Automatic end-to-end veneer grading system based on machine vision

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Abstract. In order to realize automatic grading of veneers of different quality during the processing of veneer veneers, an end-to-end veneer automatic grading system based on YOLOV3 was designed. Using YOLOV3 network as the defect detection model, self-made veneer defect data set for model training. Firstly, the system obtains the veneer surface image; then the trained model detects the obtained veneer surface image, identifies scars and cavities in the surface defects, and marks the scars and cavities with rectangular boxes respectively; finally, the quality level of the veneer is determined according to the characteristic information of the detected scars and holes, and the level signal is transmitted to the PLC system to drive the grading actuator for grading. Experiments show that the end-to-end veneer automatic grading system based on machine vision can effectively carry out the automatic veneer grading, which is helpful to realize the intelligent and automated production of veneer processing and improve work efficiency.

1. Introduction
The veneer is a very large demand for wood products, and it is also an important raw material for plywood commonly used in production and life. During the growth of wood, scars and wormholes will appear under the influence of external forces. The veneer produced from this will also have scars and holes. The existence of scars and holes will not only affect the appearance of the wood but also affect the quality of its use. The correct and effective identification and detection of scars and holes will not only affect the normal use of veneer and even cause serious consequences. Therefore, the correct and efficient detection of surface defects of veneer is still an urgent problem to be solved. To solve this problem, we try to apply machine vision technology to realize the end-to-end automatic grading of veneers. Machine vision technology has been applied in the fields of surface damage detection, object recognition and target tracking. However, there are few reports on the application of machine vision technology in the field of veneer processing. Zheng Liqiang et al. [1] designed a set of jewelry recognition systems based on machine vision to realize the automatic recognition of jewelry. By extracting the area feature and the distance feature from the image centroid to the edge, the area was judged to be within the set value range. Use the cross-correlation algorithm to process the distance feature. Hou Zhanlin et al. [2] proposed an algorithm with higher stability and less calculation for the detection of part shape defects. The width, thickness, dispersion, degree of deflection and other common shape features of parts were efficiently digitized, and the configuration process generated them. Comparing standard parameter values to complete part defect identification. Zhang Xu et al. [3] In order to solve the problem that the traditional machine vision algorithm has a low recognition rate and cannot accurately determine the surface defects in time, deep learning is used to detect aluminum...
surface defects, and the YOLOV3 algorithm is improved based on the YOLOV3 algorithm. The detection effect of very small defects on the surface. Mao Xinxiang et al. [4] built a continuous casting slab surface defect detection system based on deep learning and built a continuous casting slab surface defect detection calculation platform based on the YOLOV3 model. The gRPC framework is used to realize the end of image acquisition, image processing, and detection result storage. The end-to-end model makes the whole detection system very portable and real-time. Chen Hongcai et al. [5] proposed a defect detection method for medical glass bottles based on YOLOv3 to detect the appearance defects of medical glass bottles. Fang Liangrui et al. [6] designed a chain grate locomotive wheel fault detection system based on the YOLOv3 model to solve the problem of difficult wheel fault detection. This paper designs an end-to-end veneer automatic grading system based on machine vision. First, the YOLOV3[7] model is used to detect the surface defects of veneer veneers and mark them with target frames; then the number, area, perimeter, and pairs of target frames with different defects are extracted. The effective physical characteristic parameters such as corner lines are used to classify the veneer quality according to these characteristic parameters; finally, the Programmable Logic Controller (PLC) drives the grading actuator to sort the veneer according to the quality level information of the veneer to complete the classification.

2. Automatic veneer grading system
Compared with the traditional manual grading method and photoelectric detection grading method used in veneer processing factories, the automatic veneer grading method based on machine vision can improve production efficiency, save human resources and reduce production costs. The overall structure of the veneer automatic grading system is shown in figure 1. The system is composed of a conveying mechanism (6), a visual processing system (4), a grading actuator (1, 2, 3) and other parts.

![Figure 1. Plane structure of veneer automatic grading system.](image)

The working principle of the veneer automatic grading system is: veneer is transported to the image collection area by the conveyor belt, the photoelectric sensor triggers the camera in the vision processing system to collect the veneer surface image; the vision processing system processes the veneer surface image, Detect surface defects and extract effective feature information to determine the quality level of veneer; transmit the quality level information to the grading mechanism to drive the grading execution device to sort the veneer to the material box of the corresponding level to complete the quality of the veneer Grading.

3. Surface defect detection of veneer
The detection of surface defects of veneers an important part of the quality classification of veneers. This link includes the production of the veneer surface defect data set, the construction of the defect detection model, and the defect detection.
3.1. veneer data set

The surface defects of the veneer are mainly scars and holes produced during the growth of the wood, as shown in figure 2. Most of the deep learning frameworks use the VOC format data set, so we used the labelImg image annotation tool to create a VOC format veneer surface defect data set, marked the scars and cavities in the picture, and generated the corresponding containing annotations. Annotation file of frame type, size, and location information. The data set produced is shown in figure 3. The veneer surface defect dataset has a total of 939 images, including 1797 scar defects and 1320 void defects. In order to prevent over-fitting during model training and improve the generalization ability and robustness of the trained model, this data set adopts methods such as twisting, mirroring, deformation, and random cropping to expand the data set.

