Detection of Print Head Defect Based on Image Processing Technology

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Abstract. In the detection of dead pixels in the print head, this paper innovatively proposes a dead pixel detection algorithm based on image processing technology for the low efficiency of manual detection and high labor cost. Firstly, the ROI is extracted based on the maximum connected region. Secondly, the binarized image is preprocessed by morphological processing, and then the texture is extracted based on the periodic structural features of the image. The specific steps of texture extraction are as follows: Firstly, this paper locates the largest connected area and gains the row and column of the connected area according to the polynomial fit. Secondly, according to the up and down translation, a column of texture regions is obtained, and then other texture regions are obtained according to the left and right translation. In addition, the Canny operator is used to detect the edge of the image, getting an image with texture edges and dead pixels. Perform a close operation on the image to remove dead pixels, and then subtracted from the original image, the dead pixels in the print head can be detected. The experimental results show that the algorithm not only can accurately detect the dead pixels in the print head image, but also has low complexity and short processing time, which is good for engineering practicability.

Keywords: Dead pixel detection · Image processing technology · Texture extraction · Canny operator

1 Introduction

In the process of human-computer interaction, the printer is an important device for information data output, and the quality of the print head will directly influence the user's reading and judgment of the output information [1]. In the production process, there are many uncertainties, such as the material itself and the fabrication process, which may lead to the surface of the printing head which is not smooth and produces micron-sized bulges that are difficult to be distinguished by the naked eye, which directly leads to the unqualified products [2]. Therefore, strict inspection must be carried out before the production.

The traditional detection is carried out by visual inspection by the employee under the microscope. However, the method is susceptible to environment, attention and other human factors, and has a certain randomness, which is relatively easy to cause large human error. In addition, employees for a long time continuous work will cause

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visual fatigue. The existence of many factors will result in low detection efficiency, which will adversely affect the efficiency of the company [3].

With the development of domestic industrialization, image processing technology and machine vision are flourishing in China. The technology of detecting surface defects by machine vision has been applied in many industrial fields [4]. In the detection of flaws for small spots, the image reconstruction method using singular value decomposition proposed by Tsai can accurately detect minute defects, but since most of the tiny singular points of the print head image are not defects, the method is not suitable for processing the data in this paper [5]. He proposed a method based on partial image template matching to achieve micron-level defect detection, but the algorithm is complex and takes a long time, which is not conducive to the realization of engineering automation [6].

Aiming at the above problems, this paper based on the periodic texture features of the print head image, the polynomial fitting and Canny edge detection operator are introduced into the dead pixel detection of the print head image, and the corresponding dead-point detection algorithm is proposed. The test results show that the algorithm can accurately and effectively detect the dead pixels in the print head image, and provides a feasible algorithm for the detection of dead pixels in the print head image.

2 Principle and Preprocessing

In the production process, due to many uncertain factors such as the manufacturing process and the material itself, the surface of the print head is often not smooth, resulting in micro-scale fine protrusions. In order to detect these tiny protrusions by computer vision, this paper uses the blue light strip diffusion mode of the optical microscope camera for image acquisition, and the acquisition work is done on the experimental bench.

2.1 Print Head Area Segmentation

Since the acquired image contains other areas than the print head image, the ROI (region of interest) is extracted firstly, that is, the print head image area is segmented, and then the print head image is subjected to dead pixel detection. According to the structural characteristics of the acquired image, the maximum connected component is used to obtain the rectangular area of the print head to achieve accurate segmentation of the print head.

Image graying is a method of processing color images. It is a single-channel image that not only makes analysis easier, but also preserves the distribution of chrominance and brightness of the original color image, so this paper convert color images into grayscale images. There are many different types of color images. In this paper, RGB images are obtained. There are usually three methods for converting RGB images into grayscale images: maximum value method, average value method, and weighted average method. This paper uses an algorithm for weighted averaging of RGB components:

$$gray = 0.2989R + 0.5870G + 0.1140B \quad (1)$$

Among them, gray is the converted gray value. R, G, and B are the values of the three channels corresponding to the RGB color image. The resulting grayscale image is shown in Fig. 1:

