Assembling Defect Detection of Atomizer Based on Machine Vision

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***Abstract* - The atomizer is assembled in an automated assembly line, which inevitably creates assembly defects. In this paper, we use machine vision technology to detect assembly defects in atomizer.** **We propose two algorithms: image processing algorithm and deep learning algorithm based on convolutional neural network. For the image processing algorithm, we set the ROI for detection according to the position of different assembly defects, and design the corresponding image processing detection algorithm. For the deep learning algorithm, we adopted the MobileNet model and proposed a new training program to improve the accuracy of the detection. At the end of this paper, we evaluate the performance of the two algorithms, analyze and compare the advantages and disadvantages of the two algorithms.**

***Index Terms - Atomizer; Assembly defect detection; Machine vision; CNN***

I. Introduction

In industrial automation production, in order to ensure the quality of the product, it is necessary to perform defect detection on the product to eliminate defective products. In practical applications, machine vision is often used for defect detection, which increases the automation of production and reduces labor costs. At present, there are two types of algorithms for machine vision, one is digital image processing algorithm, and the other is deep learning algorithm based on convolutional neural network.

Jiancheng [1] uses the distance measurement method to measure the position of the part to detect whether the syringe is assembled correctly. Jing et al. [2] used the modified Hausdorff distance matching algorithm to detect the position of the part. Ardhy et al. [3] preprocessed the image using an adaptive Gaussian threshold method, and then performed a differential operation on the standard image and the image to be detected to detect whether the PCB board is defective.

In recent years, deep learning technology has made remarkable achievements in the field of image recognition. Image recognition algorithms based on convolutional neural networks have been successfully applied in many fields. In the field of industrial defect detection, some scholars have also begun to use convolutional neural networks for defect detection and classification.

Je-Kang Park et al. designed a simple CNN network structure to detect surface defects of different items. Wu Tong [4] used the X-ray imaging system to collect images of the products and label them, extract the feature of the parts using a convolutional neural network, and then train the deep learning model. Use the model to categorize the internal parts of the assembly to detect missing parts.

The research object of this paper is the atomizer. The assembly process of the atomizer requires several processes. Failure of the gripping of components can result in missing parts. The vibration of the machine, assembly accuracy, etc. may cause the assembly position of the parts to be inaccurate. Combined with the actual situation of production, the assembly defects of the atomizer can be divided into four types: missing workpiece, missing cotton core, missing metal sheet and abnormal wire position. Defect samples are shown in Fig. 1.

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| workpiece missing | cotton core missing |
| metal sheet missing | wire abnormality |
| normal | |
| Fig. 1. Images of atomizer assembly defects samples | |

At present, there is no research on the detection of atomizer assembly defects. Two algorithms for detecting atomizer assembly defects are proposed in this paper. One is the image processing detection algorithm, and the other is the deep learning detection algorithm based on convolutional neural network.

II. Image Processing Algorithm

*A. Detection Target Location and ROI Setting*

The first step of detection is to locate the target. Since the relative position of the assembly and fixture is known, we can locate the fixture position first, and then set the corresponding ROI according to the position of the defect in the assembly. The specific steps are as follows:

Step-1: Separate the foreground and background. The image has distinct foreground and background, and can be segmented by image binarization to get the fixture and assembly area. Because the background of the image is black, we use fixed threshold binary segmentation. The formula is as follows:

(1)

Step-2: Fixture positioning. Since the wire in the assembly will be outside the scope of the fixture, it needs to be handled. Apply an open operation to the image to eliminate protruding wires. Open operations include corrosion and expansion, which are used to eliminate small objects. After the fixture area is obtained, a contour search is used on the image to obtain the outer rectangular outline of the fixture. The positioning process of the detection target is shown in Fig. 2.

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| original image | binarization |
| open operation | contour |
| Fig. 2. Detection target location | |

Step-3: ROI (region of interest) setting. The corresponding ROI is set according to the occurrence area of various defects. The position of the ROI can be determined based on the relative position of the assembly to the fixture. The ROI settings are shown in Fig. 3.

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| Fig. 3. ROI settings |

*B. Workpiece Missing Defect Detection*

For the detection of workpiece missing defects, the contour screening method is proposed. Since only the fixture remains after the workpiece is missing, multiple contours appear instead of a full contour when performing a contour search. Filter the small area by setting the contour area threshold for contour filtering. The result of the contour screening is used to judge whether the workpiece is missing. If there is no contour, it can be determined that the workpiece is missing. The contour screening result of the sample with missing workpiece is shown in Fig. 4.

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| Fig. 4. workpiece missing detection |

*C. Cotton Core Missing Defect Detection*

For the detection of cotton core missing defects, a pixel statistical method is proposed. The cotton core is bright white when imaged, and the cotton core is judged to be missing by counting the proportion of white pixels in the ROI. If the ratio is less than the set threshold, it is determined that the cotton core is missing, and vice versa. The steps for white pixel statistics are as follows:

Step 1: Determine whether the pixel is a white pixel. The binarization method is used. The gray value of more than 250 is white pixel.

Step 2: Add the values of each position in the ROI area, and the obtained value is the number of white pixels.

(1)

*D. Metal Sheet Missing Defect Detection*

For the detection of metal sheet missing defect, the template matching method is used. The metal claw is a mark of whether or not the metal piece is stored, so that the detection of the metal piece can be converted into the detection of the metal claw. In order to eliminate the interference of some unrelated regions, this paper does not directly perform template matching on the original image, but performs template matching on the preprocessed image. Preprocessing operations include closed operations and binarization. The closed operation eliminates black holes, and the binarization operation splits the bright white area, that is, the detected target. Then use template matching for detection. The template matching uses the normalized squared difference method, and the formula is as follows:

(1)

The detection process of the sample with the metal piece is shown in Fig. 5.

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| original image | close operation |
| binarization | template matching |
| Fig. 5. metal sheet missing detection | |

*E. Wire Position Abnormal Defect Detection*

For the detection of wire position abnormal position, a measurement distance method based on pixel statistics is proposed. According to the distance between the wire and the vertical side of the metal jaw, we can judge whether the position of the wire is abnormal.

Similarly, we preprocessed the image, including closing and binarization, to get the target of the detection. Then, the distance between the wire and the metal claw is measured, and if the distance is not within the normal range, it is determined that the wire position is abnormal, and vice versa.

The specific steps of the measurement distance method based on pixel statistics are as follows:

Step-1: Calculate the number of white pixels in each column of the ROI, using the pixel statistics method proposed above.

Step-2: Numerical filtering. Set a threshold to filter values ​​less than this threshold in order to eliminate non-detected areas.

Step-3: The value is smooth. The data is numerically smoothed to make the maxima easier to find.

Step-4: Calculate the distance. A large number of white pixels appear at the wire and metal jaws, which are two maxima in the numerical sequence. The distance between these two extremes is the distance between the wire and the metal jaws.

The process of measuring the distance is shown in Fig. 6.

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| (a) original image |
| Pixel number  Column coordinates  (b) projection curve |
| Pixel number  Column coordinates  (c) numerical smoothing |
| Fig. 6. Distance measurement |

III. Deep Learning Algorithm

1. *Data Enhancement*

IV. Experiment And Comparison

Acknowledgment

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