Research and Implementation of Transformer Label Detection Algorithm Based on Machine Vision

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Abstract. In order to solve the problem of low efficiency and high false detection rate of transformer label detection in the process of factory production, an algorithm of transformer label detection based on machine vision is proposed in combination with OpenCV function library. In the pre-processing stage, the image noise is filtered and the vertical edge information is highlighted, then the label region is located by morphological processing and contour extraction, and the label image is screened by SVM classifier. Finally, the label character is divided into a single contour and recognized by artificial neural network. The experimental results show that the accuracy of the algorithm is 94.0%, and the average time is 0.334s, which meets the requirements of the factory production line.

1. Introduction
With the rapid development of science and technology and the advancement of factory automation process, assembly line automatic manufacturing electronic equipment has become a conventional production mode. In the circuit design and manufacturing industry, transformer is one of the core components, which plays an important role in the whole circuit system. In the actual production environment, due to machine or human error, the label of transformer may be missed, wrongly pasted or damaged, which leads to errors of technicians when using these transformers, and may have serious consequences in the circuit equipment. Therefore, these defective products need to be returned to the factory and repasted to avoid entering the market [1].

At present, in the factory, transformer labels are tested by human eyes. This method is not only workload, large speed, but also slow. Because the technical quality and experience of the inspectors are different, it will be different for different people to judge whether the transformer labels are wrong. It is easy to see the phenomenon of false detection, and the rate of false detection will rise under fatigue.

In recent years, with the rapid development of computer technology, people have higher and higher requirements for computer hardware, and the corresponding computer processing speed is also faster and faster. At the same time, image processing technology has also been greatly developed. The transformer label detection technology based on machine vision has the advantages of high automation, high detection rate, and low false detection rate [2]. Therefore, it is of great significance to use machine vision technology to detect the label of the transformer produced by the factory assembly line, which can liberate the workers from the repetitive, complicated and subjective identification work. Through machine vision technology, the captured transformer pictures are preprocessed, contour
extraction and screening, character segmentation and recognition, and finally the purpose of detecting whether the labels are correct is achieved, which avoids the influence of human subjective factors, improves recognition speed and reduces detection error [3].

2. Detecting system design

2.1. Detection Algorithm Framework

The algorithm framework of the transformer label detection system is divided into three modules. The first is the preprocessing module, which mainly performs gray-scale transformation on the captured transformer image, smoothes the noise and filters the image. The edge detection highlights the vertical corner feature, and the threshold segmentation is converted into binary operation[4,5]; the second is the label positioning module, which mainly performs morphological processing on the preprocessed image to label The region is transformed into a connected region, and all the pictures that may be labels are extracted by drawing an external rectangle through contour extraction [6,7].Finally, the images of label region are obtained by SVM training and classification [8]; the third is the label recognition module, which extracts the contour of each character in the label region, and then uses the artificial neural network training to recognize each character, and finally achieves the label Purpose of identification[9,10].The flow chart of tag detection algorithm is shown in Figure 1.

![Detection Algorithm Framework](image-url)

Figure 1. Detection algorithm framework.
2.2. MFC Display Interface
Through the MFC of Visual Studio, a host computer is designed to detect the transformer label, and the designed algorithm of transformer label detection is simulated and verified [11]. MFC display interface is shown in Figure 2.

![MFC display interface](image)

**Figure 2.** MFC display interface.

3. Implementation of label detection algorithm

3.1. Preprocessing module

3.1.1. Smooth denoising.
Because of the interference between the imaging equipment and the external environment noise, there are many noise points in the image collected by the camera. These noises cause a lot of interference to the subsequent image processing process, which increases the difficulty of label detection. Therefore, in the pre-processing stage, smooth denoising is required. The Gauss filter algorithm is used here. It is a linear filter, which weights and averages the pixel values of the whole image. For each pixel value, it is weighted and averaged by its own value and other pixel values in the neighborhood to achieve the goal of denoising.

![Gauss filtering](image)

**Figure 3.** Gauss filtering.

3.1.2. Edge detection.
Sobel operator is a kind of discrete difference operator, which is used to calculate the approximate value of the gradient of image brightness function, mainly used for image
edge detection. There are two Sobel operators, one is used to detect the horizontal edge; the other is used to detect the vertical edge, which can detect the vertical edge of the image by weighting the gray value of each pixel in the upper, lower, left and right four fields, and reach the extreme value at the edge, so that the label area can be distinguished from other areas to locate the transformer label position.

