Handlebar appearance inspection algorithm based on two-direction trace and check

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Abstract. High automatically industry production is an inevitable trend in the development of modern factory. Based on objects of precise, efficient and intelligent manufacturing and replacing heavy manual labor to lower the high error rate., this paper proposes a new product appearance dark grain detection algorithm. Firstly, the Gauss function is adapted to image preprocessing operations including noise filtering, pixel binarization, state judge, division and so on; then, "left-bottom detection" and "right-bottom detection" are combined to detect and extract the dark grain characteristics of products. The experimental results show that this two-direction combined detection algorithm described in this paper is effective in practical application. Conclusion is that the proposed method can be widely applied in product appearance detection field.

Introduction

The industrial development in modern society has gradually moved toward high automatization, mechanization and intellectuality [1]. It is an inevitable trend to replace manual operation with advanced industrial system in modern factories. The requirement of modern industrial production for quality grew much stricter than before [2-4]. Take the product appearance inspection for example, No flaws are allowed on the appearance of many products with the consideration of user's need of safety, beauty and specification standard. There is no enough research on product appearance test in China [5] and artificial inspection is the main method at the moment. As the artificial method is of low detection efficiency, and scratches such as the dark grain is not easy to be found by eye, it is of great significance to improve the present detection methods.

In this paper, a new detection algorithm is presented. Firstly, data of product image with shape characteristics, such as that of the handlebars, are collected by detection system hardware; then, the new detection algorithm in this paper is applied for image preprocessing operations including image noise filtering, pixel binarization, state judge, and division and so on; then, the lower right and lower left detection modes are combined to judge the dark grain characteristics; finally, results are sent to the user if there is a dark grain and its position.

In this paper, section 2 will present a detailed introduction of the plastic dark grain appearance detection method according to the specific operation process. Section 3 verified the efficiency and accuracy of this algorithm is by experiment. Section 4 gives the conclusion of the paper.

Plastic dark grain appearance detection method

In this paper, a plastic dark grain appearance detection method is proposed on the basis of the appearance test hardware system. The flow chart of this detection method is as shown in Fig. 1. This method can be used in the appearance detection system to finish the picking work for plastic parts with dark grain appearance.

Image acquisition.

The image of the product can be obtained with a camera tracking the plastic products on the testing stage. Parameters such as the image size and quality are set before the camera capture image. Then, the video camera is open and used to monitor plastic product in real-time. The camera will not stop until the original image data are put into the callback function.

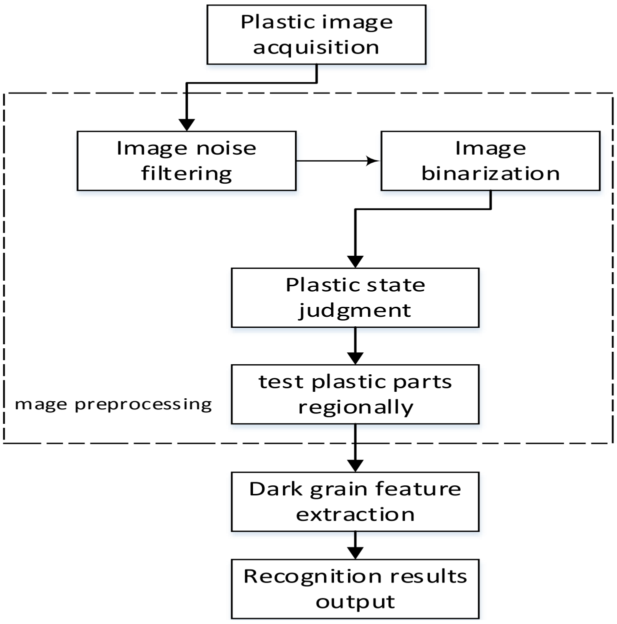

Fig 1. Detection method flow chart

Image preprocessing.

A. Image filtering. Image noise filtering is the process of image smoothing. Image obtained by camera contains isolated black and white pixels due to the noise disturbance. In this step, the gauss filter of select type is used for linear filtering to suppress isolated noise.

After successive convolution of two single-dimension gauss filters (horizontal and vertical direction), a two-dimension gauss filter can be acquired to deal with images of two-dimension, which is a two-dimension discrete zero mean gauss function as shown in Eq. 1.

$$g[i, j] = ce^{\frac{j^2 - i^2}{2\sigma^2}} \tag{1}$$

Where G is the filter with sigma, and C is a coefficient used to standardize filter template weights. C is obtained by the Eq. 2 as the follows:

$$c = \frac{1}{\sum_{i=0}^{n-1}\sum_{j=0}^{n-1} g[i, j]} \tag{2}$$

The coefficient C transforms the filter into an integer, and gray uniform area of the image will not be changed by filtering.

