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Research Article

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Thread image processing technology research based on combination of edge detection and sub-pixel positioning

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ABSTRACT

This paper introduces a new method for auto-measuring parameters of thread based on image processing techniques. According to the characteristics of the thread, this paper select median filtering method, Histogram edge detection and sub-pixel positioning and other image processing methods. Then the parameters of thread, such as the pitch diameter, half of thread angle and the pitch of thread were obtained, an example image was introduced to prove this method. It is very useful in improving the detection precision of thread.

Keywords: Thread parameters; Edge detection; Sub-pixel positioning; Curve fitting

INTRODUCTION

Thread is the most common form of connection in manufacturing machinery and equipment, it is widely used. Thread shape will affect the quality of connection seriously. But quality detection of thread has not been able to realize the automation so far, most still remain in the manual basis on micrometer. Traditional detection methods often lead to big error, low efficiency and the evaluation result was affected by human factors. In recent years, image processing technology was widely applied in the detection of thread parameters [1-3].Generally, thread was placed in a parallel light field, the projection or reflection imaging by optical system, using CCD camera as the acceptable image hardware equipment. After digitization, image processing and analysis were realized by computer. In the process of image processing, the edge point data was obtained, and the geometric parameters of the object also can be calculated [4-7]. This non-contact measurement technology will be very helpful for reducing the unqualified ones by means of measuring, analyzing and giving appropriate evaluation.

However, the precision of traditional image processing method is very limited. It can only reach pixel level precision [8-9]. The purpose of this paper is to introduce a kind of new method: According to the characteristics of thread image, median filtering algorithm was used in the process of preprocessing. Then the gray histogram segmentation method was used to make the image to a binary image. And then through the edge tracking, make the image clearer, subsequently the image was subpixel edge positioned based on polynomial interpolation. The parameters of thread, such as the pitch diameter, half of thread angle and the pitch of thread can be obtained.

The result of experiment show that this method is of high precision, good adaptability.
It can reach the sub-pixel level and can be applied to various parts image of the detection.

FUNCTIONS OF COMPOSITION AND PREPROCESSING OF IMAGE

This method is mainly realized by software, flow chart is shown as follow：

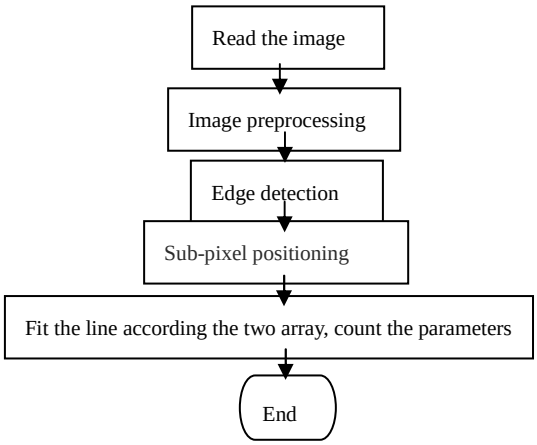

Fig. 1: A flow chart of image processing

In the process of image acquisition and generation, the image will be influenced by various noises and interference, then distortion will generated, so quality of the image will decline. In order to remove noise and improve image quality, preprocessing of image is very necessary. The main influence factors were geometric distortion that generated from imaging system and noises that generated from photovoltaic conversion, analog-digital conversion.

To reduce noise, low-passing filter can be used, but it will make the edge fuzzy because a lot of information lost. On the other hand, we could use high-passing filter for better edge, but noise was strengthened. Considering the two factors, median filter was chosen.

Median filter is a nonlinear signal processing method, corresponding to a median filter of course. The central idea of the filter is based on the local median as the filter output. It will effectively preserve useful information and reduce noise, especially for the inhibition of salt and pepper noise and impact noise. The method is very simple: scanning the image by particular window, for example 3*3, then rearranging the entire pixel according to the gray value (rising or dropping), the median was given to the central pixel. The formula is shown as follows:

$$g(m,n) = Median\{f(m-k,n-l),(k,l \in W)\} \quad (1)$$

Fig. 2: Original image

Fig. 3: Mean filter image

The number of pixels within a window usually is odd, so that there is an intermediate pixel. If the number of pixels within the window is even, then take average value of pixel. Template 3 * 3 was used here. Of course, other template (5*5、7*7) also could be chosen for better result.

The edge information was reserved perfectly after a median filtering. After repeated experimental study found that, less noise in the image, the contrast between the object and background is better. The image after median filtering is almost not affected by noise interference.

EDGE DETECTION

The purpose of edge detection is to find the boundary between the research background and object or object boundaries in an image, such as an object boundary, the shadow boundary and so on. The so-called boundary refers to its surrounding pixel gray those pixels set step change or hill shape change. Usually the object boundary was determined by the gray value of the point in the image. It is a process of finding and locating discontinuous gray value.

The classical edge extraction method is to research every pixel gray value change in a neighborhood in the image, using edge near one order or two order directional derivative variations, with a simple

Generally classical algorithm was used to find the location of the edge pixels, and the whole pixel positioning precision was gotten, the process was called coarse positioning. Owing to the reasons for noise filtering is not complete; edge may be interrupted or broadened, so there were two parts in edge detection: first extract the edge point, then get rid of some redundant point or connect the discontinuous point, finally connect a continuous curve.

The thread image has relatively simple structure and high quality. The contrast of the object and the background is big. It will increase the difficulty for subsequent image measurement if edge detection operator method was used in processing of edge extraction. This provides the possibility for the gray histogram threshold method is used to extract the edge point in the actual process of research.