![Figure 4. Sobel operator edge detection.](image)

3.1.3. Thresholding. Threshold segmentation is to select an appropriate threshold, set the pixel larger than this threshold to 1, and the pixel smaller than this threshold to 0, and then segment the original gray image containing 0-255 pixels into a binary image containing only 0 and 1 pixels. In this paper, Otsu algorithm is used, which divides the image into two parts: background and target according to the gray characteristics of the image. The gray image is divided into two parts: foreground and background. The smaller the intra class variance of these two parts, the clearer the foreground and background separation image is finally obtained.

![Figure 5. Thresholding.](image)

3.2. Label location module

3.2.1. Morphological processing. Morphological operation is a series of image processing operations based on image shape. Its basic operations include corrosion, expansion, closed operation and open operation. The closed operation is to expand first and then to corrode. The expansion can enlarge the bright area and reduce the dark area of the image, while the corrosion effect is completely opposite. Closed operation can connect many adjacent blocks as a connected region without protrusion. Through the closed operation, the label character region of the image can be connected into a connected contour, which is convenient for subsequent contour extraction.
3.2.2. Label contour extraction. The periphery of the connected region of the image is drawn to form an external rectangle to extract the outline of the transformer label. The size of transformer label is 2.3cm *0.6cm, and the aspect ratio is 3.83, so a maximum aspect ratio $E_{\text{max}}$ of 4.00 and a minimum aspect ratio $E_{\text{min}}$ of 3.28 are set. If the aspect ratio of extracted label contour is calculated between these two deviation rates, it will be retained, otherwise it will be discarded. Then according to the deflection angle of the contour, the deflection angle is kept within plus or minus 30 degrees, otherwise it will be discarded. At last, the remaining contours are transformed by affine transformation to adjust the deflection angle, and the size is adjusted to ensure that the size of each contour map is consistent, which is convenient for subsequent SVM model training.

3.2.3. SVM classification. After the above operations, some images including the label area and not including the label area will be extracted, these images will be normalized and labeled for classification, and all images with transformer label will be put into one folder, and images without transformer label will be put into another folder. A part of the pictures are used for SVM model training, the rest are used for result testing, and finally the trained SVM model is used for label classification.

3.3. Label recognition module

3.3.1. Character contour extraction. After the label positioning operation, extract the outline of the extracted label image, extract the edge outline of each character in the label and draw an external rectangle, then cut out all the external rectangles, normalize them to the same format, and then submit them to the character recognition module for processing.
3.3.2. **ANN Character Recognition.** The extracted character contour is recognized by artificial neural network. Put each English character and digital character into a separate folder, use part of the character outline for ANN model training, the rest for result testing, and finally use the trained ANN model to recognize the character of the label image to be tested.

**Figure 10.** Label recognition.

4. **Test results**

In order to verify the accuracy of the transformer label detection algorithm, 50 samples with label models of EER2834, EER3541 and EER4045 are used to detect the label through the above algorithm. The experimental results show that the accuracy of the algorithm is 94.0%, and average time is 0.334s. The processing efficiency and accuracy are higher than the level of manual detection, which meet the actual factory requirements.

**Table 1.** Transformer label test result.

| label model | Sample size | False count | Accuracy rate | Total time | Average time |
|-------------|-------------|-------------|---------------|------------|--------------|
| EER2834     | 50          | 3           | 94.00%        | 17.3s      | 0.346s       |
| EER3541     | 50          | 2           | 96.00%        | 16.2s      | 0.324s       |
| EER4045     | 50          | 4           | 92.00%        | 16.6s      | 0.332s       |

5. **Conclusion**

In this paper, a new algorithm of transformer label detection based on machine vision is proposed to solve the problem of large workload, low speed and high error detection rate of manually removing defective transformer with wrong label in the actual factory production process. In the pre-processing module, Gaussian filter can filter a lot of useless interference information, and Sobel operator plays an important role in locating the area of the label through vertical edge detection. In the tag location module, combined with the actual length and width of the tag and SVM classification, the contour of the tag area is filtered out, and the tag area is accurately located. Finally, a lot of training is carried out through artificial neural network to achieve the purpose of identifying tag characters. Through the simulation and verification of the upper computer designed by MFC, after a large number of sample tests, the accuracy of the algorithm reaches 94.0%, and average time is 0.334s, which meets the actual production needs, and OpenCV also has good portability, which can be moved to the hardware embedded system in the future, simplifying the hardware circuit.

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