3.2. Building a defect detection model

YOLOv3 is one of the best target detection algorithms at present, and its application range is also relatively wide. YOLOv3 has been continuously improved on the basis of the YOLO (You Only Look Once) [8] algorithm. It adopts a more powerful backbone neural network architecture—Darknet-53 as the main network for image feature extraction. It uses the pyramid feature map idea to introduce multi-scale feature map detection to improve the detection capability of scale targets takes into account both faster detection speed and higher detection accuracy. As a one-stage algorithm, unlike the Two-stage algorithm that first generates a series of candidate frames and then classifies samples through a convolutional neural network, the YOLO network converts object detection into a regression problem, divides the input image into NXN grids, and thenDetect the bounding box (x, y: bounding box coordinates, w, h: height and width of the bounding box) and category probability (score) of each grid. The YOLOv3 defect detection model uses three scale feature maps of 13X13, 26X26, and 52X52 to detect objects of large, medium and small scales, which significantly improves the recognition rate of small targets.

Taking into account the economic requirements in the processing of veneer, the speed of the inspection process and the accuracy of the inspection results must be ensured. Therefore, we adopted the YOLOV3 algorithm as the defect detection model. Our defect detection target data set includes scars and voids. Therefore, we need to modify the YOLOV3 network structure to build a defect detection model suitable for veneer defect detection. We need to modify the filtering of the convolutional layer before the three YOLO prediction layers. The number of devices:

\[
\text{filters} = 3 \times (\text{classes} + (x, y, w, h, \text{score}))
\]  \hspace{1cm} (1)
The only types of defects detected are scars and holes, so the number of filters in the convolutional layer before the prediction layer is modified to 21.

3.3. Defect detection
Configure the defect detection model and import the data set for model training. After 1000 rounds of training, the LOSS drops below 0.1, and the verification set mAP reaches 99.7%. The trained defect detection model can quickly and accurately detect the surface defects of the veneer collected. The surface defects of the veneer were detected on the image and marked by the target frame of different colors, as shown in figure 4.

(a) (b) (c)

Figure 4. The detected scars and hole defects are marked with red and blue target boxes respectively.

4. Feature extraction and classification of veneer defects
In this link, the detected surface defects of veneers are extracted. Effective physical characteristic parameters such as the number and size of different defects will be used as screening conditions for veneer quality classification. At the same time, a set of mechanical devices are designed for automatic sorting.

4.1. Defect feature extraction
The surface defects of the veneer mainly include scars and cavities. Through the trained defect detection model, scars and cavities are marked with target frames of different colors. Use OpenCV to perform quantity statistics, area calculation, perimeter calculation, and diagonal calculation on target frames of different colors.

4.2. Classification algorithm
At present, there is no unified standard for dividing the quality of veneer in the wood processing field. We select the effective physical characteristic parameters of the scars and voids on the surface of the veneer, such as the number, area, perimeter, and diagonal of the target frame, as the grading standard. According to the quality requirements of the veneer, the effective physical characteristics of the extracted defects are determined. The parameter setting threshold is a grading standard for the veneer.

4.3. Hierarchical implementing agencies
After finishing the classification of veneer quality grades, a set of automatic grading actuators are needed for sorting. The grading actuators are composed of PLC, air cylinders, pushrods, photoelectric sensors, etc. After the visual processing system completes the quality classification of the veneer, the grade information will be transmitted to the PLC, and the PLC will transmit the control information to
the corresponding actuator. At the same time, the veneer will be sent down along with the conveying mechanism. When it reaches the corresponding material frame When the position, the photoelectric sensor is triggered and the PLC starts the corresponding cylinder push rod to push the veneer to the material frame, thus completing the veneer sorting.

5. Results & Discussion
The trained defect detection model selects the weights that perform well in the verification set and tests them on the test set containing 281 images. The accuracy is shown in table 1. The defect detection model has the ability to detect surface defects of the veneer. Deploying the trained model on the manufactured small-scale test equipment also achieves a good automatic sorting effect.

| epoch | Scar accuracy | Hole accuracy | mAP (Mean Average Precision) |
|-------|----------------|---------------|-----------------------------|
| 857   | 0.6604         | 0.9414        | 0.8009                      |
| 906   | 0.6986         | 0.8145        | 0.7565                      |
| 967   | 0.7399         | 0.8036        | 0.7717                      |
| 1000  | 0.7136         | 0.8468        | 0.7802                      |

Analyzing the experimental results, it is found that the model's detection effect on holes is better than that of scars. The reason is that the scar features are not obvious and the identification is difficult. Later, the detection model will be improved to improve the ability to detect scars.

Due to the small number of sample data sets, over-fitting is prone to occur during training, and it also affects the generalization ability. In the future, more data sets will be produced and optimized and divided to solve this problem.

6. Conclusions
The end-to-end veneer automatic grading system based on machine vision has been tested. YOLOV3 can accurately and quickly detect the surface defects of the veneer. The grading actuator can effectively sort veneer according to the classification information to complete the classification. The system can meet the requirements of production and use in terms of detection accuracy and operating speed. The entire system realizes fully automated production, and can efficiently and accurately complete the automatic classification of veneer veneers of different quality levels. In the future, the successful application of this system will greatly reduce the production cost of veneers, reduce labor input, increase production efficiency, and improve the quality of veneers used.

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