



## Extraction and Classification Feature of Timbers texture with Wavelet, Color Moment, and Multi Layer Perceptron

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### Abstrak

Identifikasi dan klasifikasi jenis kayu secara manual seringkali bersifat subjektif sehingga memakan waktu yang lama dan membutuhkan keahlian khusus. Untuk mengatasi keterbatasan ini, otomatisasi system sangat diperlukan untuk mempermudah dalam identifikasi dan klasifikasi jenis kayu. Pada penelitian ini, mengusulkan kombinasi ekstraksi fitur kayu dilihat dari tekstur dan fitur warna kayu setelah itu proses klasifikasi hasil ekstraksi fitur. Tiga metode yang digunakan antara lain: 1) metode Wavelet untuk ekstraksi tekstur spasial, 2) metode Color moment untuk mengekstraksi informasi warna secara statistik (rata-rata, standar deviasi, dan skewness), 3) metode Multi Layer Perceptron, metode Multi Layer Perceptron digunakan untuk klasifikasi dari hasil ekstraksi Wavelet dan Color Moment.

### Abstract

The manual identification and classification of timber species are often subjective, time-consuming, and require specialized expertise. To address these limitation, an automated system is essential to simplify the identification and classification processes. This research is combined approach to timber feature extraction based on texture and color. The three methods used are: 1) The method of Wavelet for spatial texture extraction, 2) The color moment method for extraction statistical color information (mean, standard deviation, and skewness), and 3) the Multi Layer Perceptron Method, where Multi Layer Perceptron is used to classify the extraction result from Wavelet and color moment.

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## Introduction

Timber has always been one of the essential renewable materials which has natural characteristic such as beautiful color and texture. However, driven by profit and low quality practices in wood trading is causing serious negative impact on the market. at the same time, wood illegally is causing great damage to the environment. To decrease of timber illegally can used intelligent method for timber species identification for automatic detection(Huang et al. 2026).

Timber species identification method are into macro and micro categories. Macro identification judges the species through the color, texture, and smell of wood and micro identification identifies tress such as pore characteristic, timber ray characteristic, etc(Huang et al. 2026). In this research, the researchers combination micro and macro to identification of wood species with combination of Wavelet for micro identification and Color moment for macro identification. The last step is classification feature with multilayer perceptron.

Wavelet transform is method that uses high-freq(Chang and Mukai 2022)uency data contained in the faulty signal. Wavelet has the capability better frequency resolution then other method signal like (Zheng, Liu, and Huang 2024)DWT(Ahmed et al. 2023). The advantages of wavelet transform are multi-scale analysis, efficient data resentation, precise edge detection, powerful compression capabilities, effective noise reduction, feature extraction and pattern recognition (Ferrari et al. 2011).

Color can represent an entire image. its can be set to dominant color for analyzing image color strategy and image color harmony. when analyzing image, this method is selected only grays with various brightness levels as the dominant colors(Yt et al. 2024). In this research, we used color moment because it can scales differentiate images based on their own color feature. The three-color moment (Mean, standard deviation, and skewness)(Mutlag et al. 2020). The color moments are extracted from the image using probability histogram model while the gray level co-occurrence matrix (Varish 2022).

Multilayer perceptron is a unique variety of an artificial neural network, each layer of MLP has a finite number. Each layer are connected with other layer, Information transmits from one layer to the next layer. MLP classifier can be classified for binary and multiclass types of dataset, MLP classifier is better optimization by selecting the most suitable optimizer to improve convergence time and loss (Aziz et al. 2023). The MLP are composed of similar neurons with consist of input, hidden, and output layers. MLP has relationships between the input and hidden layer, both of them are all processed by weight values. The advantages of

MLP has one hidden layer that can approach non linier system with arbitrary accuracy(Dewi Girsang and Muhathir 2021).

## Method

This section describe dataset, feature extraction, classification. The dataset has 400 dataset of timber which include jati, mahoni, mindi, and sengon. Figure 1 presents the flowchart of our proposed method.

