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The Application of RBF Neural Network in the Wood Defect Detection

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Abstract

Wood defect is due to the physiological process, genetic factor or affected by the external environment in the growth period. These defects will reduce the utilization value of wood. However, it is very difficult to determine whether there are defects exist, and the degree of defects. Therefore, the effective detection of wood defect information is particularly important. A new wood defect detection method by using RBF neural network was proposed in this paper. The new RBF defect detection method can be divided into the following main steps: (1) Detect wood defects by using X-ray nondestructive testing technology. (2) Deal with defect images by using digital image processing technology. (3) Analyze the information of different defects, and extract the characteristic value of wood defects. (4) Then, the RBF neural network model was constructed. (5) Finally, the RBF neural network is trained with the known samples and simulated with the unknown samples. The experimental results shown that the RBF neural network method was effectively detect the two typical wood defects. This method provides an important theoretical basis to realize the wood defect automatic detection.

Keywords: *wood defects; Nondestructive Testing; Image Processing; RBF neural network*

1. Introduction

In 1985, Powell proposed multivariate interpolation of Radial Basis Function (Radial Basis Function, RBF) method, which provides a novel and effective means for the multilayer forward network study. In 1988, Broomhead, Lowe, Mood and Darken first apply RBF to design the artificial neural network, which make up the RBF neural network. Since then, the RBF neural network has caused wide attention, and a large number of papers about RBF neural network structure, learning algorithm and application in various fields were published. Such as the product life distribution model identification based on RBF neutral network [1]; Speech recognition based on RBF network [2]; Traffic sign recognition based on RBF network; The license plate character recognition based on RBF network [3]; Face recognition based network [4], and so on. The application involves many aspects of life now. RBF network not only has good generalization ability, but it also can avoid the cumbersome and lengthy like back propagation calculation. Moreover, it also can make learning from 1000 to 10000 times faster than the normal BP network, has the characteristics of the only approach and don't have the local minimum. RBF radial basis function neural network (RBF network) is a three layer feed forward network with single hidden layer. It simulates the

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structure of neural network that local adjustment, cover each other in the human brain to accept the domain. It is proved that a kind of local approximation network, which can approximate any function with arbitrary precision. In this paper, all kinds of wood internal information were judgment accurately and quickly by using the X-ray nondestructive testing technology. Then, the characteristic values as input feature vectors of RBF network were extracted and the effectively wood defect detection can be achieved.

2. Wood Defect Image Preprocessing

The generation of the Image Gray Level Co-occurrence Matrix, as showing in Fig.1, In the Gray image (Grayscale: Ng, Pixels: $N_x \times N_y$), any point (x, y) and another point $(x + d\sin\alpha, y + d\cos\alpha)$, which the distance of deviation from it is d. And set the gray values of the two points for $(i, j)\_i, j \in \{1,2,\cdots, Ng\}$. Let the point (x, y) move on the whole picture, we can get all kinds of the value of (i, j) ,and the gray level co-occurrence matrix (GLCM) is obtained. In the matrix GLCM, the i-th row j-th column element $G(i, j)$ is the number of occurrences for grey value of (i, j). If we also include the gray series for Ng that

The original wood defect images as shown in Figure 1 and Figure 2.

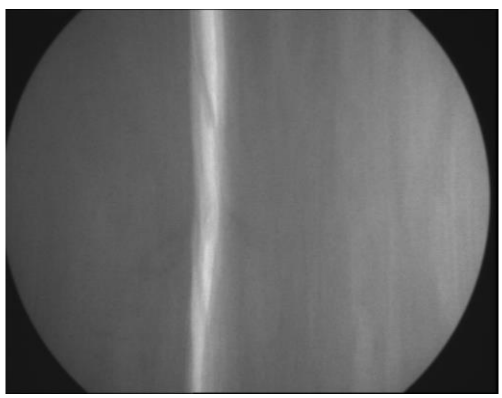


Figure 1. Original Image of Wood Crack

Figure 2. Original Image of Wood Decay

First of all, Input the corresponding statement in the MATLAB, wood defect image gray processing and make the gray-level histogram [5]. The results are shown in Figure 3- Figure 6.

