IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 4, No 2, July 2013
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

SAPWOOD OAK CLASSIFICATION USING GLOBAL AND LOCAL FEATURES

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Abstract

Classification of wood images has always fascinated researchers and is a hot area of research as it brings automation in wood industry. Wood comes in different types and for a given wood; it can have some good part and some bad part like cracks, water affected and sapwood. The objective of this paper is to classify the sapwood region and the non-sapwood region in oak wood image in order to get the good part of the wood (heart part). Color based features and texture based feature extraction strategies were employed and it was found that color based feature extraction techniques are better compared to others in order to find sapwood.

Keywords: *SAPWOOD detection, Feature Combination, Gabor Filter.*

1. Introduction

Oak-sapwood classification is one of interesting subject in wood classification. Sapwood is part of the wood which is categorized as bad part because it is less strong than the heart part. Distinguishing between sapwood and heart part of the wood is the main focus of this paper. Several difficulties were faced in setting criteria for classification of sapwood region, for example, sapwood color is hardly uniquely described because some of them are different among different woods. The coloration of the heartwood and sapwood can be sharply contrasted with each other, but the coloration can be same for both heartwood and sapwood in some other trees. This can be caused by the age of tree or environment of growth.

In order to recognize sapwood, one needs to know the characteristic of sapwood. Sapwood is the cells within the wood that is used to transfer water and minerals from the roots to the leaves store the reserved food materials and provide strength to the whole tree [1].

The system starts with an image acquisition process where the input samples are captured using a camera (This process done by Luxscan).

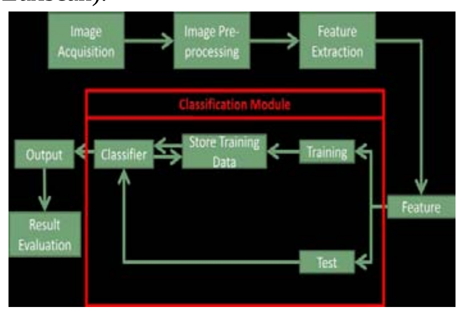

Fig 1: Flow Diagram of Process

After the input image is captured, it will be normalized through the pre-processing process. The normalized images will be used for feature extraction and important textural features are extracted here. The extracted features will be trained using our ground truth and then classified using a classifier and produces an output as shown in Figure 1.

Fig 2: Ground Truth Images

Pre-processing is applied on the input images in order to eliminate no-information area in the wood. The black background from the image seems has no information in it. It should be removed to reduce the input size and to enhance identifying the characteristic of the wood so that it will help in the recognition process. The ground truth images are formed as shown in figure 2.

2. Feature Extraction

Several different techniques were employed and these techniques are explained as follows

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2.1 Color Feature

Color features consist of hue, illumination and chromacity (saturation). Hue refers to color attribute. The luminosity is the light component of a color which is from white to black. The saturation is the intensity of the color from grey to color. There are various color space available such as RGB (Red, Green, Blue), HSV (Hue, Saturation, brightness Value) and CMY (Cyan, Magenta, Yellow) etc.

2.2 Relative Mean Intensity

In maximum type of woods, sapwood have different color from heartwood. Heartwood is considered to have the same intensities as the mean intensities of the full image [2]. Meanwhile, almost all of the sapwood has brighter intensities than heartwood. Only few of them have darker intensities. At first, it is also considered as the dark-sapwood so that absolute relative mean can be used as the feature extraction. As shown in Figure 3, sapwood are darker in that wood so that when we use the relative mean intensity features, it gives brighter heartwood and dark sapwood wood (Figure 3b). If we use the absolute relative mean features (Figure 3c), sapwood and heartwood are bright, we cannot distinguish them well.

Fig 3: a) Original Image b) Relative Mean Intensity Image c) Absolute Mean Image

Results show that when Features are extracted using absolute relative mean, could not classify the sapwood well. Moreover, other defects and cracks are also classified as sapwoods because of their lower intensities. Therefore, relative mean intensity is chosen as the feature extraction because it can give a better separation between sapwood and heartwood. The formula is defined as:

$$Features = Pixel\ intensity - Mean\ global\ image\ intensity \ldots\ldots\ldots\ldots(1)$$

Pre-processing is done to get a more compact classified sapwood region. Gaussian smoothing is used because it is good to reduce noise and to blur the images[3]. Parameters that are tuned are the kernel size and standard deviation. The size of the kernel should normally be selected large enough and increasing the standard deviation will increase the blurring.

