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# Research on the Algorithm about Optical Fiber Parameters Measurement

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***Abstract***

*We can measure the geometry parameters of the optical fiber efficiently and intelligently for the use of machine vision technology, the main operations contain threshold segmentation, removing interference, filtering, fitting etc. Compared with the traditional optical fiber measurement algorithm, this method has the advantages of high processing speed, high accuracy and not too relying on the operation level. It can also be applied to the size measurement of other small linear object.*

***Keywords****: optical fiber images, size measurement, machine vision*



## 1. Introduction

Optical fiber is one of the widely used materials in the communication field [1]. It can generally be divided into two kinds according to the several of parameters: one is physical characteristic parameters, such as dispersion, the cutoff wavelength and various loss, etc.; Another kind is geometrical characteristic parameters, including optical fiber core and cladding diameter, roundness and the concentricity error between fiber core and cladding center etc.

In recent years, with the development of the optical fiber technology, the precision measurement of the various parameters of optical fiber itself makes a very important sense in optical manufacturing and application [2]. The main measurement parameters of optical fiber including: loss, spectral characteristics, transmission characteristics; the polarization characteristics; geometric parameters and so on [3]. In order to ensure the quality, production and application department are testing the fiber strictly according to the national standard. There are mainly 4 kinds of inspection methods, they are: artificial discriminant method, image shear method, pulse counting method, digital image processing method. Extracting the edge feature that reflects the image gray change from the image is an important branch of digital image processing [4]. Machine vision can be applied to many field, the main application is in the field of the image automatic interpretation: the radiation images, microscopic images, medical images, multi-band remote sensing image, synthetic aperture radar image, space, etc. The automatic interpretation of aerial image explanation [5]. The method based on digital image processing of automatic measuring the geometric parameters of optical fiber end has the advantages of high processing speed, high measurement accuracy and not too relying on the operation level.

In the past measuring optical parameters either needs artificial participation or need high precision instrument [6]. This paper researches the method of the measurement of fiber geometry parameters by using the machine vision, and the result shows that this method is effective [7].

## 2. Algorithm Research

### 2.1. Algorithm Process

This paper gets the geometrical characteristic parameters ultimately based on the machine vision method, using the Halcon software to process the input optical fiber image. The specific process is as follows:

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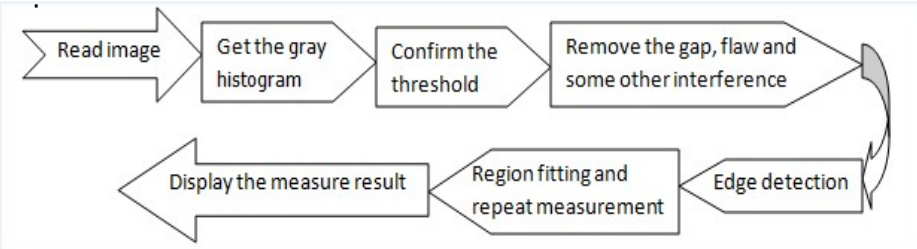



Figure1. Algorithm Process

### 2.2. Image Preprocess

Read the image which is needed to measure. Display as below:

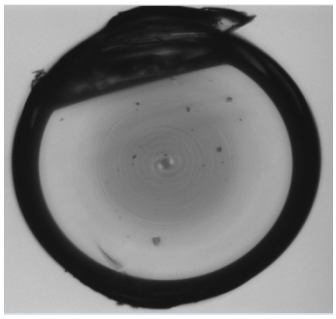


Figure 2. Source Image

Get the gray histogram of this image:

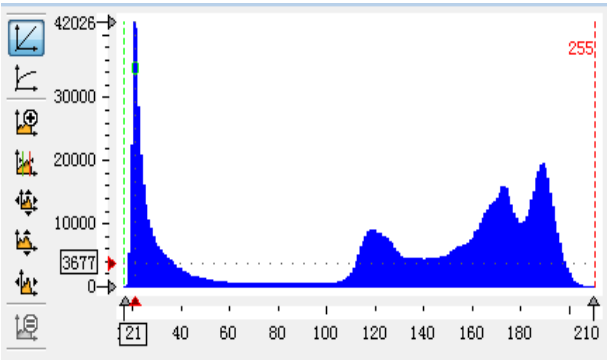



Figure 3. Gray Histogram for Source Image

### 2.3. Remove the Interference Factor

Getting the average gray value according to the gray histogram of the image and getting the needed threshold according to the relationship between them. As shown in figure we can see that the cut image is not the original fiber circular arc any longer, but the irregular linear area. This kind of boundary will interfere with the right results, so it must cut off the irregular incision area first to eliminate the influence of the diameter measurement. The cladding and fiber core will be separated according to the threshold which has been obtained, then using the threshold will be part of the incision can be found and removed. Resection of incision image below Figure 4:

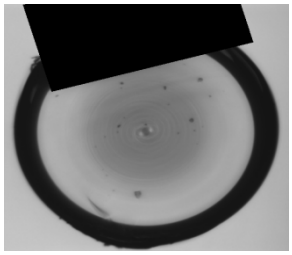


Figure 4. Remove the Slot from the Source Image

### 2.4. Edge Detection

Classic edge detection method contains the first derivative maximum point algorithm (for example, Robert operator, Sobel operator, Canny operator), the second derivative zero crossing algorithm (such as Laplacian operator, LoG operator), and so on. The new edge detection methods are the method of mathematical morphology, fuzzy operator method, neural network, wavelet analysis, genetic algorithms, dynamic programming method, the method of fractal theory, and so on.

The method of the testing image have a certain degree of ambiguity when Application of machine vision method for MEMS dynamic parameters were measured is presented in [8]. It gives a sub-pixel algorithm to overcome the problem. And a modified algorithm based on the mean shift is introduced in [9].

This paper use the Halcon operator: edges_sub_pix(Image : Edges : Filter, Alpha, Low, High : ), use the Deriche, Lanser, Shen or Canny filter to extract pixel edge.

We can get the needed cladding area by using the optimal threshold, then taking the pattern transformation of the gotten area, to get the circle which has the approximate size of the region. We can capture out the cladding region of the image from the original image by making use of the gotten round area, then wiping out the influence of cladding outer boundary. The intercepting image is shown in Figure 5, and then to measure the related parameters of the fiber core.

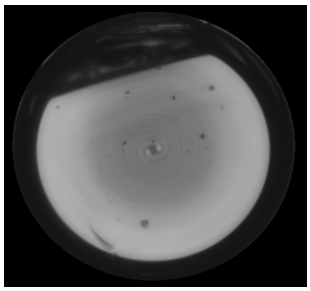
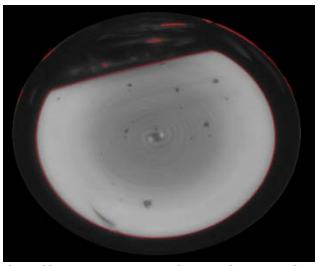
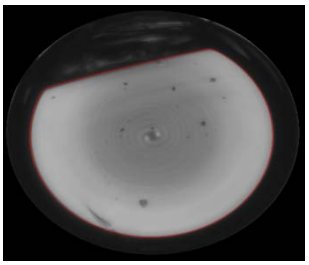


Figure 5. Remove the Cladding Peripheral Area from the Source Image

Get the edge of the fiber core according to the function operator. Then make edge selection and combination to get an optimal longest edge. Figure 6 shows the detected edges, as well as the selection and combination of the edge:



(a) Fiber core edge detection



(b) Fiber core detection edge after screening

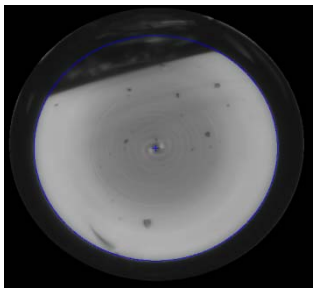
Figure 6. Fiber Core Edge

**2.5. Fitting Measurement**

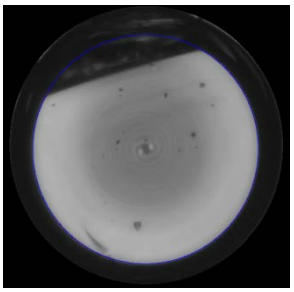
There are many existing algorithms for the circle and ellipse fitting. Circle fitting algorithms commonly are: least squares method, the Hough transform; Ellipse fitting algorithms generally contain: Hough transform, the method based on invariant moment, the least square method.

