Analysis of TFT-LCD Point Defect Detection System Based on Machine Vision

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Abstract: This paper mainly gives an introduction to the machine vision-based TFT-LCD point defect detection control system. As the use of otsu algorithm for segmentation is not good enough for TFT-LCD image in the condition of weak contrast ratio of the object and background, it is proposed to improve the threshold and extract function by Wible function, and the optimized otsu algorithm has better segmentation effect than the traditional otsu algorithm in the condition of weak contrast ratio of the object and background. After the testing by transplanting the Matlab image processing program to the hardware platform of TFT-LCD defect detection control system, the experimental results show that the detection control system can quickly and accurately process three types of defects, and the shortest detection time can be shortened to 4.5s.

1. Introduction

Thin Film Transistor (TFT) LCD that is thin film field effect transistor liquid crystal display, is widely used in computers, cell phones, MP4 and other electronic products because it can display screen information with high speed, high brightness and high contrast. [1]However, in the process of production, TFT-LCD's short circuit, open circuit or mixed with impurities and air bubbles will lead to point defects and line defects during its display, which seriously affects the display effect of TFT-LCD. Therefore, manufacturers must carry out strict inspection of TFT-LCD before delivery. [2] The traditional manual inspection method not only has low inspection efficiency, but also the subjective judgment of the inspector can easily affect the inspection results, so the automatic, efficient and eye-conforming TFT-LCD defect automatic inspection system has become a research hotspot of TFT-LCD at present.

2. Composition of TFT-LCD point defect inspection control system

The schematic diagram of TFT-LCD point defect inspection control system is shown in Figure 1, including TFT-LCD display driver, camera, industrial personal computer, manipulator, etc. The working process of the system: drive TFT-LCD to display a typical inspection screen by TFT-LCD driver, and at the same time, trigger the camera to take pictures of the screen and upload the picture to the industrial personal computer for analyzing and judging point defects and line defects under the typical inspection screen, and finally comprehensively judge whether the display of TFT-LCD is qualified.

The drive of the TFT-LCD defect inspection control system uses ARM9 as a development platform to mainly drive the TFT-LCD to display inspection screens; xxxxx camera is used; light source is used. . . . . , and xxxxx manipulator is used.

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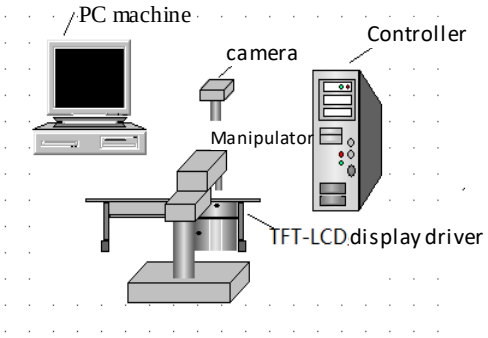


Fig.1 Schematic diagram of tft-lcd point defect inspection control system

3. Algorithm flow of TFT-LCD point defect inspection

For the advantages and disadvantages of the TFT-LCD defect inspection control system, the key lies in processing the images collected by the camera under typical screen, mainly including image preprocessing, image background removal, image segmentation, etc. The program flow chart is shown in Figure 2.

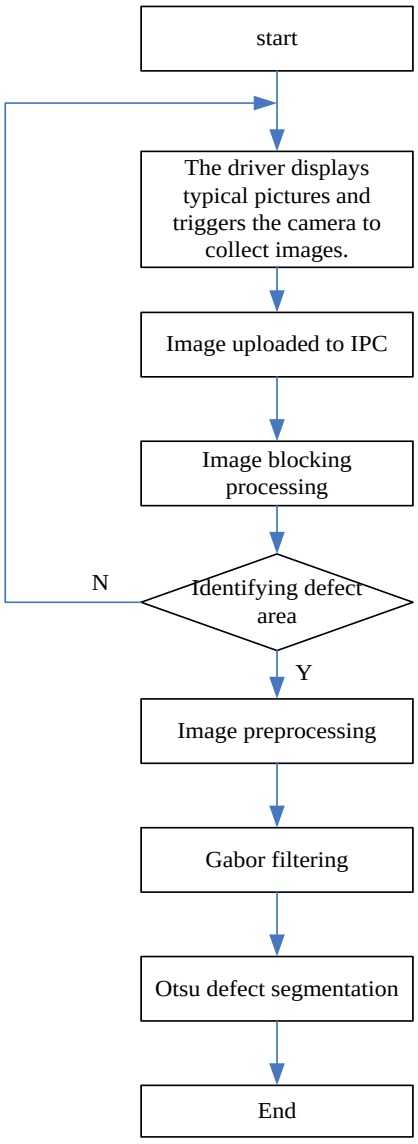
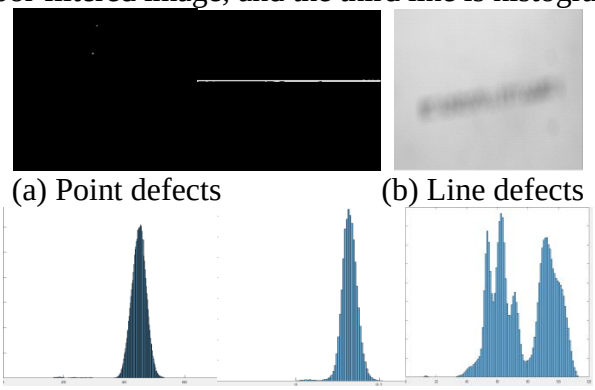