Fig. 1. Grayscale image

After obtaining the gray image, the gray image is segmented by threshold value, and the apparent foreground and the background are segmented. The so-called threshold segmentation is to set an appropriate threshold, and the pixel point higher than the threshold is determined as the target point of interest. The pixel points below the threshold are judged as background target points. There are many methods for threshold selection: histogram method, bimodal method, iterative method, Otsu method, gray scale stretching method, etc. Based on the characteristics of image data obtained, this paper uses the Otsu method for threshold selection, which is a global threshold acquisition method based on the maximum inter-class variance. Suppose that the segmentation threshold of the foreground and the background is T, and the ratio of foreground points to image is ω_0, and the average gray value is u_0. The ratio of background points to image is ω_1, the average gray value u_1. The total average gray value of the image is u, and the variance of the foreground and background images is g. Then there is

$$u = \omega_0 \times u_0 + \omega_1 \times u_1 \quad (2)$$

$$g = \omega_0 \times (u_0 - u)^2 + \omega_1 \times (u_1 - u)^2 \quad (3)$$

Equation (4) can be obtained from Eqs. (2) and (3):

$$g = \omega_0 \times \omega_1 \times (u_0 - u_1)^2 \quad (4)$$

Or

$$g = \frac{\omega_0}{1 - \omega_0} \times (u_0 - u)^2 \tag{5}$$

When the variance is maximum, it can be considered that the differences between the foreground and background are the largest at this time, and the gray value T at this time is the optimal threshold.

Suppose that the gray value of the grayscale image at coordinates (x, y) is f(x, y), and the result after the threshold processing is g(x, y), and the threshold is T, then

$$g(i,j) = \begin{cases} 1 & f(i,j) \geq T \\ 0 & f(i,j) < T \end{cases} \tag{6}$$

Where 1 is the print head pixel and 0 is the background pixel. Threshold segmentation results are shown in Fig. 2:

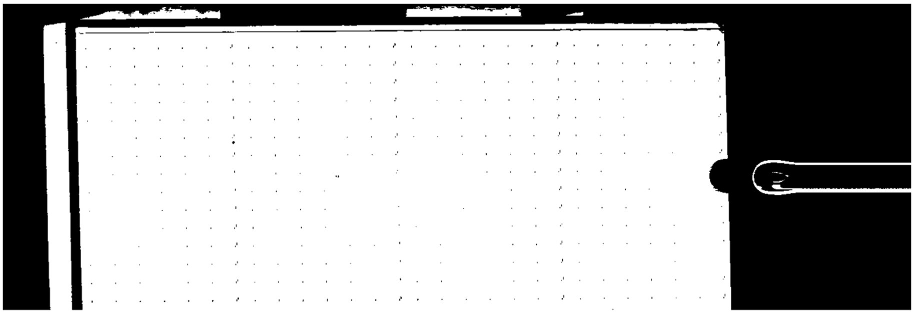

Fig. 2. Image after the first binarization

It can be seen that there are many small singular points from Fig. 2. In order to prevent these singular points from affecting the extraction of the maximum connected components, the morphological closing operation is used to remove them, and the structural elements are disc-shaped. The results are shown in Fig. 3:

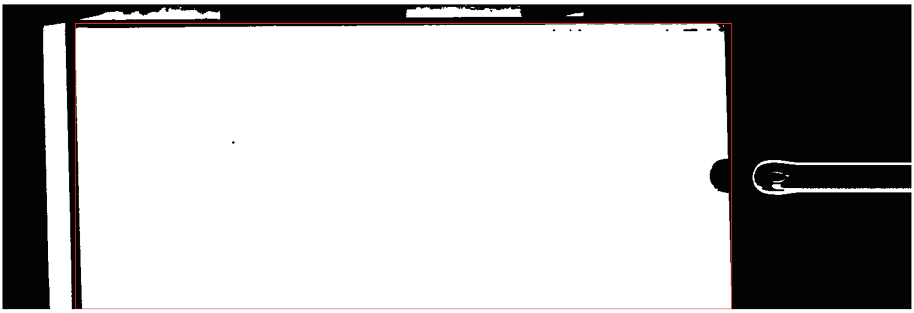

Fig. 3. Image after the first closing operation

As can be seen from the Fig. 3, after the morphological processing, the small singular points are eliminated, and the maximum white connected area is the rectangular area of the print head to be extracted. This paper obtains the starting point coordinates and the length and width data of the rectangular area and then correspond to the original image, and achieve accurate segmentation of the print head image, as shown in the Fig. 4:

