Study on the Edge Defect Algorithm of Mobile Phone Screen Contour with Self Adaptive Multiple Difference Technology

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Abstract: Aiming at the problem that the dust and scratches on the outermost edge of the mobile phone screen are difficult to detect and identify, a global and local dynamic threshold combined multiple image matching differential detection method is designed. Through the use of DLASA linear array camera, we conduct real-time acquisition of high-precision grayscale images, and use the dynamic threshold for image region segmentation and morphological extraction of screen border regions and pixel information points. Then it is contour screening, we conduct multiple differences on the screen's outermost border area and the overall area of the screen, and the loop is fitted to the judgment in order to finally identify the edge impurities and scratches at the edge of the screen. Combined with the feasibility of the experimental verification algorithm, 300 screens are randomly selected for experimental testing. The detection accuracy reaches 97.3%, the false detection rate is 0.7%, and the leak rate is 1%. The experimental results show that the algorithm can accurately detect the dust and scratches on the outermost edge of the screen of the mobile phone, and provide a reliable solution for industrial screen defect detection, which has certain practical value.

Keywords: Machine vision; Dynamic threshold; Multiple difference; Defect detection

1. Introduction

With the rapid development of the mobile phone industry, the mobile phone screen as a core key component plays a human-computer interaction function, and its quality directly affects the user's sensory experience. The traditional screen detection adopts the manual identification detection method, which has the problems of high recognition failure rate, low efficiency and high labor cost[1]. There are many researches on the detection technology based on machine vision. Detection algorithms mainly include wavelet analysis and artificial neural network[2-3], local image template matching[4], singular value reconstruction[5], Fourier transform[6] and other methods. There are many extensive researches on screen detection algorithms based on machine vision. Because machine vision technology is affected by low robustness and insufficient precision, the general algorithm can only detect dust and scratches in the normal position of the screen, and in actual industrial production, dust and scratches on the outermost edge are difficult to identify. In this paper, a dynamic threshold combined with multiple images matching differential detection algorithm is proposed to effectively identify the outmost edge defect of the screen.

2. The Implementation Process of Algorithm

2.1. The global dynamic threshold gets the screen area

The screen image is characterized by low contrast, and it is difficult to recognize the outermost edge dust and fine scratch defects. Due to the low contrast of the obtained image, it is difficult to directly separate the target area from the background area, therefore, we enhance the contrast of the image first, and then use the global dynamic threshold △T for segmentation, and the mathematical expression is described as follows:

$$\Delta T = \lambda \frac{1}{M \times N} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} | F(i,j) - G(i,j) | \quad (1)$$

$$R(i,j) = \{^{1,|F(i,j)-G(i,j)|>T+\Delta T}_{0,others} \quad (2)$$

In formula (1), λ is suppression factor, $M \times N$ represents the size of each image processed, ($M \times N$) numerical result represents the number of pixels in the detected area. ΔT reflects the overall change of the environment.

2.2. To extract the outline of the screen edge

The edge contour of the image refers to the portion where the gray level of the image local area changes significantly, that is, a gray value changes from a small buffer area to another gray value with a large difference in gray scale. The first partial derivative matrix of its X and Y directions, and the mathematical expression of the direction of the gradient amplitude are as follows:

$$P[i,j] = (f[i,j+1] - f[i,j] + f[i+1,j+1] - f[i+1,j]) / 2 \quad (3)$$

$$Q[i,j] = (f[i,j] - f[i+1,j] + f[i,j+1] - f[i+1,j+1]) / 2 \quad (4)$$

$$M[i,j]=\sqrt{P[i,j]^2+Q[i,j]^2} \quad (5)$$

$$\theta[i,j]=\arctan(Q[i,j]/P[i,j]) \quad (6)$$

of which, $P[i,j]$ and $Q[i,j]$ express respectively 2 arrays of partial derivatives in X and Y directions, and $M[i,j]$ represents the magnitude of the gradient, and $\theta[i,j]$ represents gradient direction. The larger the image amplitude is, but it may not the edge point, so the local maximum value of the pixel point needs to be further searched. Setting the gray value of the non-maximum point as 0, most non-edge points can be removed.

