NON-WOOD ANATOMY IMAGE DETECTOR FOR TROPICAL WOOD RECOGNITION SYSTEM

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ABSTRACT

A Tropical Wood Recognition System (KenalKayu) has been developed to identify the tropical wood species. The system can operates well in offline mode but when it works for the online testing, the accuracy rate will be decreased. It is because the system is not able to detect a non-wood anatomy image. As the result, the system will give the wrong answer when a non-wood anatomy image has been captured. The system considered ineffective enough and not reliable to do real-time testing. This paper proposed a detector to spot a non-wood anatomy image before it will be sent to KenalKayu for the real-time testing. The detector can differentiate between a wood anatomy image and a non-wood anatomy image. Only a valid wood texture image is kept for the further step and the non-wood anatomy image will be rejected from the system. There are two categories of database collected for the system which are wood anatomy images and non-wood anatomy images. An experiment is conducted from these two set of database. The input image features have been extracted from the image by using grey level co-occurrence matrix (GLCM). Then, the non-wood anatomy image will be identified by using artificial neural network (ANN). The result obtained is compared in order to get the best non-wood anatomy image detector module.

Keywords: artificial neural network, pattern recognition, wood recognition system, grey level co-occurrence matrix, wood anatomy image

Introduction

Currently, wood identification based on the anatomy of the wood is done by only very few certified personnel in this country. The process of training up experience personnel in performing the job is a not easy, due to the fact that there are about more than 3,000 species of wood in the Malaysian forest. Thus, there is an urgent need to apply a more structured way in performing wood identification so that it can be carried out fairly accurately and quickly.

There is an automated wood recognition system developed by Centre for Artificial Intelligence and Robotics (CAIRO), known as KenalKayu (Khalid at el., 2008) which based on wood macroscopic features. The research has been done since 2002 and it has been improved in so many ways (Rosli et al., 2008, Yusof et al., 2010, Khairudin et al., 2011, Khalid et al., 2011, Ahmad et al., 2013, Yusof et al., 2013, Ahmad et al., 2015, Ahmad et al., 2016) to ensure the system is able to recognise the wood species whether in offline or online mode. This system may replace the conventional technique in performing wood identification which are exposed to human error and biasness.

Kenalkayu can recognise a wood spesies in less than a second. This may save time, cost and human resources in performing the wood identication. It is also organised and systematic with Wood Database Management System which is developed within the system. Moreover, KenalKayu has a web-based version and can be accessed anywhere as long as it is connect with the internet.
For demo purpose, there is a PC-based Kenalkayu system that has been used for data collection, to do experiments and data analysis and also for training and testing (Halim at el., 2015). A microscopic camera has been attached with the system and the camera is equipped with a lighting system. The camera also attached with a conveyor belt system to make it operates easier for data collection. The distance target between the camera and the wood sample is fixed. This system can be used in offlline and online mode. The accuracy rate for the offline testing is up to 98% but the accuracy rate has been decreased to 62% when it has been tested with online mode.