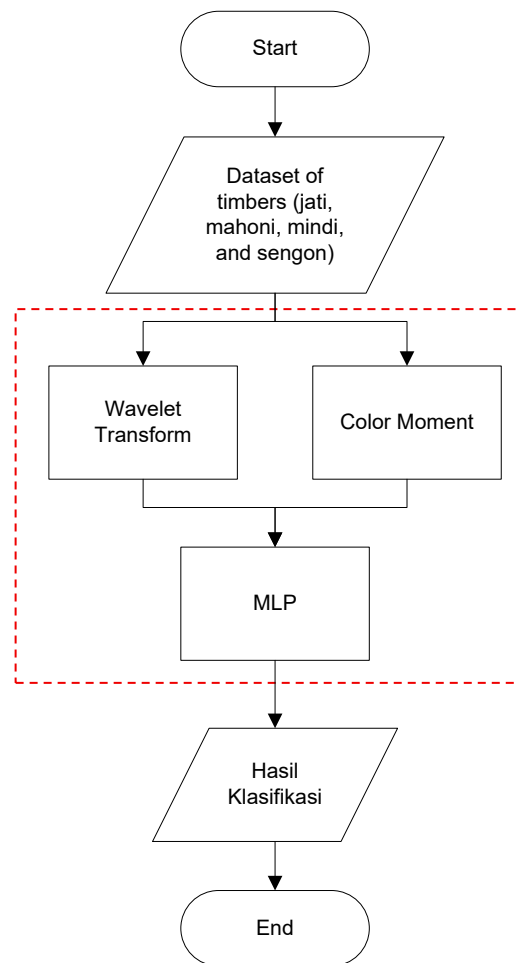


Figure 1 Proposed method

In the figure 1 can be seen the steps of our method. The first step is input dataset, the researcher have 400 dataset of timber for classification. The sampel picture of dataset can be seen in picture 1, picture 2, picture 3, and picture 4.



Picture 1 jati



Picture 2 mahoni



Picture 3 Mindi



Picture 4 Sengon

Second method is wavelet transform, wavelet transform has ability to perform multi resolution analysis, which is essential discerning both global architecture and intricate details within images. Wavelet transform mitigate this shortcoming by allowing for the analysis of images with multiple scales and resolution, thereby can capture of spatial with frequency information. In this research, we are used Haar wavelet transform to scaling  $\varphi(t)$ (low-pass) and wavelet  $\psi(t)$  (high-pass) function. These function are applied in both the x and y directions to compute the detail and approximation coefficients. (Belila and Khaldi 2024). The formula of wavelet can be seen in equation 1, equation 2.

$$\varphi(t) = \begin{cases} 1 & \text{if } 0 \leq t < 1 \\ 0 & \text{otherwise} \end{cases} \dots\dots\dots(1)$$

$$\Psi(t) = \begin{cases} 1 & \text{if } 0 \leq t < 0.5 \\ -1 & 0.5 \leq t < 1 \\ 0 & \text{otherwise} \end{cases} \dots\dots\dots(2)$$

The first equation (1) is approximate the signal scale by averaging adjacent data, the second equation (2) is capturing effectively highlighting transitions or edges in the signal. These function is resulting the application in row and column filters:

- ❖ Low-pass filter :  $[1,1] \times \frac{1}{\sqrt{2}}$
- ❖ High-pass filter :  $[1,-1] \times \frac{1}{\sqrt{2}}$

The function of  $\frac{1}{\sqrt{2}}$  serves a normalization variance between the original and transformed signal.

The third of method is color moment, color moment is a color feature representation in image processing. This method is calculation mean, standard deviation, and skewness. The equation of color moment can be seen in equation 3, equation 4, and equation 5.

$$E_i = \sum_{j=1}^N \frac{1}{N} p_{ij} \dots\dots\dots(3)$$

$$\sigma_i = \sqrt{\left(\frac{1}{N} \sum_{j=1}^N (p_{ij} - E_i)^2\right)} \dots\dots\dots(4)$$

$$S_i = \sqrt[3]{\frac{1}{N} \sum_{j=1}^N (p_{ij} - E_i)^3} \dots\dots\dots(5)$$

The similarity function of two distribution in an image is defined as the total difference between the moment of two image distribution, the equation can be seen in equation 6.

$$d_{mom}(H,I) = \sum_{i=1}^r w_{i1} |E_i^1 - E_i^2| + W_{i2} | \partial_i^1 - \partial_i^2 | + W_{3j} | S_j^1 - S_j^2 | \dots\dots(6)$$

Where (H,I) are two images being compared, variable I is the color component index (with the index notation of Hue=1, saturation=2, value=3), variable r is the number of channel (e.g.,=3), variable  $E_i^1$  and  $E_i^2$  are the second moment (standart deviation) of the two digital image distribution. variable  $S_j^1$  and  $S_j^2$  are the third moment (skewness) of the two digital image distributions. Variable  $w_i$  is the weight for each color moment.

The fourth of method is MLP, in this research MLP for classification because MLP has forward neural network which is trained with back propagation that can be approximated in optimal condition during difficult case. The MLP is a supervised learning NN that uses back-propagation algorithm, MLP has three layer architecture consisting of input layer, hidden layer or layers, and output layer or layers(Abdel-aziem and Soliman 2023). The design of MLP can be seen in figure 2.