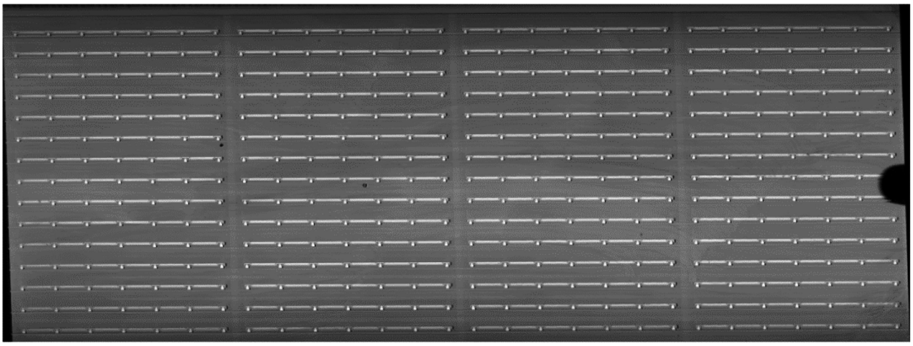

Fig. 4. Split print head image

2.2 Print Head Dead Pixels Detection

Through the analysis of the dead pixel characteristics of the previously unqualified products, it is found that if there is a dead pixel at a certain position, it appears as a sudden pixel area on the image. However, for the images collected in this paper, because the periodic texture contains some pixel mutation points, even if there are no dead pixels, the conventional detection method will detect the sudden change point. Therefore, how to eliminate pixel mutation points in periodic texture while detecting really bad points is the key point of this algorithm. This article considers that in actual engineering applications someone do not care whether the region where the periodic texture is located contains dead pixels. Therefore, the core idea of the algorithm is firstly to extract the region where the periodic texture is located and change all the regions into bright color. Secondly, use the Canny operator for edge detection on the newly obtained image, and then combined with the corresponding morphological processing, the dead pixels are detected by the difference. The specific steps are as follows:

Texture Area Extraction. It can be seen from Fig. 4 that the texture in the image has a certain arrangement regular, and this particular arrangement regular has great significance for the acquisition of the texture region. In this paper, the method of obtaining the texture region is as follows: Firstly, the binarization of Fig. 4 is performed. Secondly, the maximum connected component is extracted. Suppose that the coordinate of the starting point of the largest connected component is (x_1, y_1), and the length is h_1 and the width is w1. According to Eqs. (7) and (8) we can obtain a series of horizontal and vertical points respectively, where the horizontal and vertical points are not strictly horizontal and vertical, but have a certain angle of inclination.

$$abs(x - x_1 \leq 20)\&\&abs(w \times h - w_1 \times h_1) < (w_1 - 5) \times (h_1 - 5) \tag{7}$$

$$abs(y - y_1 \leq 6)\&\&abs(w \times h - w_1 \times h_1) < (w_1 - 5) \times (h_1 - 5) \tag{8}$$

In the formula, the new starting point is (x, y), and the length and width of the connected component with the starting point (x, y) are h, w respectively.

Then this article uses the obtained series of horizontal and vertical points to perform polynomial fitting to obtain two intersecting straight lines. The polynomial fitting selects a first-order polynomial, which is consistent with the structural features of the image. And take (x_1, y_1) as the starting point and take the two lines as the axis. Then make the left and right and up and down translation. The step length of the translation can be determined by the shortest distance between the horizontal point and the vertical point to the starting point.

Dead Pixels Detection. After extracting the texture region and turning it into a bright color, this paper uses the Canny operator for edge detection. Canny edge detection has four parts: Firstly, smoothing the image with Gaussian filter. Secondly, calculating the gradient amplitude and direction with first-order partial derivative finite difference. Thirdly, non-maximum suppression of gradient magnitude. Finally, detection and joining of edges using a dual threshold algorithm. This paper directly calls the edge function with the Canny operator, and the upper bound of the threshold was calculated as 0.08.

After the edge detection, both the edge and the dead pixels are detected. Since the dead point is roughly circular and is very different from the background edge, this article use the circular structure element to perform the morphological closing operation on the image after edge detection, which get the background edge that gets rid of the dead pixels. The background edge is then subtracted from the original image, and the dead pixels in the print head image are detected.

