Research on Phone Shell Detection Based on Machine Vision

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Abstract. With the continuous development of computer technology, machine vision technology has the incomparable advantages of manual detection, such as non-contact, non-fatigue, so it is widely used in the field of industrial detection. The traditional method of mobile phone shell detection does not meet the increasingly intelligent demand. It is of practical significance to use machine vision technology to realize mobile phone shell detection. Combined the technology of image processing technology, this paper proposes a kind of mobile phone shell detection based on machine vision method. First of all, the original image is preprocessed, and then a method combining median filter and wavelet tool is used to eliminate image noise. On this basis, image segmentation and edge extraction are carried out. The improved Canny operator is used to detect the edge of the image, which has good effect in eliminating the false edge and ensuring the integrity and continuity of the edge. Meanwhile, mathematical morphology is used to extract the characteristic parameters of the target, and the effectiveness of the detection method is verified by simulation in Matlab.

1. Introduction

With the development of computer technology, the advantage of machine vision technology in industrial online inspection is more and more obvious. Because machine vision technology has the advantages of non-contact, non-fatigue and other incomparable manual detection, it can greatly reduce the detection cost, improve production efficiency and improve product quality, so it has been widely used in the field of industrial detection. With the rapid development of communication technology, the demand for mobile communication equipment is increasing year by year. As a portable tool in communication equipment, mobile phone occupies the main market. At the same time, people's requirements for the quality of mobile phone are also increasing. If there are defects in the mobile phone shell, it cannot guarantee a higher qualified rate, resulting in a certain economic loss in production. Therefore, it is of great economic significance to take effective detection means to reduce the defects in the mobile phone shell.

There are various types of defects on the surface of mobile phone shell. The traditional surface defect detection methods include random sampling review, online identification of human eyes or real-time monitoring of production line. In general, the traditional surface defect detection methods mainly rely on manual detection, but manual detection is greatly interfered by human subjective factors, and manual detection has low efficiency and high cost. For the most part, improvements in product quality have been limited. And machine vision detection is gradually replacing manual detection, detection is more accurate and rapid. Machine vision detection technology has the following advantages: good real-time, non-contact, high precision, safe and reliable. Therefore, the application of machine vision in the detection of mobile phone shell surface defects will be an important direction of future development.
In recent years, domestic and foreign experts and scholars have carried out research on surface defect detection technology. Aganrisani et al. studied a geometric size measurement system for automobile gaskets based on machine vision, whose effect was better than that of traditional measurement methods[1]. Surface defect detection is one of the earliest application fields of machine vision technology in industrial production. In the 1990s, Professor Marr proposed a new model of machine vision theory for visual surface defect detection technology, which promoted the development of visual detection technology[2]. Tsapaev studied the application of image segmentation methods such as watershed algorithm, shape spectrum change assessment method and normalization method in surface defect detection, compared the target image and template image, and drew a conclusion about the feasibility of FCVC method in surface defect detection system [3].Liu proposed the research of mobile phone shell defect detection system[4]. Aishi first developed a platform combined with image processing technology for the extraction of raw cotton foreign fiber defects[5]. Jian et al. proposed an improved defect recognition and segmentation algorithm, aiming at the defects appearing in the production process of mobile phone glass screen, which had good detection effect in practical application[6]. Ma designed a PCB detection system using image processing technology, through the Laplace transform sharpening image, histogram threshold double peak method segmentation image, morphology processing, and got the PCB board pseudo standard image. At last, the defects such as short circuit and circuit break in PCB board were identified[7]. Liu et al. used wavelet analysis for pre-processing such as image denoising and image enhancement, used Canny operator to extract the defect boundary, and realized feature extraction and recognition of solar silicon image[8]. Zhang proposed the method of recognition and classification of mobile phone shell based on neural network classifier, and adopted the hybrid threshold segmentation method combining global threshold and dynamic threshold to realize the adaptive defect detection of shell with different materials[9]. Ren realized the precise separation between the image of the phone shell and the background, and solved the problem of large error in image matching in the Logo area by adding the best matching point[10]. In general, the defect detection system of mobile phone shell includes not only the research of defect detection algorithm, but also the design of system software and hardware. Among them, algorithm is the core of the detection system, excellent defect detection algorithm is helpful to reduce the difficulty of the overall design of the system. It has always been a difficult problem to detect the surface defects of the mobile phone shell with smooth surface and high surface quality requirements, and there is no complete solution yet.

Therefore, combining with the development trend of detection technology, this paper aims to present machine vision detection method for mobile phone shell and the key contribution is to establish a method for extracting the contour outside surface characteristics and to provide certain technical support for the phone shell detection based on machine vision. This paper is structured as follows. Section 2 reviews the basic principle of contour edge detection. Section 3 is devoted to the characteristics analysis of shell detection by simulation in MATLAB. The improved Canny operator is used to detect the edge of the image, which has good effect in eliminating the false edge and ensuring the integrity and continuity of the edge. In addition, mathematical morphology is used to extract the characteristic parameters of the target, and the effectiveness of the detection method is verified by simulation. Section 4 summarizes the full text.

2. Principle of Contour edge detection

The most important step in the size measurement of machine vision is image edge detection. The edge can be divided into two categories by the gray distribution near the edge of the image: one is step edge, the other is roof shape edge. At present, the widely used edge detection method is edge detection operator, whose basic principle is to use the first or second derivative to detect the discontinuity points in the image function.

