 followed by 10. In the second row \( f_{j,j} \) were the number of pixels 5 followed by 0, 5 followed by 5, 5 followed by 8 and 5 followed by 10.

3. Create a co-occurrence matrix C, divide each element of the matrix F with n where n is the number of all elements of the matrix F, it was 20. The matrix C depicted in Figure 3 below.

\[
\begin{array}{cccc}
1/20 & 0 & 2/20 & 3/20 \\
1/20 & 0 & 2/20 & 1/20 \\
2/20 & 2/20 & 1/20 & 1/20 \\
2/20 & 1/20 & 1/20 & 0 \\
\end{array}
\]

**Figure 3.** Co-occurrence Matrix.

From this matrix C may be calculated four features texture such as:

1. Contrast.

\[
\sum_{i=1}^{n} \sum_{j=1}^{n} (i - j)c_{i,j}
\]

2. Correlation.

\[
\sum_{i=1}^{n} \sum_{j=1}^{n} (i - m)(j - m)c_{i,j}
\]

3. Energy.

\[
\sum_{i=1}^{n} \sum_{j=1}^{n} c_{i,j}
\]

4. Homogeneity

\[
\sum_{i=1}^{n} \sum_{j=1}^{n} c_{i,j} / 1 + (i - j)^2
\]
2.2. Direction in GLCM

The direction in observation indows, such as 0°, 45°, 90° and 145° are shown in Figure 4, the arrow indicates the observation direction.

![Diagram showing direction in GLCM](image)

**Figure 4.** Direction of 0° (a), 45° (b), 90° (c) and 135° (d).

![Framework matrix for 45°](image)

**Figure 5.** Framework matrix for 45°.

The framework matrix and co-occurrence matrix for 45° is shown in Figure 5 and Figure 6.

![Co-occurrence Matrix for 45°](image)

**Figure 6.** Co-occurrence Matrix for 45°.

For the observation of 90°, the framework matrix is shown in Figure 7.

![Framework matrix for 90°](image)

**Figure 7.** Framework Matrix for 90°.
The last, the framework matrix for observation angle is 135° is shown in Figure 8.

|   | 0 | 5 | 8 | 10 |
|---|---|---|---|----|
| 0 | 1 | 0 | 2 | 3  |
| 5 | 1 | 0 | 2 | 1  |
| 8 | 2 | 2 | 1 | 1  |
| 10| 2 | 1 | 1 | 0  |

**Figure 8.** Framework Matrix for 135°.

Using the same algorithm we could count the co-occurrence matrix for the observation direction 90° and 135°. Therefore it was clear that different observation direction gives the different feature texture.

3. **Methodology**

The object in this research is the textured gray level image of wood. This wood is the famous Indonesian wood; tectona grandy or jati which dimension is 100 x 200 pixels in format bmp, it is shown in Figure 10. First step we divided or crop this image into 8 small parts, each small part has the dimension 50 x 50 pixels, it is shown in Figure 11. Next step the feature was extracted by using GLCM, the extraction used different direction as mentioned before. We limited the extraction only on contrast, correlation, energy and homogeneity, these feature are the references. Next step the we cropped the image in Figure 10 to have the test image, dimension is 50x50 pixels but the cropping is in different location compare to reference image. These four GLCM features as a results from test images than compared to the results of references images. If these test results still in the range of reference image, it has been accepted otherwise it has been rejected.

![Figure 9. Experiment’s diagram.](image-url)
The object in this research is the gray level image as mentioned before. It is shown in Figure 10. This image is textured image of jati wood or tectona grandy, it is a such kind of good quality wood from Indonesian forest. This image is representation of macroscopic texture of jati wood.

![Figure 10. Tectona grandy.](image)

The test images in this research taken from different position is shown in Figure 12. The position of test image indicated by red and yellow square.

