Research on feature extraction of veneer defects based on improved SURF algorithm

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Abstract. In this paper, when the feature extraction algorithm extracts the veneer defect features, due to the veneer rotation and a large number of surface textures, the problem of poor feature matching and long time consumption occurs, and an improved SURF algorithm is proposed. The feature matching experiments of the three types of defects such as knots, dead knots, and holes in the veneer were carried out. The experiments verified that the algorithm had good rotation invariance and high efficiency when extracting veneer defect features.

1. Introduction
At present, wood-based panels have been widely used in various fields, of which plywood is the leading product in wood-based panels. As the raw material of plywood, veneer surface defects will reduce the quality of plywood products, so the defect detection of veneer becomes an important part of plywood processing. In recent years, machine vision and image processing techniques have been gradually applied in the detection of veneer defects, and finding a suitable algorithm is particularly important for integrating veneer defect detection systems. Aiming at the defects such as knots, dead knots, holes, etc., which appear in the veneer, this paper uses an improved SURF algorithm to extract the feature points of the veneer defect features, and verifies that the algorithm has a good extraction effect on the veneer defect features.

2. SURF algorithm
Feature extraction refers to the mathematical description of the physical properties and the transformation of the original data to obtain the features that best reflect the essence [1]. Due to the complexity and diversity of the surface defects of veneer, effective feature extraction is an important prerequisite for ensuring the accuracy of recognition classification. The selection of image feature extraction methods mainly considers the detection time and recognition rate during detection. Since the veneer will shift during the detection process, the rotation invariance of the feature extraction algorithm during the detection process will directly affect the recognition rate of the defect feature. Therefore, in this paper, the improved SURF algorithm is used to extract the characteristics of the veneer defects, and the characteristics of the detection time, rotation invariance and other characteristics are tested through experiments.

The traditional SURF (Speeded Up Robust Features) algorithm is an improved feature extraction algorithm proposed by Herbet Bay et al. This algorithm is a robust local feature detection algorithm [2-3]. The algorithm has the advantages of stable characteristics, unchanged scale, brightness, and a certain
degree of stability to viewing angle and noise. The SURF algorithm mainly includes: constructing Hessian matrix, constructing scale space, feature point positioning, feature point main direction positioning, feature point main direction allocation, feature description factor generation and feature point matching.

2.1. Construct a Hessian matrix
First of all, in order to generate abrupt points (edge points) for image stabilization, it is necessary to construct a Hessian matrix (1). By using the Hessian matrix to determine whether the currently detected point is a key point, the key point is generally darker or brighter than other surrounding points, so when the Hessian matrix discriminant obtains a local maximum, the position of the point is the position of the key point [4].

\[
H(M, \sigma) = \begin{bmatrix}
L_x(M, \sigma) & L_y(M, \sigma) \\
L_y(M, \sigma) & L_y(M, \sigma)
\end{bmatrix}
\]

(1)

In order to improve the operation efficiency, the SURF algorithm uses a box filter to approximate the Gaussian second-order partial derivative. When this method is used to calculate the convolution, the amount of calculation is independent of the size of the filter, which can greatly improve the speed of the algorithm [5-6]. The Dxy, Dyy and Dxx can be obtained through the box filter, and the Hessian matrix can be simplified to:

\[
Det(H_{approx}) = D_{xy}D_{yy} - (0.9D_{xx})^2
\]

(2)

2.2. Construct scale space
The scale space of SURF is in the form of a Gaussian pyramid. The size of the image is the same between different groups, but the template size of the box filter of each group is different. The larger the number of groups, the larger the template size. The filters between different layers in the same group have the same size, but the blur coefficient gradually increases. The principle is shown in Fig 1:

![Fig 1. Building scale space](image)

2.3. Determination of feature points
The pixel points are compared with the 26 points in the scale space and the two-dimensional pixel space after Hessian matrix processing to determine the key points. Then, the stable feature points are finally determined by filtering out the erroneous positioning and weaker key points [7].

2.4. Positioning of feature points in the main direction
The 60-degree sector is rotated at intervals of 0.2 radians to scan the sum of the vertical and horizontal haar wavelet features of all points in the sector, and finally the direction with the largest sum is taken as the main direction of the feature points.
2.5. Feature description factor generation

Along the main direction of the feature point, a 4×4 rectangular area block is taken around the feature point, and the haar wavelet features of 25 pixels in each sub-area are counted. Sum of horizontal values ($\sum dx$), sum of absolute values in horizontal directions ($\sum |dx|$), sum of vertical directions ($\sum dy$), sum of absolute values in vertical directions ($\sum |dy|$). The principle is shown in Fig 2:

![Fig 2. Schematic diagram of SURF feature descriptor](image)

2.6. Feature point matching

Finally, the matching degree is determined by calculating the Euclidean distance between two feature points. The shorter the Euclidean distance, the better the matching degree of the two feature points [8].

3. Improved SURF algorithm

The traditional SURF algorithm describes the feature points in the local area of the detected object during the detection, and does not consider the number of detected feature points. When using the traditional SURF algorithm to detect the veneer image with rich texture, it will a large number of densely distributed feature points were detected. Due to the large number of feature points, the time for extraction and matching is also increased, which reduces the real-time requirements of this article, and the process of matching a large number of feature points also generates too many mismatch points, resulting in accurate matching of the overall algorithm the rate decreased [9]. In order to adapt to the detection of veneer images and achieve the purpose of improving the matching accuracy and matching speed, this paper improves the traditional SURF algorithm by reducing the number of feature points.