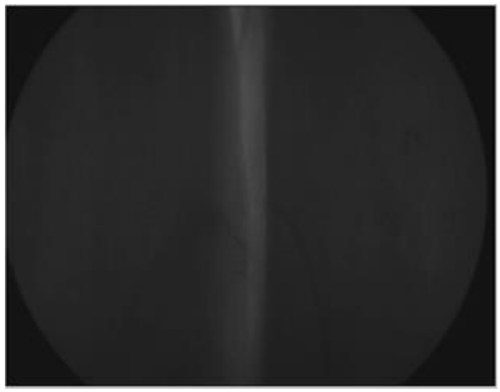


Figure 3. The Original Crack Grayscale Image

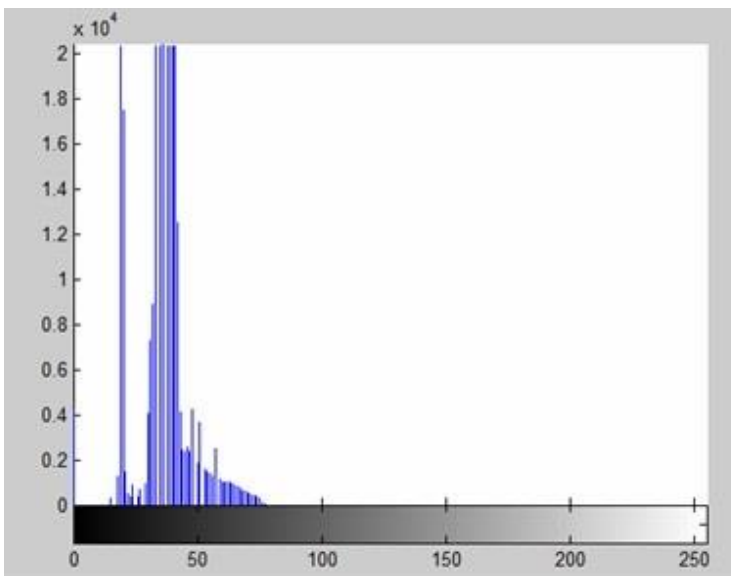


Figure 4. The Gray-level Histogram of the Original Crack Grayscale Image

Figure 5. The Original Decay Grayscale Image

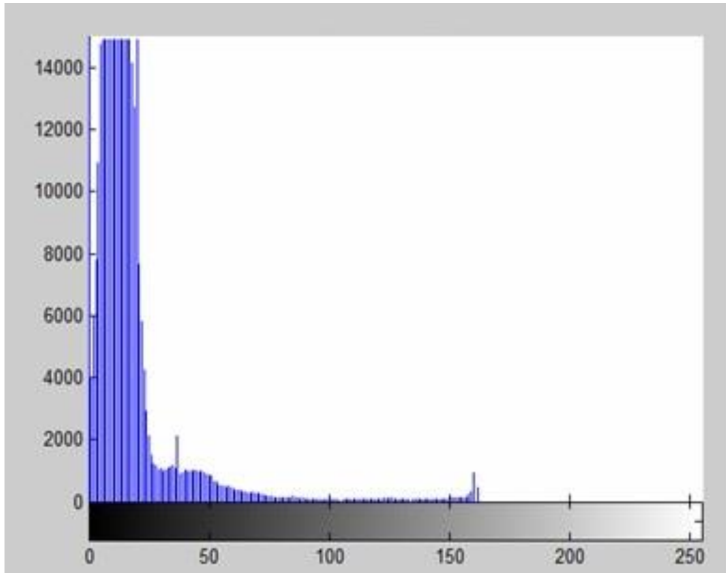
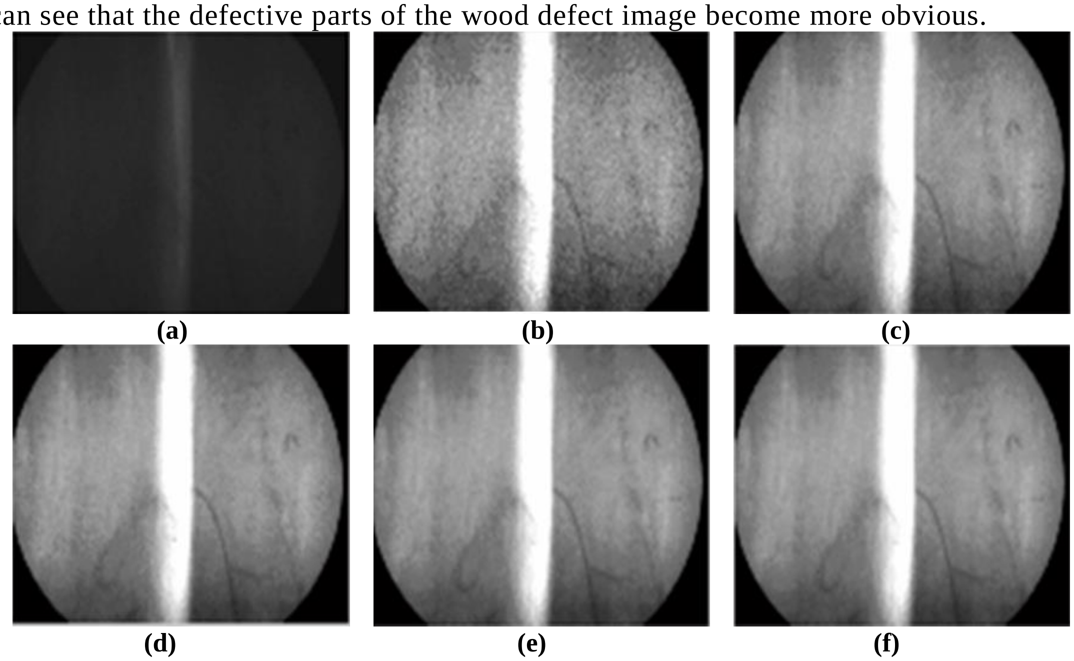