The least square method is the most commonly used in the field of fitting method, its applicability is wide and it has high precision. The principle of the method is to find the best matching function of a set of data by minimizing the error sum of squares, to obtain some absolutely unknowable truth value by using the method of the minimalist, and make the square sum of error is minimal. Its advantage is easy to implement simple by computer program; Disadvantage is it can't get irrational Numbers that determine the solution of the root. The Hough transform is one of the basic method of image recognition from geometry in image processing, the application is very wide, also has a lot of improved algorithms. The advantage of the method is noise proof; Defect is high computational complexity, but can be optimized. The scholars put forward the geometry of a concentric double elliptic arc fitting method for elliptic fit [10]. The Halcon software is used in the study on the algorithm of this paper in particular operator on circular and ellipse fitting, don't need complicated code and a large number of calculations, saving time, and the result is clear and intuitive.

Algorithm concrete implementation is: to take shape fitting to the gotten edges, fitting round and oval, respectively. As shown in Figure 7:



(a) Fiber core edge fitting circle



(b) Fiber core edge fitting ellipse

Figure 7. Fiber Core Edge Fitting

At this point, we have gotten the fiber core diameter and the center of the circle, change the edge selection parameters, multiple measurements, obtained the reasonable average and can be identified as the diameter of the fiber core and the center of the circle, and identify the radius of the long axis and short axis of the ellipse fitting, the roundness of fiber core can be obtained according to the following formula (1):

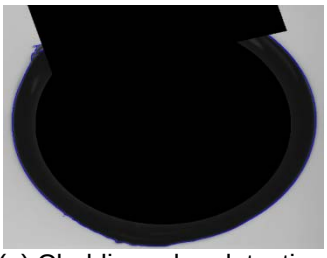
Roundness:

$$\beta = (R_l - R_s) * 2 / (R_l + R_s) \quad (1)$$

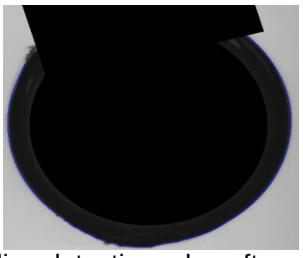
Figure 8. Remove the Slot and Fiber Core Area from the Source Image

Fiber core measurement is completed. Then cut the core part area from the original images, the part of the incision is removed from the original image at the same time and method have been given above. Measure the dimension parameters of cladding parts with the rest of the image. The image has been cut is shown in Figure 8.

Similarly, it can be tested with this method, getting the edge detection, the edge needed, and the fitting circle and fitting ellipse, the result shown in the Figure below 9, 10:

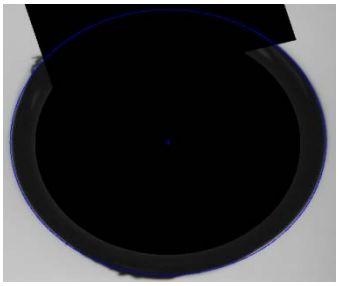


(a) Cladding edge detection

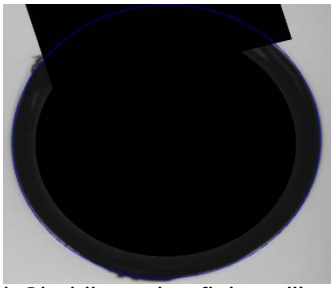


(b) Cladding detection edge after screening

Figure 9. Cladding Edge



(a) Cladding edge fitting circle



(b) Cladding edge fitting ellipse

Figure 10. Cladding Edge Fitting

Get the cladding diameter, the circle and the out of roundness after repeated experiments.

Hypothesis the center of the circle of fiber core and cladding is respectively: A(X1,Y1), B(X2,Y2)

The concentricity can be calculated by the formula (2):

$$\varepsilon = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2} \quad (2)$$

## 3. **Experimental results**

Figure 11 shows the fitting circle and ellipse, and the center of the circle according to fitting graphics.

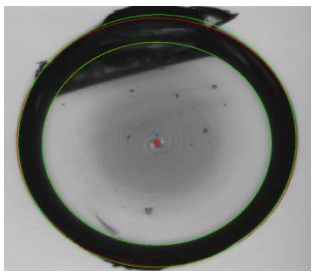


Figure 11. The Final Fitting Result

## 4. Conclusion

This paper is based on the machine vision technology, to make digital image processing to optical fiber end face images, through a variety of function operators, in addition to the interference such as cut, crack in the image. Finally through threshold processing, edge detection, the graph transformation, fitting methods to get the fiber core and cladding diameter, roundness, concentricity and other geometry parameters. Experiments show that the method largely saves human labor, and do not need to buy expensive precision measuring instruments; This method has the characteristics of intuitive, simple, rapid, and improves the measurement efficiency and saves the cost.

## Acknowledgement

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