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B. Image binarization. This image operation process can be divided into global threshold method and local threshold method according to the algorithm's operation range. In global threshold method, the threshold value of binarization transformation is determined according to the image histogram or gray spatial distribution, and transformation of the original image to binary image is completed by system based on this threshold. As shown in Fig. 3, there is great difference between the plastic parts and the background in terms of pixel value. The global threshold value method is a good method to separate the plastic from the background. The initial value of global threshold T_1 is set as 90.

Local threshold method is block binarization. After the internal image is divided into blocks, the neighborhood of the test point is defined. Then, the neighborhood calculation templates will be used to compare the gray scale of the test point with that of pixels in its neighborhood.

The internal image of plastic parts is divided into 16x12 blocks, and then the mean μ of each pixel is calculated until all the inside pixel point of the plastic parts is finished. if the pixel values is greater than μ, it will be assigned a white pixel value; If it is less than μ, it will be assigned a black pixel value.

The image of a plastic part after local threshold processing is shown as Fig. 4. It can be found that the color of the part is converted to black and white after it is away from the background.

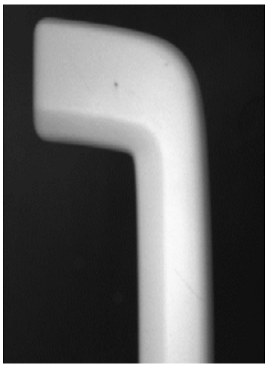

Fig.3: Global image binarization result Fig.4: Local image binarization result

C. Plastic parts state judgement. This process will determine the location of the plastic part. The image orientations are defined four directions including the front, the back, the front side and the back side. The plane to install screws is defined as the back side.

The plastic part for testing in this paper is a handlebar of a bike. According to its shape characteristic, the system begin test from top to end at the bottom, the threshold value for white pixel number of each row is set as Tw and the white pixel value calculated by the algorithm in horizontal direction is Tt. If $T_t > T_w$, it means that the image in **horizontal direction** is significantly widen and the edge of handlebar position is detected. The system defines this position as the dividing line of the image from top to bottom.

The next step is to analyze the side image of the plastic part. Parameters such as length and width input by the user are taken as the threshold value by the testing system. The position corresponding to these parameters is as shown in Fig. 5 and Fig. 6 is the flow chart of testing algorithm for the side image of the plastic part. T is the threshold value to judge the distance between the left and right sides. If the tested object is the handlebar, T value should be close to the cylinder diameter of the handlebars.