2.3 Gabor Filter

Gabor filter is also known as Gabor wavelets. A Gabor function is a complex sinusoid modulated by a rotated Gaussian. A two dimensional Gabor function consists of a sinusoidal plane wave of some frequency and orientation, modulated by a two-dimensional Gaussian.

$$g_e(x,y) = \left(\frac{1}{\sqrt{2\pi}\sigma}\right) e^{-\left(\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)} \cos((2\pi(x/\lambda)+\psi) \ldots.(2)$$

Where,

$$x' = x\cos\theta + y\sin\theta \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$y' = x\cos\theta - y\sin\theta \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

In the above equation, λ represents the wavelength of the cosine factor, θ represents the orientation of the normal of a Gabor function in degrees, ψ is the phase offset in degrees, and γ is the spatial aspect ratio and it specifies the elliptically of the Gabor function, and σ is the standard deviation of the Gaussian.

Gabor filters have various properties that make them particularly suitable for texture segmentation [4]. It has been shown that the Gabor function is a band-pass filter that can be tuned to a narrow set of frequency anywhere in the frequency domain. The output of properly parameterized Gabor channels can thus be used to reconstruct the most important features of a textured image.

2.4 GLDM

Conventional GLCM method is two dimensional as it focus on the co-occurrence of the specific pixel pair, so it is much time consuming. Therefore, GLDM as 1-dimensional GLCM can be a solution to answer this problem.

To reduce computations, the GLCM dimension can be reduced from two dimensions to one dimension by combining certain values of the matrix [5]. By focusing only on the differences of the grey level, we are only concerning on a one-dimensional GLCM with a significantly smaller size which is only 2 × G – 1 where G represents the grey level, compared to G × G for a conventional two-dimensional GLCM.

GLDM uses the joint probability density function which normalizes the GLCM by dividing every set of pixel pairs with the total number of pixel pairs used. GLDM is based on the occurrence of two pixels which have a given absolute difference in gray level and separated by a specific displacement vectors. The same texture measurements used in GLCM can also be applied for GLDM, but it must be modified to suite the one dimensional computation. In implementation, the GLDM is seen as the density function so it is easier to calculate the statistical values from it.

3. Implementation and Results

In this section, implementation of different techniques is discussed.

3.1 Relative Mean Intensity

Relative mean intensity features are extracted from images. The results in figure 4 show sapwood have much higher values than the mean and can be characterized well using this method. In order to avoid the sparse and noisy sapwood classification results, we applied the Gaussian smoothing. For the parameters, we set the kernel size to be 25 and standard deviation is 5 to achieve enough blurring and uniform sapwood region.

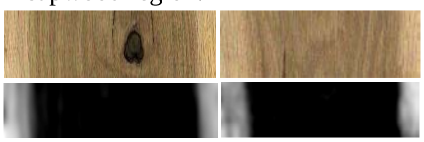

Fig 4: Result of Relative Mean Intensity feature extraction from wood patches

3.2 Gabor Filter

To analyze how Gabor filter segment the wood image texture, result was observed by convolving the Gabor filter via FFT in different orientations and scales. First, it was tested with the patches having sapwood only and the non-sapwood patches only to see how Gabor filter can give a measurements are seen in Figure 5. By observation, entropy always gives a good separation between sapwood and heartwood. In those two patches, sapwood is defined to have high entropy values. Contrast is also a good feature but it is not too obvious in characterize the sapwood. Energy is the inverse of the entropy but it is not too clear. Homogeneity fails to show the difference between sapwood and heartwood region. Therefore, for simplicity, we only use the entropy feature extracted from GLDM. It gives the high value for sapwood region (red), even though the color is not brighter than the heartwood.