2.3. Dynamic threshold region localization of local image

Local dynamic threshold is used to determine the location of the outer edge area of the screen. Based on the selection of the optimal threshold of the minimum error, a threshold value K is set, and the variable value of K maximizes the class variance of the two groups. The value of image f(x, y) grey level of M N size is [0,L-1], and recording p(k) as the frequency of k gray values, then there is：

$$P(k)=\frac{1}{\mathrm{MN}}\sum f(i,j)=k1 \quad (7)$$

Set the target and background separated by the threshold value as gray value t, and the ratio of the target part is:

$$W_0(t)=\sum_{0\le i\le t}\mathrm{P(i)} \quad (8)$$

The points of targeted part:

$$N_0=MN\sum_{0\le i\le t}\mathrm{P(i)} \quad (9)$$

The points of background part:

$$N_1=MN\sum_{t<i\le m-1}P(i) \quad (10)$$

The ratio of the background part:

$$w_1(t)=\sum_{t<i£m\text{-}1}P(i) \quad (11)$$

Target mean value:

$$u_0(t)=\sum_{0\le i\le t} iP(i)\Big/ w_{0(t)} \quad (12)$$

The background mean value:

$$u_1(t)=\sum_{t<I\le m-1} iP(i)/w_1(t) \quad (13)$$

Grand mean:

$$u=w_0(t)u_{0(t)}+w_1(t)u_1(t) \quad (14)$$

The optimal threshold of the image g:

$$g=Max[W_0(t)(u_0(t)-u)^2+W_1(t)(u_1(t)-u)^2] \quad (15)$$

The full threshold selection object of the local part is point, and the combination of pixel properties in the field of the points can restrain noise to some extent.

2.4. Multiple region combined difference

The acquired screen image has extremely low contrast in the border background area and defect area, so it is difficult to distinguish edge defect and background based on conventional image segmentation and recognition methods. It is necessary to suppress the influence of uneven screen brightness on defect detection and enhance the characteristic information of the area. After setting the grayscale threshold, it is difficult to find a pixel point of gray threshold in the extreme value area that is not larger than that of the setting. It is both an isolated point and an extreme value area. We extract the four border area of the outermost screen and the difference of the entire screen, and then separate the screen image and the four outer edge images of the screen.

$$\bullet\, I(X,Y)=I(X,Y)-B(X,Y) \quad (16)$$

Fitting and screening contour information and extracting border pixel information points, a pixel point is also treated as contour information. The loop sequentially determines whether the gray value of the pixel is the pixel value of the screen itself, and then identifies the edge dust and scratch by moving the area to the four sides respectively.

3. The Design of Screen Detection System

The main components of screen detection system designed in the paper are industrial camera, material movement platform, holder, light source and computer. The screen detection platform of the experiment is shown in picture 1, and the hardware structure is shown in picture 2.

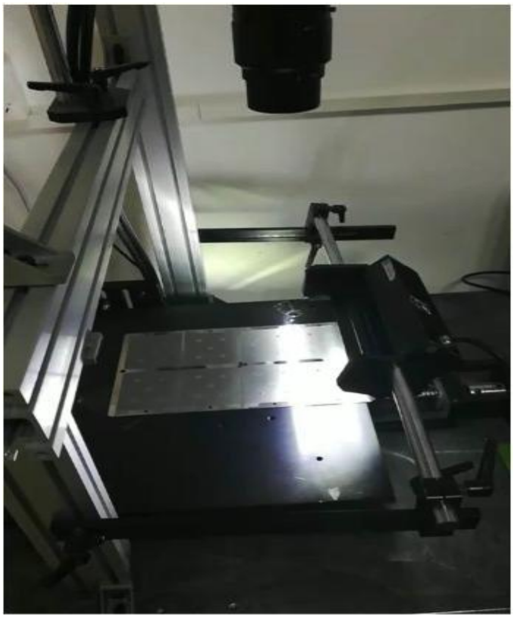

Figure 1. The screen detection experiment platform

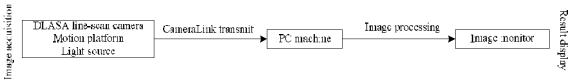

Figure 2. The hardware structure

Using Teledyne DLASA Piranha4 camera with the P4 - CM - 04 k05d model, and the main performance parameters are shown in table 1

Table 1. The main performance parameters of DLASA line-scan camera

Model	P4-CM-04K05D
Resolution	4096×4096
Horizontal frequency	50HKZ
Pixel size	10.56um
Transmission interface	Cameralink

The light source of the screen detection system uses a strip lighter to illuminate the material, and uses a low-angle strip light to illuminate the screen, and the screen emits light, and the dust and scratches of the screen are presented by grazing. It adopts the black-and-white mode of the camera, and enables the linear camera to image clearly through the uniform motion of the moving platform. And it uses telephoto lenses with large aperture and small magnification, and the model is Dheng GCO-23 telecentric imaging lens, and the magnification is 1×, and the object field is 20×15, and the working distance is 72.2cm. This can obtain better image effect. The software design process is shown in picture 3.

