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Overview of Connector Defect Detection Technology

Ning Peng[1], Hong Song[2], Wei Pu[1] and Jian Fei[1]

[1]Sichuan University of Science & Engineering, Sichuan 644005, China;

[2]Aba Teachers University, Sichuan 623002, China.

Abstract

At present, the defect detection of connectors mainly adopts the combination of machine vision and image processing to eliminate those defective connectors, so as to improve the quality of connectors. Firstly, this paper briefly introduces the working process and system design of visual detection. Secondly, the image is processed by using image preprocessing, image filtering, image enhancement and image segmentation in image processing to obtain the edge of the image. Thirdly, different algorithms in machine learning are used to extract the feature points in different connector images, Finally, the future of connector defect technology is prospected.

Keywords

Machine Vision; Connector Inspection; Image Processing; Machine Learning.

1. Introduction

In recent years, with the rapid development of machine vision technology, image processing, machine learning and other technologies, the defect detection of connector has developed towards miniaturization of volume and overall size, complexity of shape and high precision, which puts forward higher requirements for the quality of connector [1]. Connector is a high-precision electronic device, and contact resistance is called a common index to detect its quality standard [2]. The contact resistance of the stable connector is about tens of ohms. Because the connector manufacturing belongs to the traditional assembly line manufacturing, the manufactured connector often has appearance defects, such as deformation, scratch, crush and so on. These defects will affect the contact resistance of the connector, affect the electrical signal of the contact resistance and damage the overall quality of the connector. Therefore, the quality inspection of the connector is called an essential part [3].

The process of producing connectors can be roughly divided into four parts: stamping, electroplating, material plastic and assembly. In the production process, it is easy to be affected by flying debris and other external factors, so the detection of connector is particularly important. The method based on the combination of machine vision technology and machine learning can realize the effective detection of connectors, so as to ensure the production of high-quality connectors.

2. Machine Vision Inspection System

The main methods of connector defect detection are machine vision and image processing, which are composed of lighting, image acquisition, material conveying control, image detection software and so on. When the system starts running, the detected object starts to move forward driven by the motor. Every time the motor is dragged, a complete connector will completely enter the acquisition field of view of the camera. Whenever the motor stops for a short time, the detection system will carry out image acquisition and image processing on the connector and finally get the corresponding results. When the test result is qualified, the connector will continue to run forward. If the test result is

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unqualified, the test system will light a red light to indicate that the connector quality is unqualified. Take it out before continuing to work.

Machine vision is an isolated and non-destructive automatic testing system. It is a powerful means to realize automatic production, intelligent operation and fine control of equipment [4]. In the process of machine detection, the detected object and the detector are separated, which not only ensures the safety of the detector, but also ensures that the selected object is not affected by the outside world. More importantly, the machine detection has better stability, sensitivity and will not be affected by external factors to reduce the accuracy, so it can be used in the detection of connectors to complete the task of on-line detection.

3. Image Processing

The image acquired by machine vision system needs to be processed before feature extraction. Image processing consists of image preprocessing, image filtering, image enhancement, image segmentation and region processing, as shown in Fig 1.

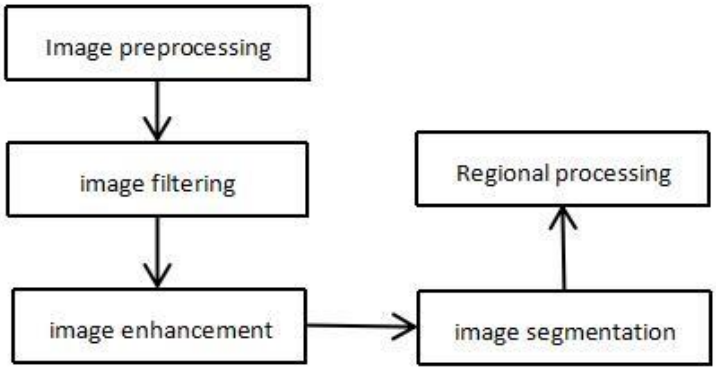

Fig.1 Image processing process

3.1 Image Preprocessing

In order to extract and enhance the information of the image, reference [5] proposed an image preprocessing method, which centers on any pixel in the image and surrounds its field, so as to establish a small field in which a new image is output to obtain the pixel gray value. Image preprocessing can improve the collected pictures, which is conducive to the later operation of image processing. The better the effect of image preprocessing is, the more conducive it is to the subsequent feature data extraction and feature engineering analysis, reduce the amount of computation of machine learning algorithm, reduce the overhead of CPU memory, and faster operation and processing speed [6]. In the external environment, the image is easy to be affected, and noise is one of them. It is an important factor causing the influence of the image. Once the picture is affected by noise, the characteristics of the picture may not be highlighted, so that the experimental results will be greatly affected. Among them, the commonly used image preprocessing algorithms include image filtering, image sharpening, image binarization, geometric transformation, edge extraction and morphological processing [7].

