Target Detection and Correction of Micro-motor Rotor Based on HALCON

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Abstract. In order to realize the high-speed and accurate inspection and correction of the micro-motor rotor during its soldering process, an identification and measurement system based on HALCON was designed. It realizes such functions as collecting, identifying and filtering images, analyzing target deviations and correcting them. Firstly, the industrial camera is used to obtain the target image. Then the image is preprocessed, after NCC template matching, ROI extraction and feature segmentation, the accurate target features are obtained. Finally, the center coordinates of the feature area are obtained to calculate the feature position deviation, and then the upper computer controls device to correct the deviation. The results show that the system can replace the manual detection to complete features recognition and correction of the target rotor and it also improves its efficiency and accuracy of the recognition and correction, providing a new method for the recognition and correction of motors in actual production.

1. Introduce

In the actual production of miniature vibration motor, each process is carried out by manual detection. It should be noted that before the spot soldering process, it is impossible to determine whether the winding copper wire is on the solder pad of PCB, and the copper wire section is required to be in the center of the solder pad as far as possible. This kind of traditional position detection is judged by the eyes of the industrial magnifying glass, and the copper wire deviated from the position is calibrated by hand. This method has low detection efficiency and low qualification rate, and the workers are easy to get tired and it has great damage to the eyes.

In this paper, an automatic detection and correction system based on HALCON image recognition software is designed to reduce labor cost[1], shorten working hours and improve product quality. The measurement software of this system is developed by C++ programming tool[2], and HALCON machine vision algorithm is used to realize the main algorithms of image acquisition, recognition and position error detection of copper wire winding on rotor PCB board welding pad.

2. Target detection method

2.1 Mean filtering

In order to reduce the interference of the image in the complex acquisition environment and achieve an easier detection process[3], the image needs to be preprocessed before image processing. As the measured target of the system is the metal surface, the foreground of the original RGB image directly collected by the camera is blurred in contrast with the background. The contrast of the image is firstly
enhanced, and convert the RGB image to grayscale image. The three channels of RGB image are transferred as the first three channels of the input image, which can effectively retain the sharpness of the image before conversion and obtain the desired black and white image. Convert the image according to the following formula:

\[ f = aR + bG + cB \]  

Where \( a=0.299 \), \( b=0.587 \) and \( c=0.114 \) are preset parameters to ensure that the converted image is not distorted.

After preprocessing, the image smoothing method is adopted to denoise the image[4]. The noise of feature image is suppressed under the condition of preserving edge feature. Then the average value of the image is filtered, that is, the value of each pixel of the image is averaged to replace the value of each pixel in the original image. Let the pixel points \((x, y)\) and \(g(x, y)\) be all the processed pixel points as follows:

\[ g(x, y) = \frac{1}{m} \sum_{n=1}^{m} f(x, y) \]  

Where \( m \) is the total number of pixels contained in the image, and \( n \) is the initial number of pixels. The average filter operator is used to diffuse the dark color after the image is blurred, and the gray level is reduced.

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2.2 Template matching

The gray distribution in the pre-processed image is complex, the foreground and background of the image cannot be simply segmented, and some global threshold segmentation methods cannot effectively extract ROI region[5]. Because the ROI region is important for image recognition, it can significantly reduce the number of pending pixels and unnecessary noise impacts. Therefore, this system adopts the segmentation of multiple sub-regions, and the template matching calculation directly carries out the gray binarization, expansion connected domain and edge feature extraction of the ROI region.

The workpiece mold is made of metal, so it is difficult to avoid the influence of light exposure in the process of obtaining the image. Therefore, it is a common image processing method to use the normalized correlation algorithm to compare the similarity of two images in the pre-stored template image[6]. The final result of NCC is between 0 and 1, so it is easy to quantify and compare the results.
As long as you give a threshold, you can judge whether the result is good or bad. The calculation formula is as follows:

$$ncc(x, y) = \frac{\sum \sum f(x+i,y+j) r(x+i,y+j) - mn\mu_f\mu_r}{\left(\left[\sum\sum f^2(x+i,y+j) - mn\mu^2_f\right]\left[\sum\sum r^2(x+i,y+j) - mn\mu^2_r\right]\right)}$$

(3)

$m$, $n$ represents the vertical and horizontal size of the window, so the computational complexity is $O(mxnxMxN)$, all pixels $(x, y) \in M \times N$. Where $\mu_f, \mu_r$ represents the mean value of the window of the image to be detected and the image of the reference template:

$$\mu_f(x, y) = \frac{1}{mn} \sum \sum f(x+i,y+j)$$

(4)

$$\mu_r = \frac{1}{mn} \sum \sum f(i,j)$$

(5)

The image generates the template before the template matching[7]. Generating the template takes two steps, the first is to delineate the area, the second is to split the area. The object to be tested is the copper wire in the plate, so the area is demarcated in the plate. Firstly, a rectangle parallel to the coordinate axis is created. Since the relative coordinates of the delimited area can be uniquely determined, the delimited area is obtained by inputting a fixed parameter into the operator. The delimited area is just a rectangle drawn, it is not really created yet and cannot be used. The delimited area is then generated to the ROI region.

After the ROI region is obtained, the operator is called to generate the template, and the subsequent detection can conduct global search according to the template to obtain all the regions that need to be detected. After the matching operator is invoked, the matching results are shown in figure 5.

3. Feature extraction

The key of feature extraction is to divide the threshold range[8]. The system uses a method similar to one-dimensional average to find the binarization threshold. After the image is transformed into grayscale, the difference of feature grayscale distribution is enlarged, so the lower the grayscale value is, the closer it is to the real feature. Therefore, it is necessary to determine the threshold of the boundary between the feature object and the background area. Firstly, an initial threshold can be set, which can be generated randomly by the system or intuitively obtained by using HALCON gray histogram. The steps are as follows:

- Set the pixels less than the dividing threshold $T$ as the feature data $G_1$, and the pixels greater than the dividing threshold as the background data $G_2$;
- The arithmetic mean value was calculated for the two groups of data respectively, the feature pixel mean value $M_1$ and the background pixel mean value $M_2$ are obtained;
- Calculate the new threshold value $T'=(M_1+M_2)/2$;
Repeat steps 1, 2 and 3 with the newly obtained threshold until the new threshold is calculated to be equal to the previous threshold.

Call operator for global threshold segmentation, input the calculated threshold parameter, and filter out the pixel set falling in the threshold set, as shown in the figure.

4. Conclusion
This system designs a set of machine vision based on micro-motor rotor detection and correction system. The system can automatically collect the target image and quickly screen out the defective workpiece. It can also, through the transplantation and development of the upper computer, analyze the target position deviation and correct the deviation. The defect rate of the system after detection and correction is 2% lower than that of the traditional manual method, and the working hours are obviously lower than that of manual work under the same workload. From the design requirements and objectives, the system can meet the production needs.

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