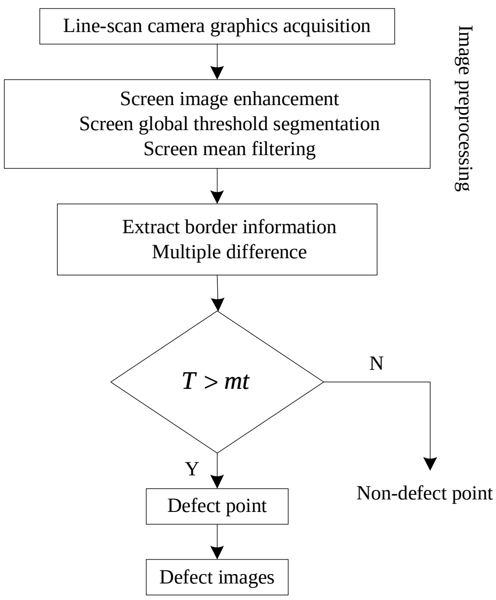

Figure 3. The design of screen detection software

4. Screen detection Experiment

4.1. Image preprocessing

Since the contrast of the acquired image is not enough, the image is pre-processed first, using image information enhancement, global threshold segmentation, mean filtering and other pre-processing methods. The experimental results are shown in the following pictures.

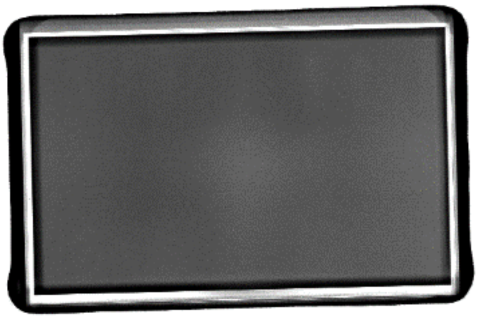

Figure 4. Enhance image contrast

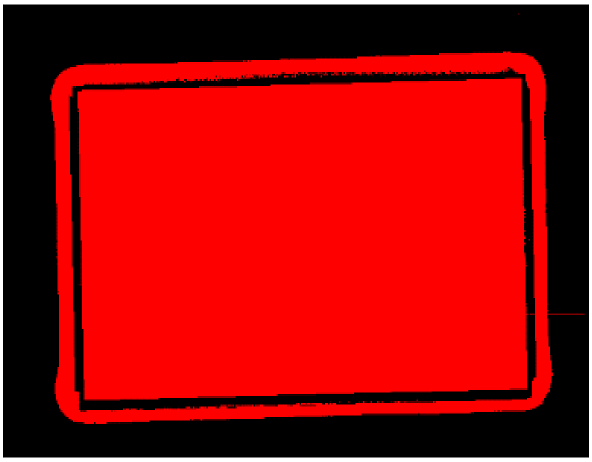

Figure 5. The region obtained after global dynamic threshold segmentation

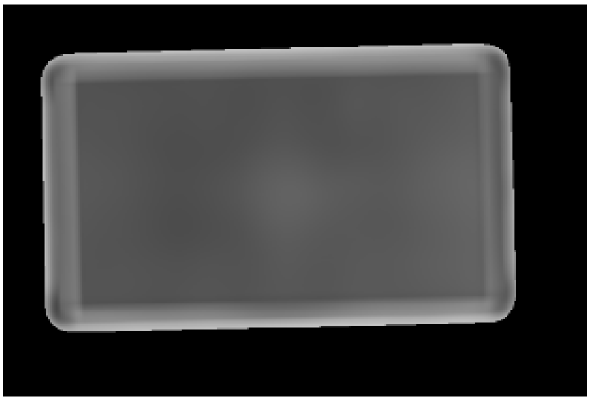

Figure 6. Mean filtering

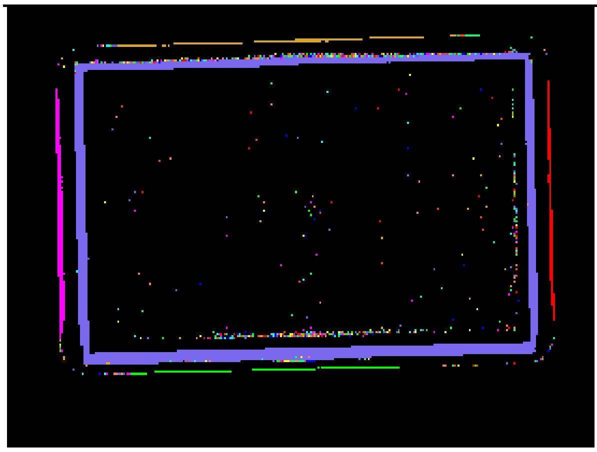

Figure 7. Local dynamic threshold segmentation

4.2. Edge contour information judgment

The outermost edge area of the screen and the middle area of the screen are separated, the contour information is filtered, and the pixel information points of the border are extracted. One pixel point is regarded as contour information, and each contour pixel object is sequentially determined cyclically.