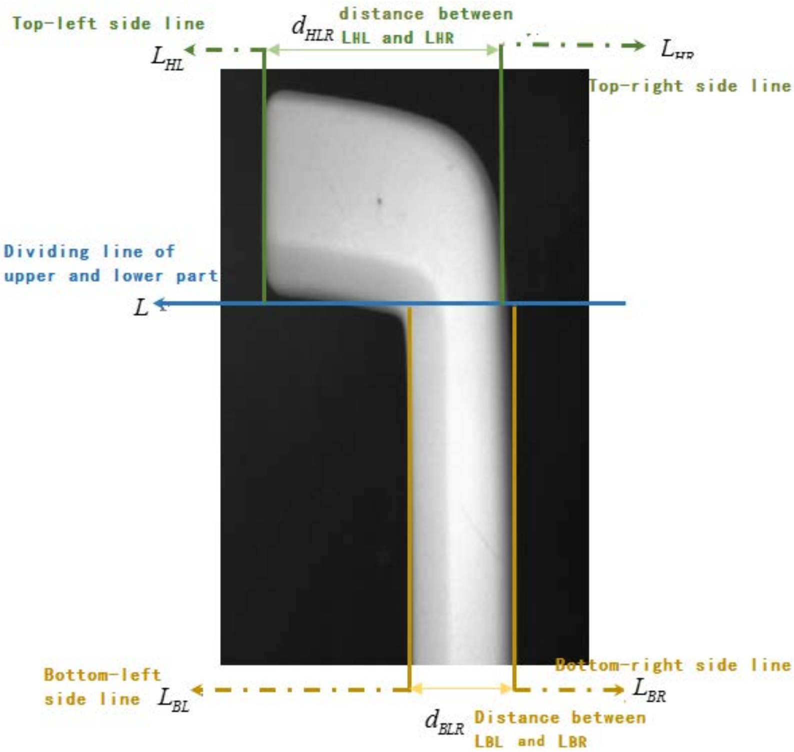

Fig.5 Parameters and its position in the image

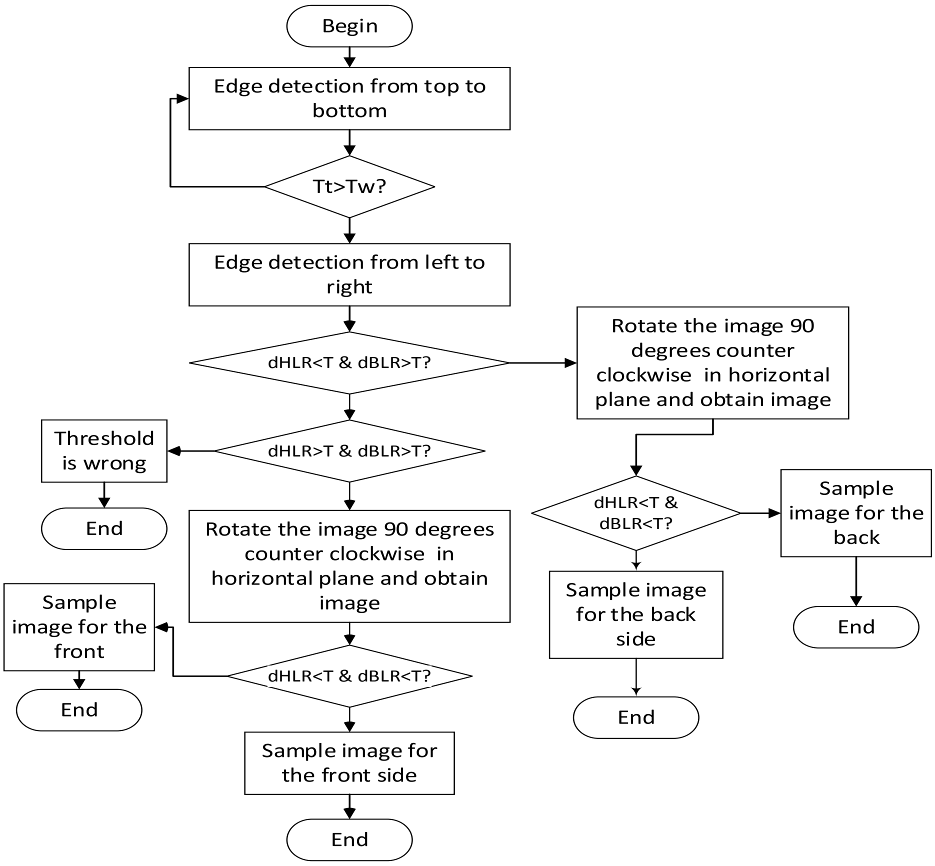

Fig.6 Testing flow chart for the side image of the plastic part

D. Plastic testing zoning. In this step, the detection area of the plastic part will be designated. It will be divided into the top detection area and the bottom one. The top detection area is between the top left line and the top right one in the image; the bottom detection area is between the bottom left line and the bottom right one.

Dark grain extraction.

A. Dark grain extraction theory based. Based on further analysis to the image of the plastic object with dark grain after preprocessing, it can be found that, the pixels of the normal part in plastic parts surface are endowed with white corresponding pixel values in binary operation; while the pixels of defects in plastic parts are endowed with black because its value can not reach local binarization threshold. Dark grains caused by scratch or collision are always slender and have continuity within a certain range. Also these dark grains have certain directions, which seldom change. Therefore, this algorithm adopts track and prediction method for continuous directional detection to the suspected dark grain defects.

If the system scan image from left to right, from top to bottom, this detection is defined as "right-bottom detection"; if it is from right to left, from top to bottom, it is called “left-bottom detection". During "right-bottom detection" process, if image scanning module detected dark grain pixels, it will take this point as the center and traverse pixels along its bottom and right direction. When it discovers the next bright spot, it will take this spot as a new center and continue the scan along its right and bottom direction, and so on. “left-bottom detection” process will works in the same way.

B. Dark grain extraction operation steps. This section will establish a dark grain track-prediction-extraction model, and the dark grain detection process will be described in detail. In order to facilitate discussion, in a track-forecast template, define that x represent any pixel in image, parameter L is the length for tracking and forecast, Lmax represents the longest tracking length, Variable i is the number of current scanning line, j is the number of columns scanning at the moment; Constant I is the maximum number of lines of image pixels, J is the maximum number of columns, Lmax represents the longest tracking length, which is a threshold of dark grain pixels for detection. Constant I, J, T can be modified and reset.

In this algorithm, “left-bottom detection" and "right-bottom detection" will begin as soon as the pixel of dark grain is detected. The whole process schematic diagram is as shown in Fig. 7 and Fig. 8, while x_{22} and x_{33} are supposed as dark grain pixels.