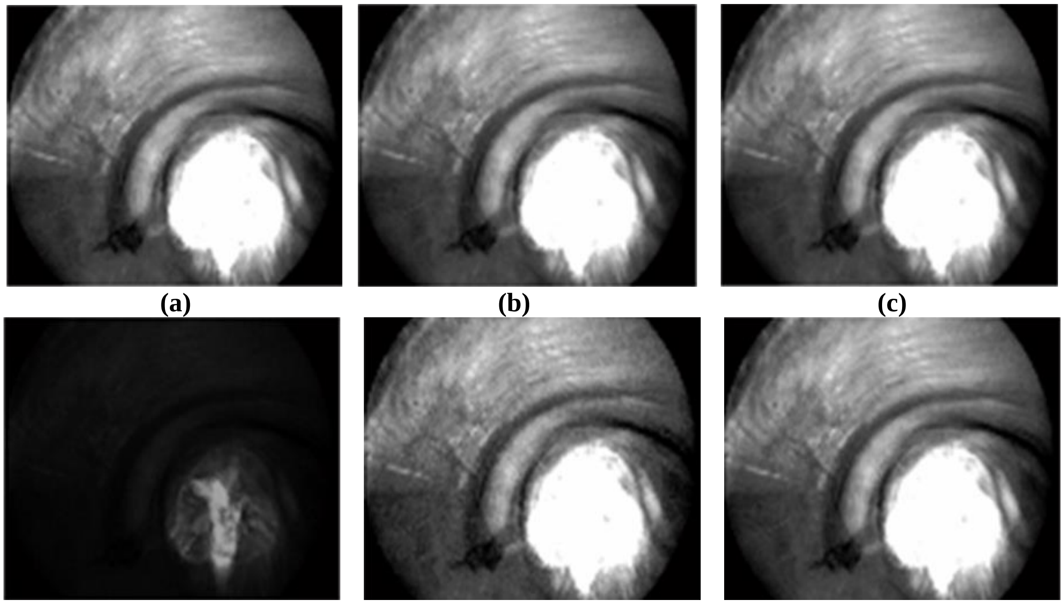
Figure 6. The Gray-level Histogram of the Original Decay Grayscale Image

Deal with the obtained image by using mean filtering, median filtering and secondary wiener filtering, respectively [6]. The results are shown in Figure 7 and Figure 8. We can see that the defective parts of the wood defect image become more obvious.