3.2 Image Filtering

Image filtering can be divided into two processing methods: spatial domain and frequency domain. It takes advantage of the redundancy of image data and the fact that the gray value of noise is obviously different from the pixel value in the field, so as to achieve efficient denoising results. In the process of image filtering, the better the effect of image filtering, the more convenient the later eigenvalue extraction will be, and the more accurate the result of image defect detection will be. Image filtering methods include mean filtering, Gaussian filtering and median filtering.

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3.2.1 Mean Filtering

Mean filter is a low-pass filter. Its basic principle is to scan the pixels with the size of (M and N are odd) in the image and form a new template together with its adjacent pixels. The expression is shown in formula 1:

$$\overline{g}(x,y) = \sum_{(x,y)\in S} f(x,y) \tag{1}$$

3.2.2 Gaussian Filter

Gaussian filter is a method to suppress noise. Its principle is to perform sliding window convolution on each pixel of the original image. Like mean filtering, its template is in the form of odd number multiplied by odd number. The expression is shown in formula 2:

$$G(x,y) = \frac{1}{2\pi\sigma} exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \tag{2}$$

3.2.3 Median Filter

Median filter is a nonlinear filter, which is a filtering method based on ranking statistical theory to reduce edge blur. It uses a moving window with an odd number of points and replaces the value of the center point of the window with the average of the sum of other points. The process is shown in Figure 2, and the expression is shown in formula 3:

$$g(x,y) = \underset{(x,y)\in S}{median}\{f(x,y)\} \tag{3}$$

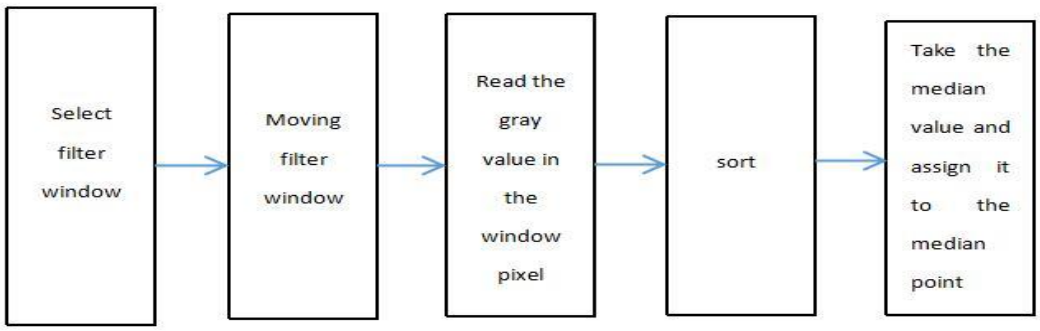

Fig. 2 Flow chart of median filtering

At present, the three filtering methods have no big deviation in the results of image processing, but in order to select a better method, it is necessary to introduce the peak signal ratio of the image, which can well compare the effects before and after processing the image. Under the comparison of multiple experiments, it can be concluded that the peak signal ratio of median filter is the largest, so median filter is a better method.

3.3 Image Enhancement

After the electrical connector shell of the detected object is processed by image filtering, the image noise is improved, but after filtering, the edge detail features and surface detail features of the detected object become more or less blurred. For subsequent image analysis, segmentation and recognition, it is necessary to improve the image information of the detected object and enhance the edge detail in the image [8]. Only the feature region of the image to be recognized is strengthened, so it is easy to distinguish the feature region from the background region and improve the contrast between them. There are two common image enhancement methods: spatial domain enhancement and histogram equalization.

3.3.1 Spatial Domain Enhancement Method

The most common methods in spatial domain enhancement method are linear change, logarithmic change and power-law change. The contrast and brightness of the image can be significantly improved by linear transformation. The expression is shown in equation 4:

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$$g(x,y) = a * f(x,y) + b \tag{4}$$

Coefficient a is used to adjust the contrast of the image. The value range of common coefficient a is 0.0 ~ 3.0, and coefficient B is offset to adjust the brightness.