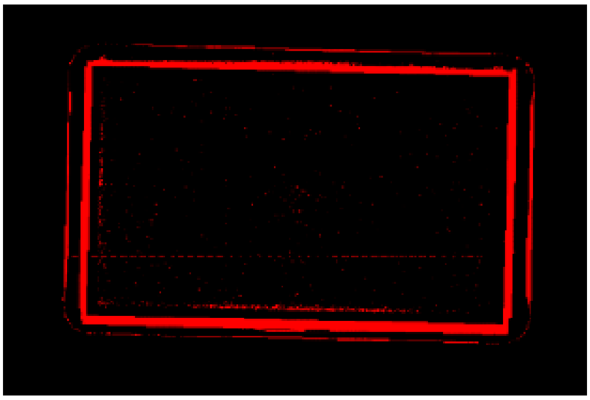

Figure 8. Local dynamic filtering binarization

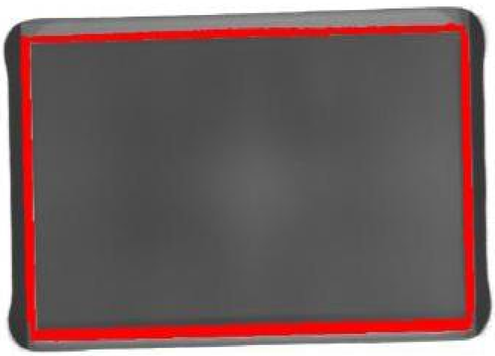

Figure 9. The obtained screen border area

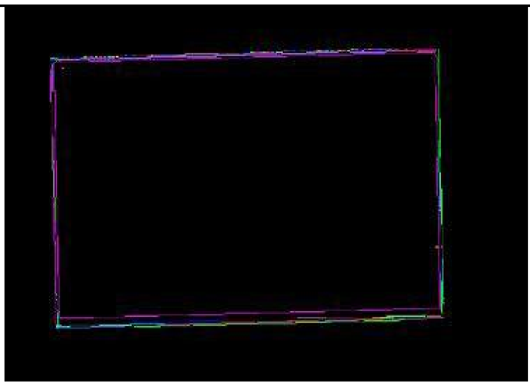

Figure 10. Loop determines edge object information

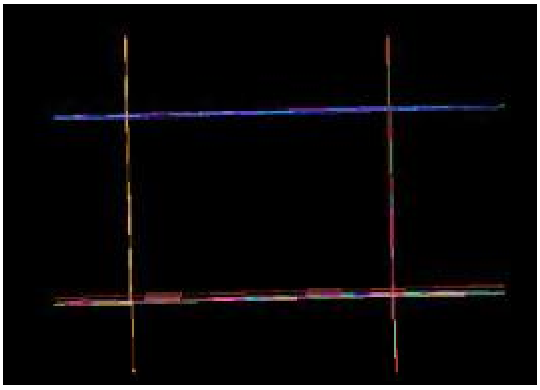

Figure 11. Edge pixel information fitting

4.3. Screen detection results and analysis

Detecting and analyzing on the random 300 screens, the screen defect detection contents are the scratch of edge, the edge dust, the dust in common area and scratch. After finishing the detection, manual recheck is required to confirm, and there are 3 screens of missing measure and 3 screens of misdetection. The experimental data are shown in table 2. The outermost edge contour defect of the screen is difficult to detect. It can be verified by experiments that the algorithm can effectively solve the problem of screen contour edge defect detection.

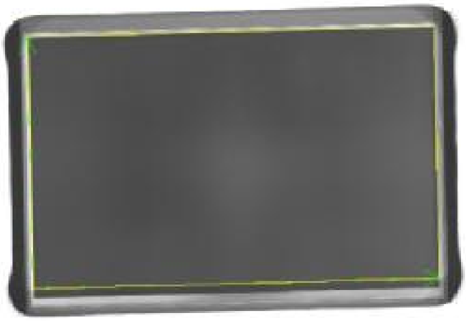

Figure 12. Qualified screen

Figure 13. Screen scratches and edge dust

Figure 14. Screen dust

Figure 15. Screen edge dust

5. Conclusions

Aiming at the problem that the defects in outermost edge region of the screen is difficult to be detected and identified, this paper proposes a dynamic threshold combined multiple image matching differential detection method. It can not only identify defects in common areas of the screen, but also identify defects in the outer edge of the screen effectively. Experimental verification of the algorithm shows that it can effectively identify the defects of the edge areas on the screen that are difficult to be identified. The algorithm has effectiveness and high robustness, providing a reliable solution for industrial screen defect detection.

Table 2. Screen detection results

Sample information	Quantity	Defect detection	Missing measurement	Misdetection	Omission ratio	False decting ratio
Group 1	100	3	1	1	1%	1%
Group 2	100	6	0	2	0	2%
Group 3	100	4	2	0	2%	0

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