![Figure 12. Test image location](image)
4. Results and Discussion
The results of reference extraction is explained from Table 1 to Table 8. The features are contrast correlation, energy and homogeneity.

**Table 1. Feature Texture of Jati1**

| Direction | Contrast   | Correlation | Energy   | Homogeneity |
|-----------|------------|-------------|----------|-------------|
| 0°        | 0.1873     | 0.7657      | 0.3143   | 0.9063      |
| 45°       | 0.2970     | 0.6236      | 0.2660   | 0.8571      |
| 90°       | 0.2735     | 0.6579      | 0.2714   | 0.8671      |
| 35°       | 0.3419     | 0.5675      | 0.2529   | 0.8401      |

The results in Table 1 showed that the biggest value of contrast was in direction of 45°, it was 0.2970. For the other features were in the direction of 0°, correlation was 0.7657, energy was 0.3143 and homogeneity was 0.9063.

**Table 2. Feature Texture of Jati2**

| Direction | Contrast   | Correlation | Energy   | Homogeneity |
|-----------|------------|-------------|----------|-------------|
| 0°        | 0.2163     | 0.9049      | 0.1658   | 0.8924      |
| 45°       | 0.3711     | 0.8360      | 0.1302   | 0.8278      |
| 90°       | 0.3567     | 0.8434      | 0.1329   | 0.8320      |
| 135°      | 0.4444     | 0.8055      | 0.1177   | 0.7988      |

The results in Table 2 showed that all features value similar to Table 1. The biggest value of contrast was in direction of 45°, it was 0.3711. For the other features were in the direction of 0°, correlation was 0.9049, energy was 0.1658 and homogeneity was 0.8924. This similarity continue to other Table such as Table 3, Table 4, Table 5, Table 6, Table 7 and Table 8. Therefore from reference images showed in Figure 10, the extraction of the GLCM features such as contrast, correlation, energy and homogeneity gave the fixed phenomena, contrast in direction 45° and correlation, energy and homogeneity in direction 45°.

**Table 3. Feature Texture of Jati3**

| Direction | Contrast   | Correlation | Energy   | Homogeneity |
|-----------|------------|-------------|----------|-------------|
| 0°        | 0.2351     | 0.8310      | 0.1658   | 0.8924      |
| 45°       | 0.3853     | 0.7174      | 0.1302   | 0.8278      |
| 90°       | 0.3576     | 0.7431      | 0.1329   | 0.8320      |
| 135°      | 0.4415     | 0.6782      | 0.1177   | 0.7988      |
### Table 4. Feature Texture of Jati4

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2976   | 0.8229      | 0.1733 | 0.8561      |
| 45°       | 0.4498   | 0.7276      | 0.1434 | 0.8006      |
| 90°       | 0.3718   | 0.7755      | 0.1580 | 0.8261      |
| 135°      | 0.4715   | 0.7143      | 0.1414 | 0.7924      |

### Table 5. Feature Texture of Jati5

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2257   | 0.7890      | 0.2483 | 0.8888      |
| 45°       | 0.4856   | 0.5412      | 0.1787 | 0.7844      |
| 90°       | 0.4233   | 0.6010      | 0.1883 | 0.8041      |
| 135°      | 0.4640   | 0.5621      | 0.1812 | 0.7908      |

### Table 6. Feature Texture of Jati6

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2445   | 0.8506      | 0.2080 | 0.8805      |
| 45°       | 0.4273   | 0.7388      | 0.1577 | 0.8036      |
| 90°       | 0.3604   | 0.7834      | 0.1674 | 0.8280      |
| 135°      | 0.4319   | 0.7369      | 0.1552 | 0.7990      |

### Table 7. Feature Texture of Jati7

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2359   | 0.8703      | 0.1927 | 0.8837      |
| 45°       | 0.4973   | 0.7230      | 0.1345 | 0.7841      |
| 90°       | 0.4302   | 0.7635      | 0.1424 | 0.8039      |
| 135°      | 0.4790   | 0.7358      | 0.1352 | 0.7850      |
The results of jati1 showed that homogeneity has the biggest value compared to another feature, it is clear because jati 1 has mostly dark region. This dark region gives this big value to homogeneity. In contrast to jati1, jati 7 has mostly light region therefore gives the big value in homogeneity too. The summary of all value is explained in Table 9.

