Optik 126 (2015) 2231–2235

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Study on the identification of the wood surface defects based on texture features☆

Xie YongHua, Wang Jin-Cong*

Northeast Forestry University Mechanical and Electrical Engineering College, Harbin, China

ARTICLE INFO

Article history:
Received 12 April 2014
Accepted 23 May 2015

Keywords:
Wood
Defects detection
Texture features
GLCM
Tamura texture

ABSTRACT

Wood surface defect detection technology is the intersect multidisciplinary technology between computer vision and pattern recognition, which has a high value and is widely used in the field of timber production and deep processing. This paper mainly takes three common defects such as dead knots, poles and living knots of wood for the study, it deeply researches on image segmentation and pattern recognition methods of wood. To ensure the reliability of the results of wood defect recognition, the selection of characteristic values is the crucial aspects of pattern recognition. Haipeng Yu extracted texture of the wood based on GLCM, Xuebing Bai also classified texture of the wood based on GLCM. In addition, researchers used wavelets, Markov random, fractal, local binary pattern and histogram to make some useful attempts with the study of wood texture feature extraction. The above study only applied a texture analysis method. As the diversity and complexity of the wood surface defect images, the success rate of using a certain type of feature detection method is still less than ideal from the application point of view. The study proposes a hybrid wood surface texture features based on defect detection method, which combines the integration of Tamura texture and GLCM method advantages of these two methods, so that the accuracy and robustness of the algorithm are effectively protected.

1. Introduction

Texture that describes the surface properties of the image or image area corresponding to the scene is a global feature, which is not based on the characteristics of pixels but a feature-based regional nature. The feature is not due to local regional variations cannot successfully identified, it needs to perform statistical calculations on the region including a plurality of pixels [1–3]. As a statistical feature, it is often with rotational invariance, and it has strong resistance to noise capability. These features and color features are different.

Tamura texture features, GLCM features are the most typical and representative analysis to characterize the texture features among statistical methods. HARALICK etc. extracted from GLCM texture features in the 11 parameters, such as angular second moment, contrast, correlation, variance, deficit moment, sum of average, sum of variance, variance of various entropy, entropy and difference and difference entropy [4,5]. Tamura texture feature is proposed based on the texture of human visual perception on psychological research and there are six kinds of features following, regularity, rough, roughness, contrast, direction and linearity.

The shape of the target to be extracted are usually used as the image feature quantity extracted feature, for example, the shape of dead Festival and live festival defects are round or oval, and the shape of poles defects is the long oval [6–8]. But they also have some common problems that are following, feature extraction method has not perfect mathematical model, goal deformation cannot get the correct results, the target of the shape information reflected by many shapes characteristic is not identical to the intuitive sense of human. Furthermore, 3-D object which is seen from the performance of the 2-D images is actually just a projection plane of objects in space. The shape is often not true 3-D object shape which reflected from 2-D images [9].

Due to changes in viewpoint, it may produce a variety of distortion, so there are few scholars chosen it as the characteristic quantities of classifier.

2. Tamura texture

Tamura took the measure of human subjective psychology as a standard and proposed six basic texture features, which include coarseness, contrast, directionality, linearity, regularity and

☆ Supported by "the fundamental Research Funds for the Central Universities", Item Number: 2572015BB12.
* Corresponding author.
E-mail addresses: wangjincong@foxmail.com, 857040732@qq.com (W. Jin-Cong).

http://dx.doi.org/10.1016/j.ijleo.2015.05.101
0030-4026/

roughness [10–12]. The most important of these characteristics are mainly the coarseness, contrast and directionality of the texture. These texture characteristics correspond well to the visual perception of human, has been applied in many image retrieval system. Here mainly introduce the calculation of the coarseness, contrast and directionality.

2.1. Coarseness

(1) Calculate the moving average, for the $2^k \times 2^k$ window, its moving average is:

$$a_k(i,j) = \sum_{i'=i-2^{k-1}}^{i+2^{k-1}-1} \sum_{j'=j-2^{k-1}}^{j+2^{k-1}-1} \frac{p(i',j')}{2^{2k}} \tag{1}$$

(2) Calculate the deviation of the horizontal and vertical

$$c_k(i,j) = \max(|a_k(i-2^{k-1},j) - a_k(i+2^{k-1},j)|, |a_k(i,j-2^{k-1}) - a_k(i,j+2^{k-1})|) \tag{2}$$