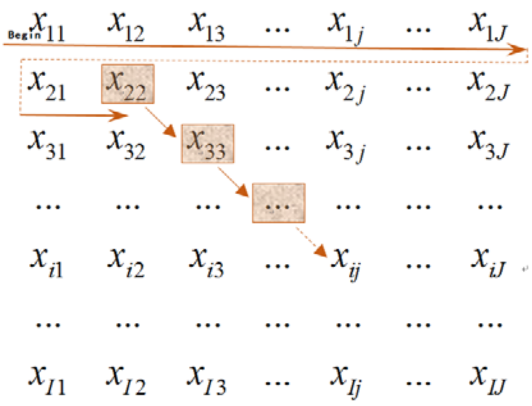

Fig. 7 right-bottom detection

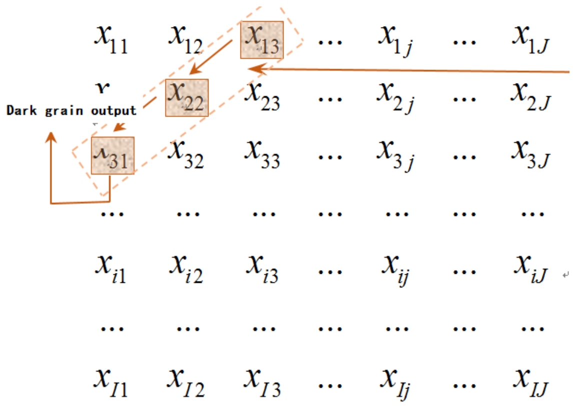

Fig. 8 left-bottom detection

According to the predicted characteristics of dark grain, concrete scanning operation and its algorithm flow chart is as shown in Fig. 10:

Step 1: Data initialization : L=0; L_{max}=0;I=0; J=0; i=0 is defined as the first pixel in left side;

Step 2:"Right-bottom detection" will begin from left side to right side to check if there is any dark grain. If a dark grain exist, the location will be stored and go to Step 3;otherwise, the scan will continue, when i=I, Right side detection will begin for the next line, that is i=0, j+j+1, it will stop until i=I and j=J, then, go to step 8.

Step 3: Mark the bright spot pixel and let L=0

Step 4: Calculate using Eq. 3:

$$L = L+1 \ i = i+1 \ j = j+1 \tag{3}$$

As soon as a dark grain pixel is discovered, the pixels in its right and bottom directions will be checked to see if there is a scratch.

Step 5: Determine whether parameters meet the requirement of Eq. 4. If it is true, it means that the dark grain length exceeds the threshold, or the "right-bottom detection" reaches to the edge position, then go to **Step 6**; Otherwise, restarting from the stored scanning position in **Step 2**

$$L < L_{\max} \ i < I \ j < J \tag{4}$$

Step 6: Check if pixel x_{ij} is a dark grain pixel. If it is true, go to **Step 4 and Step 5;** otherwise, go to **Step 7.**

Step 7: Check if $L > L_{\max}$. If is true, restarting **Step 2** from the stored scanning position; otherwise, go to **Step 8.**

Step 8: The dark grain detection is finished, the dark grain with $L > L_{\max}$ will be marked by wireframe and sent to the users.

Experiment

After image preprocessing and dark grain extraction operation, the result for the collected image is as shown in Fig.9. The picture in left is the front of the tested plastic part, and the picture in right is the result after image preprocessing and extraction. It can be learned that the algorithm in this paper can detect and mark the dark grain with good performance in terms of high accuracy and speed.

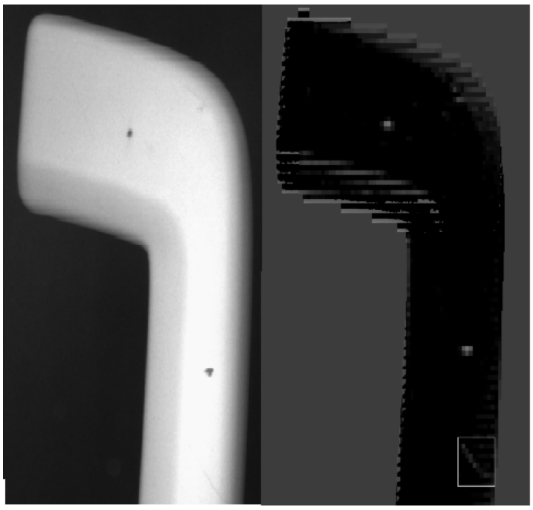

Fig. 9: The result of dark grain extraction

Conclusion

In this paper, image preprocess such as noise filtering and binarization are combined with the dark grain image feature extraction algorithm, and a new dark grain detection algorithms is presented on this basis. This algorithms is of fast calculation speed, which can realize the advantages of real-time response. Also, this algorithm is of high identification accuracy, and it can be used for surface testing system, which can accomplish the pick work for plastic parts with dark grain appearance accurately and efficiently.

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