Table 8. Feature Texture of Jati8

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2563   | 0.8218      | 0.2086 | 0.8788      |
| 45°       | 0.5627   | 0.6054      | 0.1555 | 0.7839      |
| 90°       | 0.4702   | 0.6731      | 0.1675 | 0.8112      |
| 135°      | 0.5065   | 0.6467      | 0.1608 | 0.7983      |

The results of test image extraction, showed in Figure 11, is explained from Table 10 to Table 17. The features are contrast (con), correlation (cor), energy (en) and homogeneity (hom).

Table 9. The results of reference sample.

| Features   | Sample | Direction |
|------------|--------|-----------|
| Contrast   | Jati 7 | 45°       |
| Correlation| Jati 2 | 0°        |
| Energy     | Jati 1 | 0°        |
| Homogeneity| Jati1  | 0°        |

The results in Table 10 showed that the biggest value of contrast was in direction of 45°. For the other features were in the direction of 0°.

Table 10. Feature Texture of Test1

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2257   | 0.7890      | 0.2483 | 0.8888      |
| 45°       | 0.4856   | 0.5412      | 0.1787 | 0.7844      |
| 90°       | 0.4233   | 0.6010      | 0.1883 | 0.8041      |
| 135°      | 0.4640   | 0.5621      | 0.1812 | 0.7908      |

Table 11. Feature Texture of Test2

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2118   | 0.8955      | 0.1857 | 0.8941      |
| 45°       | 0.3390   | 0.8334      | 0.1472 | 0.8366      |
| 90°       | 0.3098   | 0.8493      | 0.1528 | 0.8505      |
| 135°      | 0.3786   | 0.8148      | 0.1381 | 0.8196      |
The results in Table 11 is from test2, it showed that the biggest value of contrast was in direction of 45°. For the other features were in the direction of 0°, it was same with Table 10.

Table 12. Feature Texture of Test3

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2269   | 0.8960      | 0.1956 | 0.8882      |
| 45°       | 0.3524   | 0.8365      | 0.1632 | 0.8372      |
| 90°       | 0.2935   | 0.8657      | 0.1762 | 0.8598      |
| 135°      | 0.3653   | 0.8329      | 0.1591 | 0.8268      |

Table 13. Feature Texture of Test4

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2033   | 0.8700      | 0.2137 | 0.8989      |
| 45°       | 0.3070   | 0.8013      | 0.1795 | 0.8510      |
| 90°       | 0.2759   | 0.8229      | 0.1893 | 0.8642      |
| 135°      | 0.3511   | 0.7749      | 0.1682 | 0.8316      |

In Table 13, it was the results of test4, there was an anomaly compared to Table 10, 11, and 12. In Table 13 the biggest value of contrast was in direction of 135°. It was for Table 14 and Table 15 too, therefore the anomalies of contrast were occurred in Table 13, 14, 15 and 17 which represented the area test4, test5, test 6 and test8.

Table 14. Feature Texture of Test5

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.3004   | 0.8333      | 0.1682 | 0.8552      |
| 45°       | 0.4623   | 0.7378      | 0.1385 | 0.7977      |
| 90°       | 0.3743   | 0.7879      | 0.1536 | 0.8254      |
| 135°      | 0.4677   | 0.7346      | 0.1387 | 0.7943      |

Table 15. Feature Texture of Test6

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2167   | 0.8238      | 0.2417 | 0.8927      |
| 45°       | 0.3569   | 0.7055      | 0.1923 | 0.8293      |
| 90°       | 0.3004   | 0.7568      | 0.2077 | 0.8541      |
| 135°      | 0.3574   | 0.7077      | 0.1923 | 0.8285      |
Table 16. Feature Texture of Test7