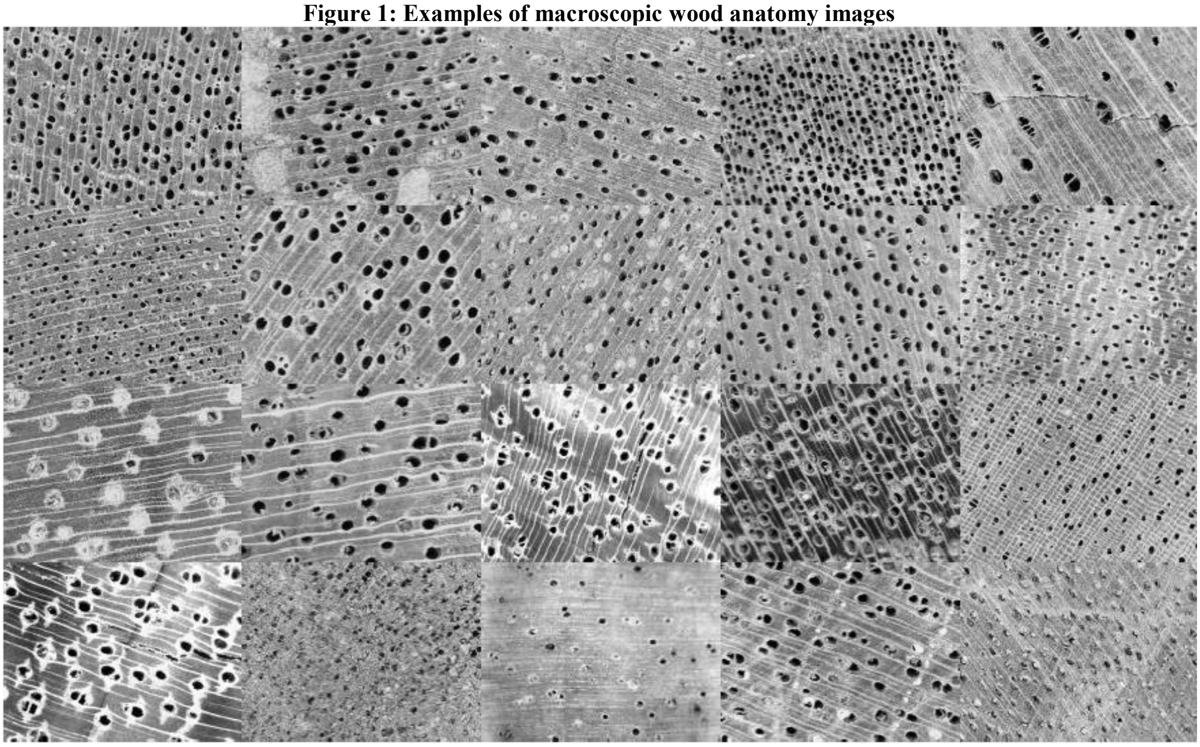
One of the main problem of the system is it cannot detect any non-wood anatomy image that has been captured by the attached microscopic camera. The system will give a wrong answer as it receives the input image as a perfect wood anatomy image. The non-wood anatomy image must be rejected before it becomes an input for KenalKayu. A pre-processing module needs to be developed to detect non-wood anatomy image in order to ensure that only valid wood anatomy image will be sent as input to Kenalkayu. As the result, Kenalkayu will be more robust and reliable during the online testing mode.

This study is focused on developing a pre-processing module for KenalKayu. A non-wood anatomy image detector has to be developed to detect non-wood anatomy image captured by the system. We need to label & separate it for automatic deletion in order to preserve good quality input image. If the input image is not an anatomy wood image, the module will reject the input image from the system.

MACROSCOPIC WOOD ANATOMY IMAGE

Wood species is identified by its macroscopic features. Macroscopic features include physical features and anatomical features that are very visible with a hand-lens or with naked eye. The anatomical features include porosity, vessel arrangement and abundance, ray size relative to vessel diameter, ray height, presence or absence of storied structure. Some woods have distinctive combinations of macroscopic anatomical features that can be readily identified with a hand-lens. The scope of this research is focused on the macroscopic features in wood identification as this method is recommended by wood anatomy experts from Forest Research Institute of Malaysia (FRIM) as a more practical method to be applied in the industry. Figure 1 shows an example of the macroscopic anatomy of 20 different wood species in Malaysia.

Figure 1: Examples of macroscopic wood anatomy images



Most of the woods structures characteristics are finest examinational from the cross-section plane of the wood. Wood plane are divided into three types, or geometric surfaces of reference, that shows the type of plane exposed after a cut has been prepared. The three mentioned surfaces are the radials section, tangential section and cross section. Figure 2 shows the three mentioned surface of wood.

The cross section is formed by cutting the cells vertically to the way of growth in the tree. The cross section is the equivalent plane seen on a stump after cut down a tree. It is imperative to decide which reference surface you are looking when recognising wood because cell and tissue composition is three-dimensional and different based on direction.

Figure 2: The wood surfaces; (X) cross section surface, (T) tangential surface and (R) radial surface.