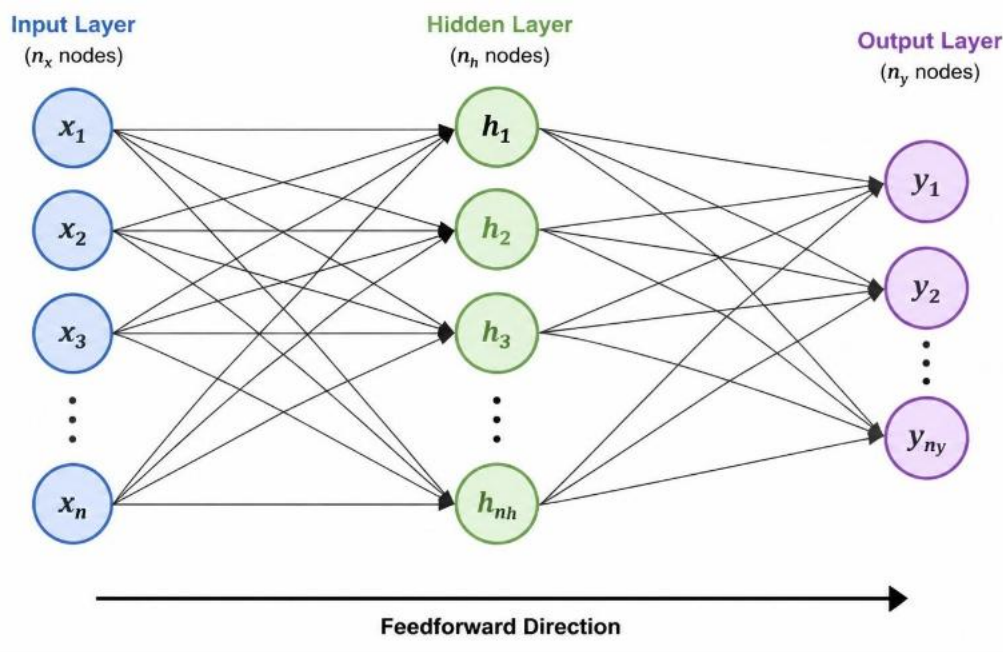


Figure 2 the design of MLP

The calculation of output, input, and bias variable as :

$$C_i = \sum_{i=1}^n E_{ij} I N_i + B_i \dots\dots\dots(7)$$

Where  $E_{ij}$ ,  $N_i$ , and  $B_i$  are weight for input variable and bias variable, for the activation of function can be seen in equation 8:

$$S_i = \frac{1}{1 + e^{cj}} \dots\dots\dots(8)$$

For the output ultimate variable can be seen in equation 9:

$$O_i = S_i(\sum_{i=1}^n E_{ij} I N_i + B_i) \dots\dots\dots(9)$$

## Results and Discussion

The classification performance of the Multi-Layer Perceptron (MLP) was evaluated using two different feature extraction methods: Gray-Level Co-occurrence Matrix (GLCM) and Wavelet Color Moments. The evaluation metrics accuracy, precision, recall, and F1-score were calculated across four wood classes (Jati, Mahoni, Mindi, and Sengon) with a test support of 16 instances (4 samples per class). The evaluation metrics accuracy, precision, recall, and F1-score were presented in Table 1.

Table 1. The evaluation metrics accuracy, precision, recall, and F1-score

Metric	Previous Research (GLCM MLP)	Proposed Method (Wavelet Color Moment MLP)
Accuracy	0.81	0.94
Precision	0.89	0.95
Recall	0.81	0.94
F1-Score	0.81	0.94

The model utilizing GLCM features achieved an overall accuracy of 81%. While the model perfectly identified Mindi wood (F1-score: 1.00), it struggled with class confusion between Mahoni, Jati, and Sengon. Mahoni exhibited perfect recall (1.00) but low precision (0.57). Mathematically, achieving 0.57 precision with 4 True Positives means there were

exactly 3 False Positives. Jati suffered from a low recall (0.50), meaning 2 out of 4 samples were misclassified. Sengon had a recall of 0.75, meaning 1 sample was misclassified. Because Mindi had perfect precision and recall, the 3 misclassified samples (2 Jati and 1 Sengon) were all falsely predicted as Mahoni, causing Mahoni's low precision score.

Switching the feature extraction to Wavelet Color Moments yielded a substantial improvement, raising the overall accuracy to 94%. Jati classification improved to perfect precision and recall (1.00/1.00). Mahoni precision increased significantly from 0.57 to 0.80. With perfect recall (4 True Positives), a precision of 0.80 indicates only 1 False Positive. Sengon performance remained static (Precision: 1.00, Recall: 0.75), indicating exactly 1 missed sample. Therefore, the single False Positive absorbed by the Mahoni class was this specific Sengon sample.

When compared to the previous research framework utilizing GLCM-MLP, the proposed Wavelet Color Moment-MLP model demonstrates a substantial performance leap. The previous GLCM approach struggled significantly with misclassifications, misidentifying 50% of the Jati samples as Mahoni. This occurred because grayscale texture analysis cannot differentiate between the highly similar structural grain boundaries of these specific species. The classification accuracy by shifting from the previous grayscale texture-based paradigm to a multi-resolution color distribution method.

## **Conclusion**

In conclusion, integrating color and spatial frequency via Wavelet Color Moments provides a vastly superior discriminative feature space compared to the previously established GLCM baseline for wood species classification. The proposed Wavelet Color Moment-MLP method achieved a final accuracy of 94%, delivering a substantial 13% improvement over the 81% accuracy yielded by previous GLCM-MLP research. This quantitative leap confirms that capturing color distributions alongside spatial frequencies is critical for resolving class confusion, particularly between structurally similar woods like Jati and Mahoni that grayscale texture analysis alone fails to separate. Future research should prioritize a visual audit of persistently misclassified samples to clean dataset anomalies, alongside scaling the test dataset to validate the generalizability of these accuracy improvements.

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