(3) Determine the size of the window

$$\hat{k}(i,j) = \underset{k}{argmax} c_k(i,j) \tag{3}$$

(4) Calculate the average size of the window

$$\text{coarseness} = \frac{1}{wh}\sum_{(i,j)} 2^{\hat{k}(i,j)} \tag{4}$$

2.2. Contrast

Contrast describe the brightness of the image, it is affected by different black and white or shades of gray, use the following equation to calculate the contrast,

$$\text{contract} = \frac{\sigma}{\sqrt[4]{\alpha_4}} \tag{5}$$

Deviation of black and white,

$$\alpha_4 \frac{\bar{p_4}}{\sigma^4} = \frac{(1/wh)\sum_{(i,j)}(p(i,j)-\bar{p_1})^4}{\sigma^4} \tag{6}$$

2.3. Directionality refers to the orientation of the image in gray value. Calculate directionality requires the following four steps,

(1) Calculate gradient of each pixel. Gradient means the direction grow the fastest around the pixel of the gray value. Horizontal gradient Δh equals to the deviation of three gray values between the left and right pixels, while the vertical gradient Δv is the deviation of three gray values between up and down pixels.

$$g = \begin{pmatrix} \Delta_h \\ \Delta_v \end{pmatrix}$$
$$\Delta_h = \sum_{k\in\{-1,0,1\}} p(i+1,j+k) - p(i-1,j+k) \tag{7}$$
$$\Delta_v = \sum_{k\in\{-1,0,1\}} p(i+k,j+1) - p(i+k,j-1)$$

(2) Calculate the gradient vector in polar coordinates

$$(|g|,\phi) = \left(\frac{|\Delta_h| + |\Delta_v|}{2}, \quad \tan^{-1}\left(\frac{\Delta_v}{\Delta_h}\right) + \frac{\pi}{2}\right) \tag{8}$$

(3) Calculate the tilt angle of the vector $n_\phi(k)$ means the proportion of pixels to meet the condition of histogram $\frac{2k-1}{2n} < \frac{\phi}{\pi} < \frac{2k+1}{2n}(\text{mod}1)$ and $|g| > t$.
(4) After getting the histogram, calculate the sum of values changes surrounded the peak. Directionality is equal to the sum of the changes between trough to trough.

3. GLCM

HARALICK proposed the concept of GLCM in 1979 firstly, experiments show that GLCM is a very successful method which has been widely used in image processing. Texture feature extracted by GLCM is line with the human visual characteristics, most scholars recognize it as a pattern characteristic quantities for classification [13,14].

Start from the pixel point with gray i, while the other pixel point with gray j occurs at the same time in distance (Dx, Dy). Define the probability of occurrence between these two gray throughout the image, compare with mathematical notation,

$$p(i,j,\delta,\theta) = \{(x,y)|f(x,y) = i, f(x+Dx, y+Dy)\} = j; \quad x,y = 0,12,\ldots,N-1\} \tag{9}$$

where $i, j = 0,1,2,\ldots,L-1$. x, y is the coordinates of the pixels in the image, L is the number of gray levels. δ is the number of pixels in adjacent intervals, θ represents the direction. Thus, the probability of two simultaneous pixel gray level, will coordinates (x, y) of the spatial to (i,j) of the gray pair in description, which forms the matrix that is called GLCM.

HARALICK etc. extracted 11 texture features from GLCM parameters, such as angular second moment, contrast, correlation, variance, deficit moment, sum of average, sum of variance, variance of various entropy, entropy and difference and difference entropy. In these eleven parameters, angular second moment, contrast, correlation, entropy and the variance are the most representative. The reaction may be better strength of the wood grain, texture of the cycle, the thickness and texture textured surface shading. To optimize the choice of texture feature, the paper only take the amount of these five texture features.

(1) Angular second moment,

$$f_1 = \sum_{i=0}^{L-1}\sum_{j=0}^{L-1} \hat{P}_\delta^2(i,j) \tag{10}$$

(2) Contrast,

$$f_2 = \sum_{i=0}^{L-1}\sum_{j=0}^{L-1} (i-j)^2 \hat{P}_\delta^2(i,j) \tag{11}$$

(3) Correlation,

$$f_3 = \frac{\sum_{i=0}^{L-1}\sum_{j=0}^{L-1} ij\hat{P}_\delta^2(i,j) - \mu_1\mu_2}{\sigma_1\sigma_2} \tag{12}$$

(4) Entropy,

$$f_4 = \sum_{i=0}^{L-1} j \sum_{j=0}^{L-1} \hat{P}_\delta(i,j) \log \hat{P}_\delta(i,j) \tag{13}$$

(5) Variance

$$f_5 = \sum_{i=0}^{L-1}\sum_{j=0}^{L-1} (i-\mu)^2 \hat{P}_\delta^2(i,j) \tag{14}$$