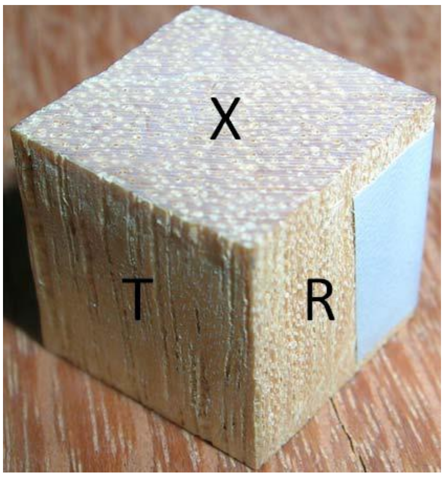
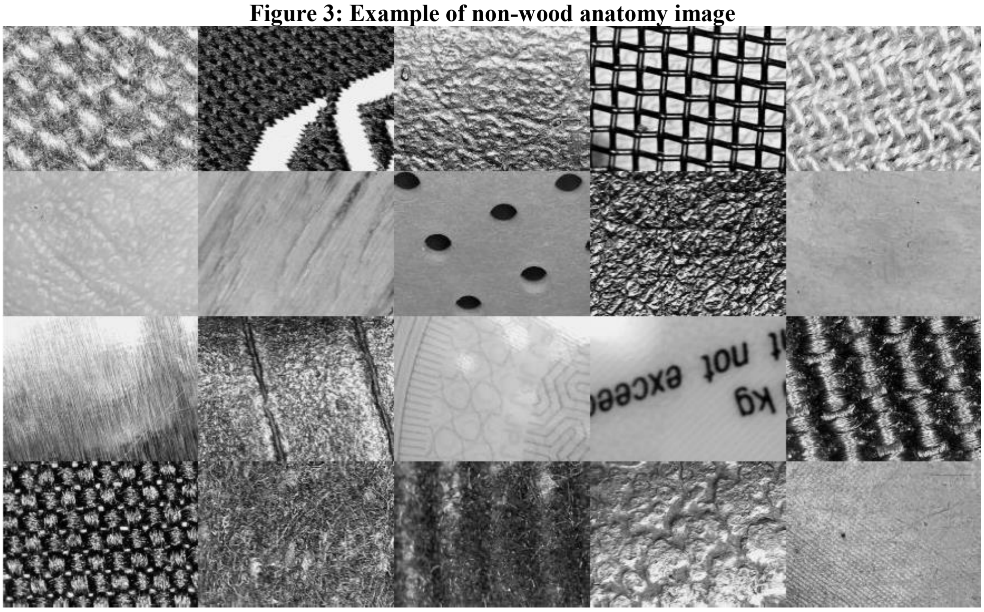


IMAGE DATABASE AND DATA ACQUISITION

The wood samples for this project are obtained from FRIM and cut into cubes, approximately 1 inch by 1 inch in size. 5,000 wood anatomy images have been captured from 20 different tropical wood species as shown in Figure 1. Meanwhile, 5,000 non-wood anatomy images are captured from random object such as fabrics, papers, skin texture, plastic, leather and many more. Figure 3 shows example of the non-wood anatomy images. The microscope camera that has been used to capture the pattern of the surfaces intended is MAXGear Digital Microscope HD USB Camera. The image size in database is 640 x 480 pixels.

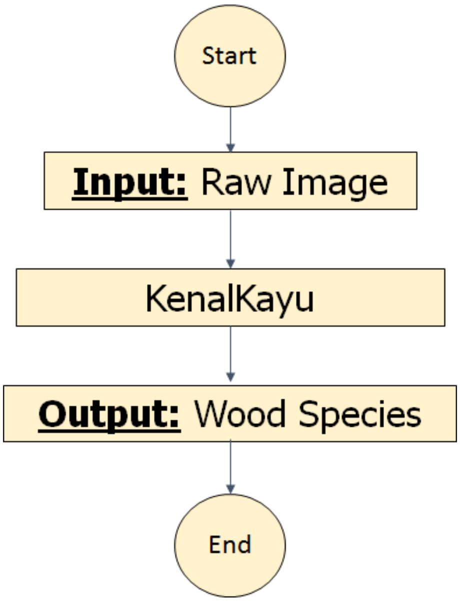
Figure 3: Example of non-wood anatomy image