Logarithmic variation is often used to simplify formula derivation and simple operation. It can simplify complex mathematical formulas, convert addition operation into multiplication operation, extract common factors and facilitate calculation. In image processing, logarithmic change can map low gray value to high gray value and narrow band to wide band, so as to compress the dynamic range between the maximum and minimum values of pixels to a certain extent, make the pixel difference uniform, make the image more perfect and highlight the feature factors. The expression is shown in 5:

$$g(x,y) = c * log(f(x,y) + 1) \tag{5}$$

Power variation is the form of exponential function, also known as γ Transformation. It uses nonlinear transformation to correct too bright or too dark images. When γ< 1, the low gray area of the image will be stretched and the high gray area will be compressed; When γ> 1, on the contrary. The mathematical expression is shown in equation 6:

$$g(x,y) = c * [f(x,y)]^{\gamma} \tag{6}$$

3.3.2 Histogram Equalization

Histogram equalization histogram equalization algorithm is highly representative in image enhancement [9]. Histogram can summarize the general statistical law and information of pixels, so that the image can be preliminarily displayed digitally. People can roughly see the distribution of pixel gray value, distribution frequency, brightness and contrast of the image through the histogram, which helps to select the gray threshold for later image segmentation, and is also the basis for image edge extraction and detail enhancement [10]. Whenever an image is given, the result of its corresponding histogram equalization processing is determined. The probability of gray level is:

$$P_r(r_k) = \frac{n_k}{n} = 1,2,\ldots\ldots,L-1 \tag{7}$$

Compared with spatial domain enhancement method, histogram equalization plays a greater role in image processing and subsequent algorithm detection, so histogram equalization method is more used in image enhancement.

3.4 Image Segmentation

After image enhancement, it is necessary to separate the target region from the background region, which requires the use of image segmentation technology, and the commonly used image segmentation method is binary segmentation. Image binarization is an important content of digital image processing and an indispensable means to extract target information from images [11] [12]. Each picture usually has a gray level. After binarization, there are only two gray levels, 0 and 255 respectively. We can set a threshold T through the result of histogram equalization. If the pixel value of the image is $f(x,y) > T$, the gray value of the image is assigned as 255 and the pixel is white; If the pixel value is $f(x,y) < T$, the gray value of the image is assigned as 0, and the pixel is a black pixel. The expression is shown in equation 8:

$$g(x,y) = \begin{cases} 1, f(x,y) > T \\ 0. f(x,y) < T \end{cases} \tag{8}$$

3.5 Regional Processing

Region processing is to further process all possible defect regions obtained by image segmentation, so as to obtain the exact image of the defect region, so as to facilitate the extraction of the characteristics of each defect [13].

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4. Machine Learning Algorithm Detection

At present, there are many different algorithms for connector surface defect detection. In reference [1], for the electronic plug-in provided by the manufacturer, firstly, the edge detection and Hough transform are used to obtain the parameters of the positioning hole, and the fisheye detection algorithm is used to detect the size and number of Fisheyes, and then the edge algorithm is used to measure the length, width, inclination and spacing of pins, Finally, morphology and subtraction method are used to detect the surface defects of the connector. Literature [3] uses edge detection algorithm and double threshold blob extraction algorithm to detect 9pin connector. Literature [6] uses Canny edge algorithm to extract the boundary of the connector, and uses improved local signal-to-noise ratio algorithm and SVM algorithm to detect the defects on the surface of the connector. Literature [13] used various algorithms in Halcon platform to study the surface defects of electrical connectors. Literature [14] uses k-means algorithm and improved Yolo V3 algorithm to detect surface defects of electrical connectors. Reference [15] uses Hoff circle detection algorithm, edge detection algorithm and sparse LS-SVM defect classification judgment to detect electrical connectors. It can be seen that edge detection algorithm has been widely used in connector defect detection. The edge detection algorithm can draw the general outline of the image and separate the detected object from the background, and it can meet the requirements of accurate edge location and noise suppression, which can not be met by other algorithms. The purpose of using different algorithms is to obtain more accurate detection results when studying connector defect detection, so as to obtain better quality connectors.

5. Research and Prospect

Different algorithms can be used to detect different types of connectors. This paper detects the defects of connectors based on machine vision, image processing and machine learning algorithms, which can detect the quality of connectors efficiently and quickly, but there are still some deficiencies: for example, the classification ability still needs to be improved, and it is still unable to realize the detection within the completely unmanned monitoring range, Spending too much time on image detection and so on are the areas that need to be improved in connector defect detection in the future. Here are some suggestions:

(1) A variety of algorithms are combined with the third-party software platform to detect the defects of the connector, and strive to obtain an approximate detection rate of 100%.

(2) Strive for one or more algorithms to play a role in the defect detection of different connectors at the same time, so as to avoid that different types of connectors need different algorithms for research.

(3) Because image processing needs to process too many images, so it takes too much time, resulting in too slow detection speed, so it is also necessary to study algorithms to improve the detection speed.

The defect detection of connector defect detection in China has just begun. I believe that with the passage of time, the accuracy and efficiency of connector defect detection will be higher and higher.

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