Two-peak shape histogram method is threshold algorithm in a kind of direct and simple method. Its purpose is to try to select the optimal threshold, so that the detection error of object detection and background is minimum. Assume the image includes only the detection of object and background, then the histogram graphics like a valley between two peaks. It is minimum error value at the bottom of the graph. Therefore can intuitively in the gray level histogram find the bottom of the range, and thus determine the threshold size. As can be seen from the graph, the bottom of the value is in between, through the actual measurement, to determine the threshold of 165. Then according to the threshold value, a binary image formed. It is a sharpening image. Then scan the image column by column and search the image edge, then obtain the edge contour curve finally.

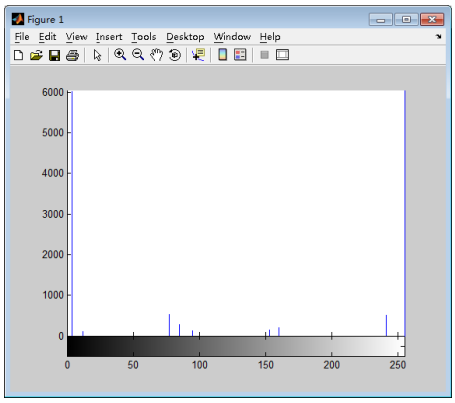

Fig. 4: Gray histogram

The edge line extracted is discontinuous; the results can not be used to calculate the coordinates of edge points, so we need to introduce contour tracking. The purpose of contour tracking is to obtain only a single pixel edge contour, and remove burrs on the contour and other non contour line noise. The basic method of contour tracking is: find the target object pixels on the contour according to some strict criteria, and use some characteristics of these pixels, other pixels on the object could be founded according to some tracking criterion. Searching from left to right, from bottom to top in the image, the first black point found must be the bottom left of the boundary points, recording the coordinates of this point, so the adjacent boundary point lies in one of its right, upper right, upper, upper left point.

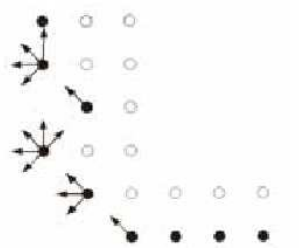

Fig. 5: Contour Tracing Algorithm

Fig. 6: Edge Detection Image

Use the following criteria: track from the first boundary point, the search direction is along the defined initial upper left. The top left point is the boundary point if it is black, otherwise the search direction 45 degrees clockwise until the first black point was found. Then this black point was defined as the new boundary point, then the search direction was defined as lower left ,continue to use the same method to search for the boundary point, until return the original point.

SUB-PIXEL POSITIONING AND MEASUREMENT OF PARAMETERS

Analysis image according to the given target characteristics (such as noise filtering, prominent characteristics, feature extraction and fitting grayscale characteristics, etc.), to identify and locate the features the most consistent with the target, realize the goal is better than that of integer pixel accuracy of positioning, called image sub-pixel positioning technology. There are many kinds of sub-pixel positioning method. This paper uses polynomial interpolation positioning method.

Suppose R is the gradient magnitude of any point in image, R0 is the gradient mode of edge point P0 (m, n), R-1, R1 respectively is two gradient magnitude of adjacent pixel point P-1, P1 in the gradient direction .Through the sub-pixel coordinates is:

$$x = m + \frac{R_{-1} - R_1}{R_{-1} - 2R_0 + R_1} \cdot \frac{\omega}{2}\cos(\theta) \quad (2)$$

$$y = n + \frac{R_{-1} - R_1}{R_{-1} - 2R_0 + R_1} \cdot \frac{\omega}{2}\sin(\theta) \quad (3)$$

Where ω is distance from the adjacent pixel point to the edge point, where θ is angle of the gradient direction with the positive X axis.

In this paper, the rules are as follows: scan the image and record the edge sub pixel coordinates, then we will obtain two one-dimensional arrays. For each element in the two arrays, then we will get the turning point, we will get four arrays. Then the least square method was used realize curve fitting [10-12,]. It was not necessary that all the points fitting the curve. But the curve can reflect the given basic data trends and weaken the influence of error. So it is very accurate.

Calculating average valve of the horizontal ordinate of the four fitting curve every arrays, it can be expressed as D_1、D_2、D_3、D_4; So we will obtain:

External diameter of thread:

$$d = D_4 - D_1 \quad (4)$$

Bottom diameter of thread

$$d_1 = D_3 - D_2 \quad (5)$$

Pitch diameter of thread

$$d_2 = \frac{d + d_1}{2} \quad (6)$$

Pitch：

$$p = \frac{D_2 - D_1 + D_4 - D_3}{2} \quad (7)$$

As to spiral angle, we can obtain it by fitting line according the turning points. In Matlab, it could be expressed as: Plot(x1, y1, 1) [13]. For example, the standard pitch is 2.550, the average value of image processing is 2.554, so the deviation is 0.005, and it can meet the requirement of the measurement precision. Once the detection system is fixed, there is a fixed ratio between the image distance and the actual size. So the image distance multiplied by the proportion of value, it is the actual size.

Table2. Outcome of the pitch

Number	1	2	3	4	5	···
result	2.553	2.542	2.557	2.555	2.536	···

CONCLUSION

This method could be applied in measurement of regular screw threads. With help of this method, it is very convenient and quick in screw thread image processing. Deviation is so small that it can be ignored. The greater the amount of image data, the precision of the results is higher.

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