SYSTEM OVERVIEW

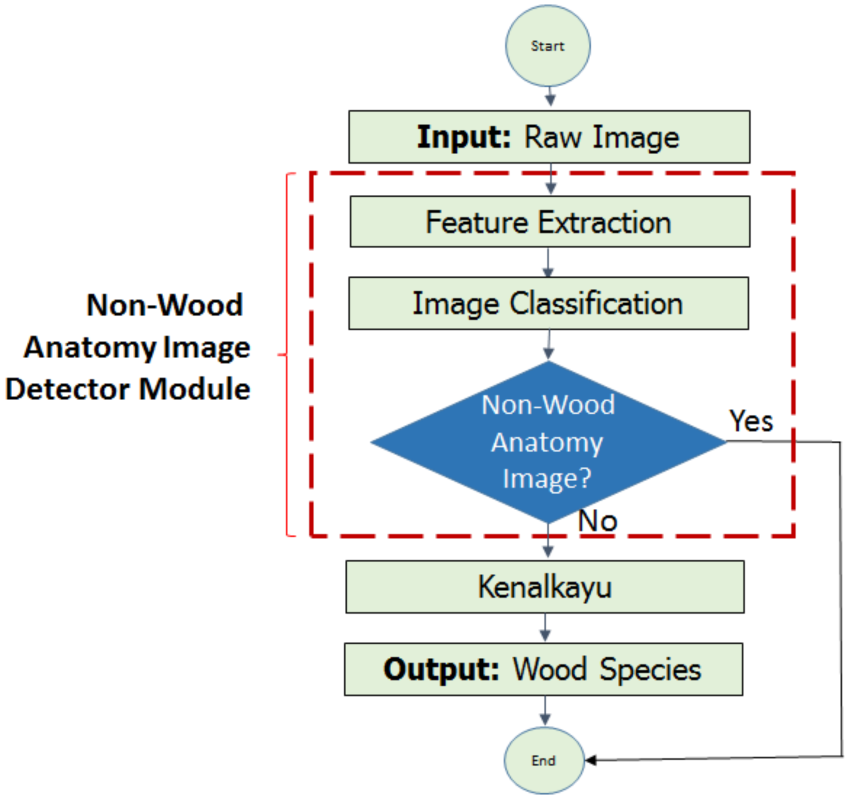
In this section, we will explain methods that have been used for this paper. Figure 4 shows the process flow for current KenalKayu system. The system operates well in offline mode where the accuracy rate is up to 98%. The input for the system is a raw image captured by a microscopic camera. Then the image will be processed in the system and the output of the system will be the wood species.

Figure 4: Process flow for KenalKayu system



The proposed process flow is shown in Figure 5. In this research, KenalKayu is equipped with a non-wood anatomy image detector module. An image captured will be checked whether it is a valid wood anatomy image or not. If not, the module will reject the image from the system. If the wood image anatomy is detected, it will be the input for KenalKayu. This is to ensure that KenalKayu received only a valid wood anatomy image as the input image for the system. So that the system will be more robust if we run it in an online mode. This will increase the accuracy rate of the system.

Figure 5: Process flow for KenalKayu system with Non-Wood Anatomy Image Detector module



There are 2 sub-modules in non-wood anatomy image detector module which are feature extraction and image classification. For feature extraction sub-module, a method called grey level co-occurrence matrix (GLCM) has been used to extract features from the raw image. While for the image classification sub-module, artificial neural network (ANN) will be used to classify whether the input image is a valid wood anatomy image or not.

A. Feature Extraction Sub-Module

Feature extraction is an important process to extract information, features or properties from the texture of input image captured by the microscopic camera. The analysis of texture requires the identification of those texture attributes which can be used for identification of the non-wood anatomy image. In many machine vision and image processing algorithms, simplifying assumptions are made about the uniformity of intensities in local image regions. Conversely, images of real objects often do not exhibit regions of uniform intensities (Tuceryan, 1998). In our case, the macroscopic anatomy image of wood is not uniform but contains variations of intensities which form certain repeated patterns called visual texture. The patterns are made up of several structural elements such as vessels or pores, wood parenchyma or soft tissue, rays and fibers (Menon, 1993).

GLCM which have become one of the most well-known and widely used texture feature extraction method (Haralick, 1973, Haralick, 1979). In this approach, textural features of an image is based on the assumption that the texture information on an image is contained in the overall or average spatial relationship which the grey tones in the image have with one another. More specifically, this texture information is adequately specified by a set of grey tone spatial dependence matrices; that are computed for various angular relationships and distances between neighbouring resolution cell pairs on the image. The features from these grey tone spatial dependence matrices.

For each input image, the co-occurrence matrices are calculated from four directions, which are horizontal, vertical, diagonal 45° and diagonal 135°. A new matrix is formed as the average of these matrices that is used for extracting the features. In this way, the extracted features will be rotation invariant at least for 45° steps of rotation.