(a) Gray level image; **(b)** Image after gray level adjustment processing; **(c)** Image after mean filtering processing; **(d)** Image after median filtering processing; **(e)** Image after wiener filtering processing; **(f)** Image after secondary wiener filtering processing

Figure 7. The Processing Result of Crack Defect Image



(a) (b) (c)

(d) (e) (f)

(a) Gray level image; **(b)** Image after gray level adjustment processing; **(c)** Image after mean filtering processing; **(d)** Image after median filtering processing; **(e)** Image after wiener filtering processing; **(f)** Image after secondary wiener filtering processing

Figure 8. The Processing Result of Decay Defect Image

In order to check whether there is distortion in the results of image processing. Do addition operation for the edge image and the image after quadratic wiener filtering. In MATLAB, add operation was implementation through function imadd ( ). The results of addition operation are shown in Figure 9 and Figure 10.

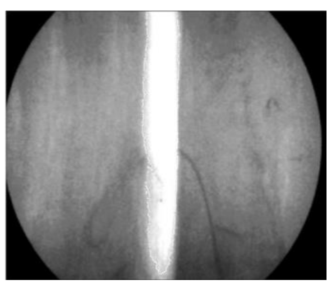


Figure 9. The Addition Operation Result of Crack Image

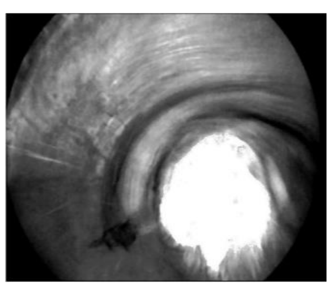


Figure 10. The Addition Operation Result of Decay Image

From the result we can see that divide the defect parts from other parts will make the defect parts more clearly and at the same time retaining the various characteristics of the defective parts. The method is very effective and valuable. It laid the foundation for the extraction of characteristic value.

In order to make the feature extraction of image more convenient for observation, we make the reversal operation for the image which processed by using above method [7, 8, 9]. The following results are obtained. The defective parts are clearly separated, more conducive to the selection and extraction of the characteristic values. The image inversion results as shown in Figure 11 and Figure 12.

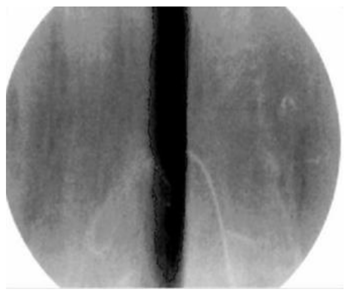


Figure 11. The Inversion Results of Crack Image

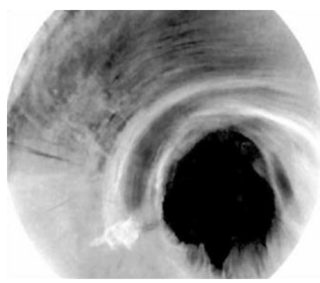


Figure 12. The Inversion Results of Decay Image

3. Feature Extraction of Wood Defect Images

In order to differentiate crack and decay, selecting appropriate features value is necessary to reflect the perimeter, area, length-width ratio and gray average of defect shape [10-11].

The extraction of length-width ratio. On the extraction of length-width ratio, is not easy to ensure the geometrical center of defect , then we can consider using elliptic complexes as the center of defect (see below) , the geometric center of the ellipse as geometry center as defect. The center of an ellipse is easy to ensure. Specific count of length and width consult the formula:

$$l = \sqrt{(y_1 - y_2)^2 + (x_1 - x_2)^2} \tag{1}$$

The (x1, y2) , (x1, y2) is the endpoint coordinates of the length or width crossing the set center. Calculate the length and width, draw the length width ratio of defect.

$$Z = r_{\max} / r_{\min} \tag{2}$$

The extraction results are shown in Table 1.