The improved SURF algorithm (ISURF) is implemented as follows:

This article reduces the number of feature points by screening out some feature points. In order to avoid the insignificant features caused by the features being screened out, the improved SURF algorithm performs screening by way of Figure 3, to ensure that the difference in the number of feature points around the screening point does not fluctuate sharply. To filter out feature points, you must first set the required image feature point threshold M, the radius R of the feature point Pi and the distance D between the feature points Pi, D is determined by the number of feature points in the image, the more feature points, the more D small. Calculate the number of feature points Q in the image through the Hessian matrix. If the number of feature points Q is greater than M, then determine a P0 feature point by random sampling, and find other P1–P4 feature points through the positional relationship, and traverse in turn Pi feature point set circle domain, all the feature points contained in it are screened out until it meets the requirement of less than or equal to the set feature point threshold. Otherwise, no such operation is performed. The improved algorithm can greatly speed up the screening of feature points, which indirectly improves the matching speed of the algorithm.
Through the above analysis, the feature extraction process of the improved algorithm is shown in Fig 4 below:

![Improved SURF algorithm feature extraction flowchart](image)

Fig 3. Schematic diagram of detection method

4. Experimental results and analysis

4.1. Rotation invariance test

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During the veneer detection process, the initial position of the veneer to be tested and the vibration generated by the operation of the device may cause the veneer to rotate sideways. When the veneer rotates sideways, the pixels in the veneer image also rotate accordingly, causing the original gradient size and direction of the veneer image to change. Therefore, the rotation invariance and extraction time of the feature extraction algorithm will affect the recognition rate and recognition speed of the entire recognition process [10].

Therefore, in this paper, the feature points of three types of veneer defects such as holes, dead knots and knots are extracted to check the rotation invariance and detection running time of the improved SURF algorithm. The experiment will rotate clockwise at a fixed angle and increase sequentially, setting seven sets of rotation angles and comparing the changes of the data obtained before and after the rotation. 20 image samples are taken for each type of defect, and the size of each image sample is 256×256. As shown in Fig 5:

![Fig 5. Experimental sample diagram](image)

Taking the dead node as an example, under the improved SURF algorithm, the schematic diagram of the surface defect feature point matching of the veneer non-rotation test sample is shown in Fig 6.

![Fig 6. Schematic diagram of matching feature points of veneer surface defects](image)

Table 1 and Fig 7 are the experimental data of the non-rotation experimental samples under the improved SURF algorithm.
Table 1. Improved SURF algorithm feature points correct matching number

| Defect Image group | Knots | Dead knots | Holes |
|--------------------|-------|------------|-------|
| Group1             | 98    | 148        | 66    |
| Group2             | 107   | 174        | 71    |
| Group3             | 94    | 144        | 67    |
| Group4             | 110   | 170        | 77    |
| Group5             | 96    | 140        | 63    |
| Group6             | 114   | 168        | 69    |
| Group7             | 90    | 145        | 65    |

Fig 7. Line graph of improved SURF algorithm matching number

It can be seen from Table 1 and Fig. 7 that under the condition of non-rotation experimental samples, the number of matching points of dead node defects is the most correct, and the volatility between different experimental groups is also the largest. The number of correct matching points of hole defects is the least, but the number of correct matching of each group is relatively stable.

Table 2 and Fig 8 are the experimental data of the rotating experimental samples under the improved SURF algorithm.

Table 2. Improved SURF algorithm feature points correct matching number

| Defect Image group | Knots  | Dead knots | Holes |
|--------------------|--------|------------|-------|
| Group1             | 123    | 230        | 90    |
| Group2             | 116    | 225        | 85    |
| Group3             | 122    | 227        | 87    |
| Group4             | 115    | 222        | 88    |
| Group5             | 118    | 230        | 91    |
| Group6             | 121    | 231        | 88    |
| Group7             | 120    | 230        | 91    |
It can be seen from Table 2 and Fig 8 that under the conditions of the rotation experiment sample, the number of correct matching points of the three types of veneer defects is more, and the difference between each group is small compared to the correct matching number, and the overall appearance is stable status.

It can be seen from the graph comparison between the above non-rotation experiment and the rotation experiment that the improved SURF algorithm has good rotation invariance and is more stable when detecting the feature points of rotating samples.

4.2. Run time comparison

In order to compare the difference between the traditional algorithm and the improved algorithm, verify the effectiveness of the improved algorithm and the speed in terms of time, refer to the experiment of the rotation angle above, use the rotation experiment sample to conduct the experiment, and count the running time of the two algorithms analysis. For the three types of veneer defect images identified and detected on the veneer surface, in order to reflect the universality of the detection algorithm, when evaluating the detection algorithm, it is expressed as the average running time. The average running time data is shown in Table 3.

| Algorithm      | Average running time (ms) |
|----------------|---------------------------|
| SURF           | 760                       |
| Improve SURF   | 643                       |

It can be seen from Table 3 that the improved SURF algorithm has a significant reduction in the average running time compared to the traditional SURF algorithm, which verifies the effectiveness and speed of the improved algorithm.

5. Conclusion

The selection of feature extraction algorithm is an important part of the veneer defect detection method. In this paper, when the traditional SURF algorithm performs feature extraction on veneer defects, the feature extraction time is long, and it will be affected by the rotation of the veneer defects. Through the experiment, the algorithm was used to extract the feature points of the three types of defects such as
knots, dead knots and holes in the veneer defects under the condition of defect rotation and non-rotation, and the extraction effect of the three types of defects in the SURF algorithm was improved through the analysis of experimental data. It is verified by experiments that the improved SURF algorithm has good rotation invariance and extraction speed for veneer defect feature extraction.

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