Figure 2 Program Flow Chart

Since the images acquired by the camera are relatively large, it is first necessary to block the acquired images in order to improve the efficiency of program operation. According to the actual sample screen size, this paper divides it into four blocks and locks the defective block for subsequent image processing. Secondly, noise reduction pretreatment is carried out on the defective block so as to reduce the interference of external environment and control system hardware equipment. According to the characteristic that the background texture of TFT-LCD changes periodically, Gabor wave filtering is adopted to eliminate the periodic background, so that Gabor filter can filter the images of various defects as shown in Figure 2. The first line is TFT-LCD defect map, the second line is Gabor filtered image, and the third line is histogram.



(a) Point defects (b) Line defects

(c) Plane defects

Figure 3 Image Processed by Gabor Filtering

4. Image segmentation

Image segmentation shall be adopted to identify the defects and background of the image processes by Gabor filtering, the advantages and disadvantages of which will directly affect image processing, and the commonly used image segmentation methods include threshold segmentation and region segmentation. The ostu algorithm of threshold segmentation has been adopted in this paper, and for its simple calculation and not effected by brightness variations under certain conditions, [7] is widely used in image segmentation.

4.1 Algorithm schematic of ostu

The working principles of ostu algorithm are as the follows [8]: The image is divided into two categories of background and objective, and the probability P1(k) assigned to the background is calculated by formula (1), where ai is the number of pixels of gray value I; the probability P2(k) assigned to the background is calculated by formula (2); then, the average gray value of background and target can be calculated by formulas (3) and (4); The average gray value of the whole image is calculated by formula (5)and the k value of the maximum variance of formula (6) is the optimal threshold.

$$p_1(k) = \frac{a_i}{\sum_{i=0}^{k-1} a_i} \tag{1}$$

$$P2(k) = 1 - P1(k) \tag{2}$$

$$\overline{p_1(k)} = \sum_{i=0}^{k-1} \frac{i * p_i}{p_1(k)} \tag{3}$$

$$\overline{p_2(k)} = \sum_{i=k}^{L-1} \frac{i * p_i}{p_2(k)} \tag{4}$$

$$P = p_1(k) * \overline{p_1(k)} + p_2(k) * \overline{p_2(k)} \tag{5}$$

$$\sigma^2(k) = \lambda_1 * (P - \overline{p_1(k)}) + \lambda_2 * (P - \overline{p_2(k)}) \tag{6}$$

The ostu algorithm is adopted to segment Gabor filtered image and the segmentation effect is shown in figure 4. When the defect and background have a strong contrast, the segmentation effect is good, while the contrast is weak the effect is deficient, so the otsu algorithm needs to be optimized.

Figure 4 Effect of Ostu Algorithm

4.2 Ostu algorithm improvement

The otsu algorithm is optimized by Weibull function, and the formula is shown in equations (6). The distribution function can be symmetric or asymmetrical, where C is exponential when 1<y<3 and Rayleigh when y>3. The equation can be used to optimize objective and background separation formula (4)and replaces hard exponential functions. The optimized formula is shown in equation (7), and the threshold is the minimum value of the function.

The threshold segmentation effect after optimization of otsu algorithm is shown in figure 5. The weak contrast defects in figure (a) were identified, while the less noise in figure (c) and the weaker contrast between the objective and the background were strengthened, and the segment effect of optimized otsu algorithm is obviously superior to the traditional one.

$$f(a,b,x,y)=\frac{y}{x}*(\frac{a-b}{x})^{(y-1)}\exp[-(\frac{a-b}{x})^{y}] \tag{7}$$

$$\mu(t)=\omega_1*\mu_1(t)+\omega_1*\mu_1(t) \tag{8}$$

Among: $\mu_1(t)=\sum_{i=0}^{k-1}[(\frac{i-\overline{p_1(k)}}{x})^{y-1}*(\frac{i-\overline{p_1(k)}}{x})^{y}]*\frac{p_1(k)}{\overline{p_1(k)}}$

$$\mu_2(t)=\sum_{i=k}^{\text{L-1}}[(\frac{i-\overline{p_2(k)}}{x})^{y-1}*(\frac{i-\overline{p_2(k)}}{x})^{y}]*\frac{p_2(k)}{\overline{p_2(k)}}$$

Figure 5 The threshold segmentation effect of the optimized otsu algorithm

5. Conclusion

This paper focuses on introducing the TFT-LCD defect processing program of the defect detection control system under the typical screen and according to the weak contrast between some defective objective and background after Gabor filtering, optimized otsu algorithm is proposed to achieve better segmentation of objective and background. The experimental results show that the otsu algorithm after the optimization of defect segmentation with low contrast is superior to the traditional one. Transforming image processing program of Matlab to the hardware platform of TFT-LCD defect processing program to have a test which can detect the point defects with a diameter of 0.1mm and above, line defects with a width of more than 0.05mm and a length of more than 2mm, and the detection time can be shortened to 4.5 seconds. Namely, TFT-LCD of 700-800 can be detected per hour, equivalent to 5-8 manually detected quantity.

References

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