Table 1. The Length, Width End Coordinate of Defect

	length		width	
	point 1	point 2	point 1	point 2
crack	(456, 127)	(456, 457)	(430, 292)	(482, 292)
decay	(531, 285)	(531, 436)	(463, 361)	(599, 361)
decay	(531, 285)	(531, 436)	(463, 361)	(599, 361)

The calculation of the length-width ratio were: decay 6.35, crack 1.11.

(2) extracted from the gray level mean value

In the software Image J, open the image to be extract, select the edge of the defect, then we can read the selected gray average, defect can be replaced by the approximate ellipse, gray average of crack is 13.942, gray average of decay is 6.313.

In this section we extract length-width ratio, gray level mean value of defect, which reflect the shape and gray level of defect.

4. RBF Neural Networks

On the whole, the organization structure of the brain (cerebral neuron network) and activity patterns as the background of the neural network structure and working mechanism, which reflect the basic characteristics of the human brain but not a true representation of the human part, that is to say, it is a kind of abstract, simplification or imitation. Nowadays, there are many types of the artificial neural network referring to the biological neural network, while they have the same basic unit: the neuron structure [12,13]. The model diagram of the neuron is shown in Fig 13.

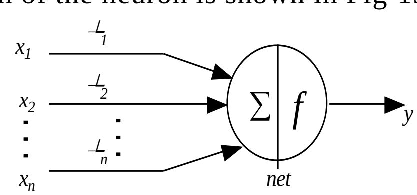


Figure 13. The Model Diagram of the Neuron

RBF neural network consists of three layers: the input layer, hidden layer and output layer. When we determined the number of the eigenvalue species we extracting, the number of neurons in the input layer was identified. Then we input the eigenvalue in the form of the feature vector into the output layer, and the output layer nodes pass the input signal to the hidden layer next, which is composed of the radial function such as Gauss kernel function. While the output layer node is usually a simple linear function. The model diagram of RBF neural network is shown in Figure 14.

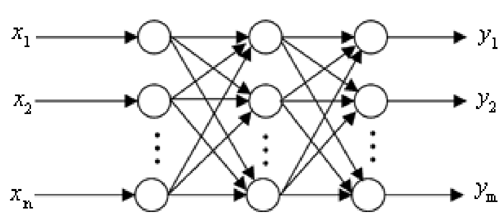


Figure 14. The Model Diagram of RBF Neural Network

When a component value of the input or output vector is too dense, the pretreatment of the data can make the point in a long distance. While we have determined the number of neurons N in the input layer of the network to be 2. In order to simplify the network structure, we use the self-defined defect codes, in which 1 representing the crack and 0 representing the decay. So we could design one neuronal representing two types defect in the output layer of this network and the number of output neuronal is one. Moreover, the transfer function of hidden layer is the Gauss kernel function and the transfer function of output layer is linear function.

The learning pattern of RBF neural network we have designed has two steps, the first step is unsupervised learning and the second is supervised learning. In the first step, we trained the 20 groups of characteristics values of the crack and decay obtaining from the input.

5. Conclusion

We have concentrated on the test and readjustment of the designed network in the simulation stage. According to the experimental results we have obtained, we came to a conclusion that when the rangeability is not exceeding 0.2 in the vicinity of 1 for the output value of the simulation result, we considered the measured samples as the crack type; while the rangeability is not exceeding 0.2 in the vicinity of 0 for the output value of the simulation result, we considered the measured samples as the decay type. After the experiment, the distinguishing crack and decadent accuracy rate reaches above 85%, indicating that RBF network we have designed has a preliminary success.

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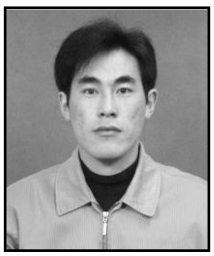

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