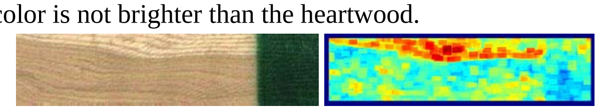

Fig 6: Entropy feature extraction from GLDM

3.3 Relative Mean Intensity + Gabor features and ANN

Gabor features is combined with relative mean features. For Gabor feature, we select the scale and orientation, which is at scale = 3 and first orientation (0^o). Some of specific characteristic for sapwood. We used 5 sapwood patches and 5 non-sapwood patches from 5 training images. Unfortunately, we could not infer any separation between texture of sapwood and non-sapwood in different orientations and scales. On the other hand, although in some patches the non-sapwood have more random texture, but some Gabor features of heartwood may also have the same texture characteristic with sapwood. This makes the criteria of sapwood texture not clearly defined by Gabor.

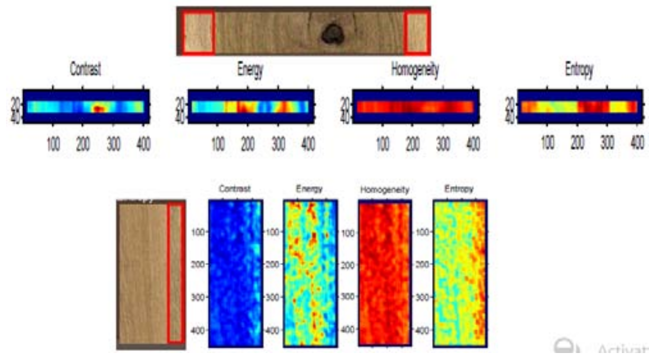

Fig 5: Image textures extracted from GLDM statistical measurements

Direction of orientation is selected to be 0 deg, since the most of the sapwoods in our sets has uniform vertical pattern. If we choose smaller distance than 5, it could not give a clear separation while if we choose a bigger distances the result even worse. After, GLDM is applied in several image patches that contain sapwood, image textures of the four statistical the classifier output using this combined feature is shown in the figure 7.

Fig 7: CLASSIFICATION RESULTS using Gabor + RELATIVE MEAN FEATURES

Visually, it seems worse since it gives more false positive classification of sapwoods. The classifier output with Gabor and relative mean features give lower classification performance. It is shown in the parameters derived from confusion matrix, as the following: Accuracy = 0.8992, TPR =0.2470, FPR =0.0311, F_score =0.0896.

3.4 Relative Mean Intensity + GLDM and ANN

GLDM is combined with relative mean features so that the classifier can have input from color as well as the texture features. The performance measures from confusion matrix are as follows: Accuracy =0.95, TPR =0.61, FPR =0.0169, F_score =0.372. From these measures, it can be seen that actually the network only gives TPR 0.61. Otherwise, it is tried to use these combined GLDM and Relative Mean features to the testing images. Results are shown in figure 8.

Fig 8: Classification results for GLDM + relative mean features

4 . Conclusion

Sapwood and heartwood can be classified well in our strategies, by using the appropriate combination of features extraction method and classifiers. The best features extraction method for supervised and unsupervised classification is the relative mean intensity and GLDM. Ground truth images are created but with imperfect masking which may lead to a reduced performance in classification. Whereas in unsupervised, the evaluation is based on visual assessment of sapwood region. To summarize, we conclude that classifiers can work well if we have good training set and the sapwood has a uniform criteria in most of the cases.

References

[1] Z. Zhang, et al. Locating the Wood Defects with Typical Features and SVM. 2008. School of Information Technology, NanJing Forestry University.

[2] J.Yi Tou. Texture classification on wood images for species recognition. December 2009. Faculty of Information and Communication Technology, Universiti Tunku Abdul Rahman Malaysia.

[3] ‘The colour Image processing Handbook’ by S.J Sangwine and R.E.N Horne, Chapman & Hall.

[4] ‘Fundamentals of Computer Vision’ by Mubarak Shah, University of Central Florida, Orlando

[5] ‘Texture analysis aids interpretation’ by Satinder Chopra and Vladimir Alexeev, Arcis Corp.,Calgar

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