For each orientation of an image, there are 5 features to be extracted which are angular second moment, contrast, correlation, entropy and inverse difference moment. This will give the total of 20 features to be extracted using this feature extractor.

B. Image Classification Sub-Module

Classification is a process that assigns input data into one or more of specified classes based on extraction of significant features or attributes and the processing or analysis of these attributes. A classification problem happens when an entity needs to be allocated into a predefined cluster or group based on the quantity of observed attributes related to that objects. So, basically recognition is the ability to classify. In this research, we need to classify whether the input image is a valid wood anatomy image or not.

There are many types of ANN with different combination of architectures, activation function and training procedures. Among the ANN models, the multilayer perceptron (MLP) is the most popular model (Omatu, 1995) and thus, the MLP was used in the work of this research. We proposed the use of back-propagation neural network in our wood recognition system. The type of ANN used is a three-layer standard feed forward network with back-propagation error correction.

The neural network consists of a series of input neurons, a hidden layer and a layer of output neurons. These layers are fully connected. Each input neuron represents the textural features and the output neuron represents a distinct image types. Input parameters are normalized and scaled to a range of 0 to 1 and the output values for each mineral are presented as probabilities in the range of 0 to 1. The nature of each function and each weight within the network is determined during training process. By propagating corrections based on the squared error back through the network, the next cycle will modify the weight matrices and bias values until the network converges to a correct solution.

EXPERIMENTAL & RESULTS

In this experiment, we have 2 set of image dataset. The first dataset containing 5,000 wood anatomy images and the second dataset is containing 5,000 non-wood image. For each dataset, 4,500 images are used for training and remaining of 500 images are used for testing. This is equivalent to 90% of training set and 10% for testing set. Training set refers to use the same images that have been trained by ANN while testing images are images which have not been used for training.

The experiment is conducted to determine the accuracy rate of the pre-processing module and to find the best ANN parameters to be used for the non-wood anatomy image detector. The selection of the best parameters is pertinent in order to obtain an accurate and reliable wood recognition system that is able to detect non-wood anatomy image correctly.

Table 1 shows the results of the comparison between using the default ANN parameter and the best ANN parameter. From the result of Table 1, it can be observed that the result in the best ANN showed an increase of the accuracy rate for testing data and a reduced of training duration from 249.26 second to 36.2 second when compared with the default ANN. Thus, in order to improve the accuracy rate of the system as well as to reduce training duration, the best ANN parameters are chosen as the parameters that will be used in the pre-processing module.

Table 1: Comparison of the result between using default ANN parameter and the best ANN parameter

Default ANN Parameters		Best ANN Parameters	
Parameters	**Value**	**Parameters**	**Value**
Hidden Layer	30	Hidden Layer	20
Momentum	0.7	Momentum	0.4
Learning Rate	0.09	Learning Rate	0.05
Max Epoch	1500	Max Epoch	300
Training Duration	249.26s	Training Duration	36.12s
Accuracy in Training Data	0.9436	Accuracy in Training Data	0.9167
Accuracy in Testing Data	0.886	Accuracy in Testing Data	0.893

CONCLUSSIONS

Conventionally, wood identification based on its anatomy is done by only few certified personnel in this country. The wood identification is done by using naked eyes and aided with a glass magnifier. It will takes 2 to 3 years of training in recognising the wood species and the job is not easy due to fact that there are about more than 3,000 species of wood in the Malaysian forest. To overcome this problem, CAIRO has developed an automated tropical wood recognition system known as KenalKayu since 2002 and it has been improved in so many ways to ensure the system is able to recognise the wood species whether in offline or online mode. KenalKayu gives a high accuracy rate up to 98% for offline testing mode. Unfortunately, it becomes a big challenge to capture a good quality image while running online mode for the system. The system is unable to identify non-wood anatomy image – even it does, it is a wrong answer. It gave a wood species as the answer, even if the input is an invalid wood anatomy image.In this research, KenalKayu is equipped with a non-wood anatomy image detector module. An image captured will be checked whether it is a valid wood anatomy image or not. If not, the module will reject the image from the system. If the wood image anatomy is detected, it will be the input for KenalKayu. This is to make sure that KenalKayu received only a valid wood anatomy image as the input image for the system. From the experiments, we are able to proof that the pre-processing module can detect non-wood anatomy image. By using this module, the accuracy rate for online testing will be increased.

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