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The research on the method of extracting the wood cell parameters

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Abstract. By using the image processing technology, the relevant parameters are extracted, including quasi-circular degree, the surface area, perimeter, width and thickness of cells, wall thickness, ratio of wall to cavity, ratio of cavity to diameter and cell density. After sampling, with the parameter values of cells obtained compared to the standard values, the error is within 10%. Afterwards, the value range of the cell parameters of each species is determined, which provides data basis for the recognition of wood species.

Keywords: parameters, quasi-circular degree, sampling, wood species

1 Introduction

There are many defects in the application of traditional wood species recognition methods[1-4]. Therefore, it has become an urgent problem, waiting to be solved, to use computer in the identification of wood species. The recognition of wood species in the micro field of cells can effectively solve the bottleneck problem caused by the recognition based on artificial experience[5-6]. The main procedures are: analyze and calculate the annual ring age of the annual ring images photos; select the cells in the annual rings of trees over ten years old and make cell slices; capture the images of the annual rings, veins and cells; make mathematical analysis of the cells in the micro field and abstract the microscopic cellular feature parameters, to identify the wood species[7-10]. However, different image processing methods and different cell parameters will affect the recognition results, so in this paper, some reference values for the identification of wood species are presented, which are based on the parameters including quasi-circular degree, the surface area, perimeter, width and thickness of cells, wall thickness, ratio of wall to cavity, ratio of cavity to diameter and cell density, and the parameter range of common wood species are given. These provide data support for the recognition of wood species.

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2 The definition of microscopic cellular feature parameter

On the basis of the enlarged images of wood slices and the cell image, in order to facilitate the acquisition of experimental data, we establish the mathematical model of the approximately hexagonal structure of board base cells. The parameter definitions of the simulated cell contour and the real cell contour are compared.

(1) Quasi-circular degree

The quasi-circular degree in a broad sense refers to the degree of approximation between an image and a standard circle or oval. In practice, the quasi-circular degree plays an important role.

$$F_1 = \frac{|P_1|}{\sum_{n=1}^{+\infty}(|P_n| + |P_{-n}|)} \tag{1}$$

In formula1-1， P_n indicates the boundary Fourier coefficient through the chain code method, and the chain codes are c_1 , c_2 , c_3 , … c_i , …, c_M , respectively, which are completed clockwise to the contour curve of cells.

$$P_n \cong \frac{1}{2\pi nj}\sum_{m=1}^{M} a_m e^{j}\left[\frac{\pi}{4}C_m - 2n\pi\frac{\sum_{k=1}^{m} a^k}{\sum_{k=1}^{M} a^k}\right] \tag{2}$$

In this formula, N = ± 1, ± 2, ... ； $a_k = \begin{cases} 1, & if C_k is\ even; \\ \sqrt{2}, & if C_k is\ odd; \end{cases}$ k=1， 2， ...， M.

Move the coordinate origin to the centroid, and the parametric equation of the curve C can be written as:

$$U(t) = \sum_{n=1}^{\infty}(P_n e^{jnt} + P_{-n} e^{-jnt}), \quad 0 \le t < 2\pi \tag{3}$$

If the values of all the terms except for $|P_1|$ in the Fourier coefficient P_n are 0, the contour shape indicated by $U(t) = P_1 e^{jt}$ is a circle with a radius of P_1. Then, when C is a circle, its quasi-circular degree will be 1, and when C is other shapes $0 < F_1 < 1$, the features such as translation, rotation, size and starting point will meet invariance [34].

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(2) The area and perimeter of cells

There are two common methods for calculating the area:

① Pixel counting method

In the technology of digital image processing, the measurement of the area of a target objective includes the measurement of its interior and boundary points [11-15]. In binary images, the enclosed area is composed of sets of interconnected black pixels in a great number, so the calculation of the number of black pixels in this enclosed area is to solve the area of the object region. Here, the number of pixels is adopted as the unit. Thus, based on this idea, the formula for calculating the area of the object region is:

$$S = \sum_{x=1}^{N} \sum_{y=1}^{M} f(x, y)$$

(4)

In this formula, S is the cell area, $f(x, y)$ is the gray value of the pixel of which the abscissa is x and ordinate is y. If the object and its background are represented by 0 and 255, respectively, the calculation of cell area will be the count of $f(x, y) = 0$. In using the pixel counting method to calculate the area, the segment representation the most commonly used.

All the coordinates of the pixels obtained with the chain code method can be connected to the pixels with the same ordinates with lines, and the length of all the segments is the area of the cell, as shown in Figure 5-7. From this, what can be obtained is shown in formula 5:

$$S = \sum_{k=1}^{m} x_{k2} - x_{k1}$$

(5)

In formula (5), S indicates the total area of the cell, the endpoint abscissa of each end of the connecting segment with the same vertical within the cell area is x_{k1}, x_{k2}, respectively. m is the total number of segments dividing the cell region.

② The area calculated by using boundary coordinates

According to Green's Theorem, it can be seen that in a rectangular coordinate system, the area of a closed object area contour can be represented by the integral of the contour curve, which is

$$S = \frac{1}{2} \oint (xdy - ydx)$$

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(6)

In this formula, the integral is calculated for the target closed contour curve boundary. In practical calculation, to calculate the area covered by the closed contour curve region using Green's theorem, discretization should be carried out first, as shown in formula 7.

$$S = \frac{1}{2}\sum_{i=1}^{N_b}[x_i(y_{i+1} - y_i) - y_i(x_{i+1} - x_i)]$$

$$= \frac{1}{2}\sum_{i=1}^{N_b}[x_i y_{i+1} - x_{i+1} y_i]$$

(7)

In this formula, N_b is the number of boundary points, x_i and y_i are the coordinates of the endpoints of the line.

4 Conclusion

In this paper, a recognition algorithm based on the cellular microscopic digital features, to extract the relevant parameters of board cell images, including quasi-circular degree, the area, perimeter, width and thickness of cells, wall thickness, ratio of wall to cavity, ratio of cavity to diameter and cell density and so on. The calculated results obtained are compared to the standard values, and through analysis, it is found that the error range is basically within 10%. The digital image processing technique is used to extract the mathematical feature parameters of cells, and the wood species are judged according to the standard parameter database. By using this method, the speed of wood species recognition can be improved, and it can also effectively reduce the instability due to the high dependence of the recognition method on the pixel feature of images. The method has a high recognition accuracy and robustness. Moreover, this method also gets rid of the restriction of wood species recognition on the experience of operators, to study the microscopic field of wood cells, which is of great significance to wood species recognition. However, the wood cells are affected by various factors, such as temperature, humidity and so on, and the samples for experiment are not diversified enough. Therefore, as the follow-up experiment progresses, it will be a work focus to constantly update the experimental database of samples.

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