Traditional edge detection operators include gradient operator, Log operator and Canny operator. The first three edge detection operators are all based on gray differential method, which can achieve
better detection only when the image contains no noise or very little noise. Canny operator has the following three criteria to judge whether it is the optimal stepped edge detection operator:

1. High signal-to-noise ratio. In general, the higher the SNR, the better the detection.
   \[
   \text{SNR} = \frac{\int_{-\omega}^{\omega} G(-x)dx}{\int_{-\omega}^{\omega} f^2(x)dx} \tag{1}
   \]
   Where, \(f(x)\) represents the impulse response with a boundary of \([-\omega, +\omega]\), and \(G(x)\) represents the edge.

2. High positioning accuracy. The detected edge is as close to the real edge as possible. In the following formula, it is reflected in seeking a filtering function \(f(x)\) to maximize the Loc. In other words, the deviation between the detected edge and the actual position is the least.
   \[
   \text{Loc} = \frac{\int_{-\omega}^{\omega} G(-x)f(x)dx}{\int_{-\omega}^{\omega} f^2(x)dx} \tag{2}
   \]

3. Edge response. The average distance between the filter and the maximum edge response is required to be as large as possible to clear edge response.

   For mobile phone shell, when there are no defects, the integrity of the shell surface is very good, but defects will affect its integrity. If the gray value of the image is regarded as a binary function of coordinates \(x\) and \(y\), then the reflection of the defect edge position on the function image is at the discontinuous points such as inflection point and jump point. Therefore, edge features can be used for defect detection.

   The calculation steps of Canny operator in this paper are as follows.
   
   1. The Sobel operator is used to obtain the partial derivatives of \(S_x\) and \(S_y\) in two directions of the image point by point.
      \[
      S_x = [f(x-1,y-1) + 2f(x,y-1) + f(x+1,y-1)] - [f(x-1,y+1) + 2f(x,y+1) + f(x+1,y+1)]
      \]
      \[
      S_y = [f(x-1,y-1) + 2f(x-1,y) + f(x-1,y+1)] - [f(x+1,y-1) + 2f(x+1,y) + f(x+1,y+1)] \tag{3}
      \]

   2. The gradient amplitude \(G(x, y)\) of each point is obtained, and the gradient image is obtained.
      \[
      G(x, y) = \sqrt{S_x^2 + S_y^2} \tag{4}
      \]

   3. Calculate the average value of the gradient amplitude of the whole graph \(T_L\) as the low threshold of Canny edge operator.

   4. Using \(T_L\) as the classification point, the mathematical expectation \(EH\) and \(EL\) of high and low gradient amplitudes are obtained respectively.

   5. The high threshold of Canny operator is obtained.
      \[
      T_H = \frac{EH}{EL} T_L \tag{6}
      \]

   Since the target area segmented from the phone shell image is very small, the average gradient amplitude can be used to approximate the gradient amplitude of the background. Similarly, the ratio of the gradient of the target to the background can be replaced by the ratio of the average gradient of the high and low regions.

3. Simulation analysis of shell detection

By comparing the common image processing algorithms, this paper improves the algorithm appropriately, and uses the basic techniques of image enhancement, image segmentation, image morphology processing and so on to complete the detection of the surface of the mobile phone shell. The process of detection is shown in Figure 1.

Due to the influence of unstable field environment, the mobile phone shell image acquisition process will produce a certain amount of noise, resulting in false detection and other phenomena, so it is necessary to image denoising operation in order to improve the quality of the image.
In general, the better the denoising, the more detail is lost in the image. It may even eliminate features needed for subsequent processing. Therefore, it is very important to choose a reasonable denoising method, which requires both denoising and preserving features. Figure 2 shows the effect of mean filtering and wavelet denoising respectively. The denoising effect of the image denoised by mean filtering is very good, but some features, such as small scratches, have become insignificant, and the highlighting of these details is required for defect detection, as shown in Figure 2(c). Compared with the image after mean filtering, the details of the image after wavelet denoising are more prominent, but the effect of noise removal is not good, and even the phenomenon of local noise aggravation appears as shown in Figure 2(d).

The two denoising methods are complementary to each other with their own characteristics. Here, in order to preserve as much detail of the case as possible and to suppress noise, this paper will simultaneously use the two denoising methods combined with their respective advantages, as shown in Figure 3(c) and Figure 4(c).

After image preprocessing, edge detection and morphological processing results of the mobile phone shell are obtained, as shown in Figure 3(d)-(e) and Figure 4(d)-(e). Then, according to the scratch features of the mobile phone shell (as shown in Figure 4), geometric features such as area, perimeter and roundness are extracted from the defect features to obtain the measurement parameter results, as shown in Table 1.

| Gradient mean  | Area of the defect | Perimeter of the defect | Roundness of the defect |
|---------------|--------------------|------------------------|------------------------|
| 0.1033        | 143.3750           | 139                    | 134.7585               |

Figure 1 Process of shell surface inspection

Figure 2 Comparison of two different denoising methods
In order to analyze the different connected components of a binary image separately and extract its characteristic parameters, each connected domain need to be marked. Label operation can be realized by using bwlabel function in Matlab, so that each target object presents a different color, which is easy to identify and distinguish. Figure 3(f) shows the marked and colored mobile phone shell image. Figure 4(f) shows the marked and colored defect image of the mobile phone shell.

4. Conclusion

Combined with the development trend of image detection technology, this paper focuses on the detection method based on machine vision, aiming at the mobile phone shell. The shell detection method is mainly established by extracting contour features of the outer surface. First of all, the original image is preprocessed, and then a method combining median filter and wavelet tool is used to eliminate image noise. On this basis, image segmentation and edge extraction are carried out. The improved Canny operator is used to detect the edge of the image, which has good effect in eliminating the false edge and ensuring the integrity and continuity of the edge. Meanwhile, mathematical
morphology is used to extract the characteristic parameters of the target, and the effectiveness of the detection method is verified by simulation in Matlab.

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