The advantages of this algorithm are that it can not only avoid complex illumination compensation of the image before binarization, but also accurately detect the dead pixels in the print head image. In addition, the algorithm has low complexity and short running time.

3 Experiment and Result Analysis

This paper uses the blue-ray diffuse mode of the optical microscope camera for image acquisition, and the acquisition work is done on the experimental bench. After the image segmentation of the collected print head image is performed according to the maximum connected component method proposed in this paper, the algorithm proposed in this paper is used to detect the dead pixels. First, the segmented image is binarized, as shown in Fig. 5.

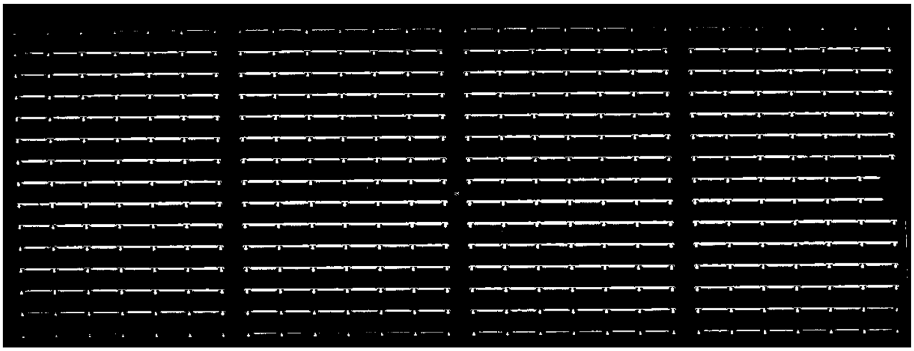

Fig. 5. Image after the second binarization

It can be seen from the above figure that the binarization result of the edge region is not ideal due to uneven illumination, which further affects the extraction of the texture region. However, the traditional illumination compensation method is not suitable for processing the image. Therefore, the polynomial fitting method mentioned above is used to extract the texture region. The results of the polynomial fitting are shown in Fig. 6.

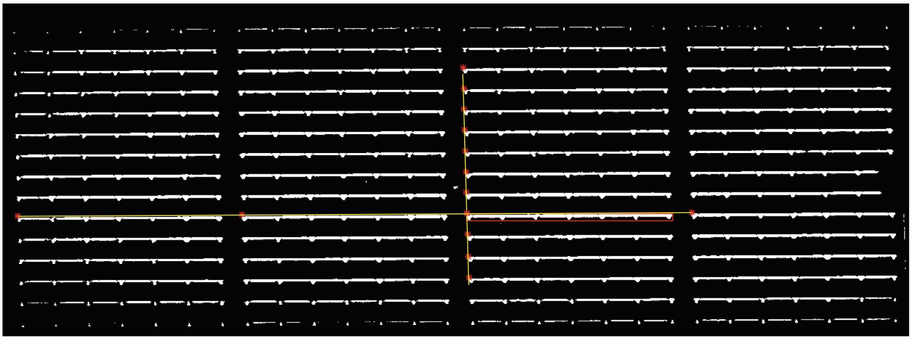

Fig. 6. Polynomial fitting result

According to Fig. 6, this paper uses the straight line shown in the figure as the axis, respectively, up and down and left and right to obtain the texture area, as shown in Fig. 7:

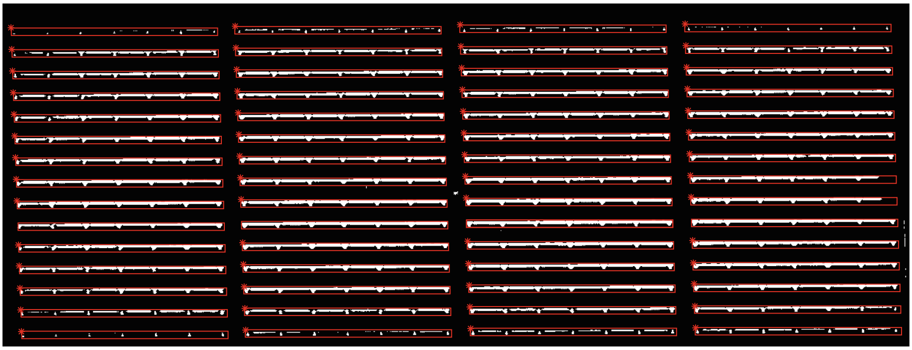

Fig. 7. Texture area positioning result

Turn it into a bright color, that is, set the gray value of the texture area to 255, and the resulting image is shown in Fig. 8:

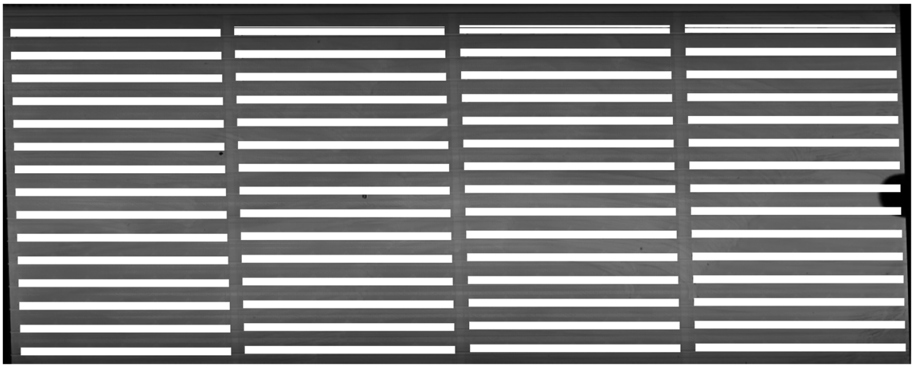

Fig. 8. Remove texture area results

Next, the Canny operator is used for edge detection. This paper directly calls the edge function and selects the Canny operator. The threshold is calculated as 0.08. The processing results are shown in Fig. 9.

Fig. 9. Edge detection result using canny operator

It can be seen from Fig. 9 that both the texture edge and the dead pixels are detected at the same time. However, since the shape of texture edge and dead pixels are obviously different, and the dead pixels occupies less pixels, the morphological closing operation is performed on the Fig. 9, and the structural element is selected as the disc shape. The texture edge image with the dead pixels removed is shown in Fig. 10.

Fig. 10. Image after the second closing operation

By subtracting the Fig. 9 from the Fig. 10, the dead pixels can be detected, as shown in Fig. 11.

Fig. 11. Dead pixels detection result

Corresponding to the original image of the location of the dead pixels, as shown in Fig. 12. By comparing with Fig. 1, it can be seen that the locations of the dead pixels are all located.

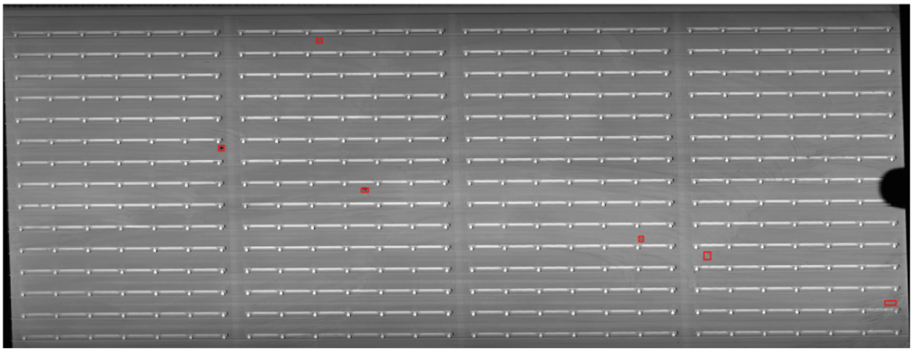

Fig. 12. Dead pixels positioning result

At this point, this paper accurately detected all the dead pixels in the print head image.

4 Conclusion

This paper combines the principle of computer vision and the corresponding software platform to propose a specific algorithm and processing flow for the detection of dead pixels in the print head. The experimental results show that the proposed maximum connected component algorithm can accurately segment the print head region. The polynomial fitting method can not only accurately acquire the texture region, but also remove the influence of illumination unevenness. Canny operator is used for edge detection and then morphological closing operation is performed. Then the dead pixels can be detected quickly and accurately by subtracting from the previous image, so we can make a judgment on whether the print head product is qualified. And the proposed algorithm has low complexity and short running time, which meets the requirements of real-time system. With the mass production of the print head, the print head dead pixels detection idea and detection method proposed in this paper have great theoretical reference and practical value for the print head production enterprise.

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