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2682   | 0.8432      | 0.1861 | 0.8686      |
| 45°       | 0.5581   | 0.6696      | 0.1333 | 0.7701      |
| 90°       | 0.4543   | 0.7341      | 0.1458 | 0.7989      |
| 135°      | 0.5010   | 0.7056      | 0.1381 | 0.7794      |

Table 17. Feature Texture of Test8

| Direction | Contrast | Correlation | Energy | Homogeneity |
|-----------|----------|-------------|--------|-------------|
| 0°        | 0.2522   | 0.8162      | 0.2132 | 0.8761      |
| 45°       | 0.4207   | 0.6900      | 0.1749 | 0.8150      |
| 90°       | 0.3669   | 0.7337      | 0.1846 | 0.8328      |
| 135°      | 0.4531   | 0.6674      | 0.1660 | 0.7992      |

The results of test4 showed that homogeneity has the biggest value compared to another feature, it is clear because test4 has mostly medium dark region. This medium dark region gives this big value to homogeneity. In contrast to test7, test7 has mostly light region therefore gives the big value in homogeneity too. The summary of all value is explained in Table 18.

Table 18. The results of test sample.

| Features    | Sample | Direction |
|-------------|--------|-----------|
| Contrast    | Test 7 | 45°       |
| Correlation | Test 2 | 0°        |
| Energy      | Test 1 | 0°        |
| Homogeneity | Test4  | 0°        |

The feature of all references were collected in form of one dimension vector. All vector are given in Table 19. In this vector we collected contrast only for direction of 45° and other feature, correlation, energy and homogeneity were for direction 0°.

Table 19. The feature of references

|   | Contrast | Correlation | Energy | Homogeneity |
|---|----------|-------------|--------|-------------|
| Jati1 | 0.2970 | 0.7657 | 0.3143 | 0.9063 |
| Jati2 | 0.3711 | 0.9049 | 0.1658 | 0.8924 |
| Jati3 | 0.3853 | 0.8310 | 0.1658 | 0.8924 |
| Jati4 | 0.4498 | 0.8229 | 0.1733 | 0.8561 |
| Jati5 | 0.4856 | 0.7890 | 0.2483 | 0.8888 |
| Jati6 | 0.4273 | 0.8506 | 0.2080 | 0.8805 |
| Jati7 | 0.5581 | 0.8703 | 0.1927 | 0.8837 |
| Jati8 | 0.4207 | 0.8218 | 0.2086 | 0.8788 |
Table 20. The feature of test.

|      | Contrast | Correlation | Energy | Homogeneity |
|------|----------|-------------|--------|-------------|
| Test1| 0.4856   | 0.7890      | 0.2483 | 0.8888      |
| Test2| 0.3390   | 0.8955      | 0.1857 | 0.8941      |
| Test3| 0.3524   | 0.8960      | 0.1528 | 0.8882      |
| Test4| 0.3070 * | 0.8700      | 0.1682 | 0.8989      |
| Test5| 0.4677 * | 0.8333      | 0.1682 | 0.8552      |
| Test6| 0.3574 * | 0.8238      | 0.2417 | 0.8927      |
| Test7| 0.5581   | 0.8432      | 0.1861 | 0.7794      |
| Test8| 0.4531 * | 0.8162      | 0.2132 | 0.8761      |

Note: * for direction 135°

5. Conclusions.

The results of this extraction is shown in Table 1 to Table 18, either Table 9 or Table 18 gave the same result and consistence; therefore we can make conclusion that contrast is best in direction 45° and for contrast, correlation and homogeneity are the best for direction 0°. We have to work on other object to strengthen this conclusion by working on other textured images for example radar image, medical image, and industrial image.

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