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Image processing method for multicore fiber geometric parameters

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ABSTRACT

An image processing method has been developed to obtain multicore fiber geometric parameters. According to the characteristics of multicore fiber, we using MATLAB to processing the sectional view of the multicore fiber (MCF), and the algorithm mainly concludes the following steps: filter out image noise, edge detection, use an appropriate threshold for boundary extraction and an improved curve-fitting algorithm for reconstruction the cross section, then we get the relative geometric parameters of the MCF in pixels. We also compares different edge detection operator and analyzes each detection results, which can provide a meaningful reference for edge detection.

1. Introduction

In recent years, the development of traditional single-core optical fiber has into a bottleneck period [1,2], and because of its potentially huge transmission capacity, multicore optical fiber have attracted more and more attention [3–5]. With the deepening research of the multicore fiber, it has been widely used in many fields, like the light sensor, light detection, optical fiber transmission system, etc [6–8].

In the fiber transmission network with multicore fiber, the connection between the fiber bundle will directly impact on the performance of the whole system, how to connect optical fiber with the control of connection loss is very important [9]. Therefore, as a connection reference of the optical fiber, it is necessary for us to understand the geometric parameters of the multicore optical fiber cross-section. Traditionally, there have some method to get geometry parameters of fiber cross section, including near-field image method, refractive near-field method, side-looking method [10,11]. But these measuring methods are complex, and expensiveness of instrument. Application of image processing technology to processing the collected optical fiber end-face images and get the parameters of the optical fiber is the current development trend.

In this paper, we use 36-core optical fiber as the research object. According to the characteristics of multicore fiber end-face, which obtained by high resolution CCD camera, we put forward that use image processing method to process the sectional view of the multicore fiber. Through the noise processing, boundary detection, bit-manipulation, we used geometric fitting to reconstruction the geometric parameters of the fiber cross section, and a curve-fitting algorithm are improved to adapt to the characteristics of multicore optical fiber end-face. Then through image recognition, we can recognition the shape and test the size of the optical fiber end-face under the premise of retain original features of the physical information. In addition, we also compared and analyzed different edge detection operator.

2. Principle analysis

The end-section image of MCF were processed using image processing software (MATLAB). According to processing sequence, the method can be divided into four parts: image preprocessing unit, image segmentation unit, image edge detection unit, fitting and calculate unit. Principle block diagram is shown in Fig. 1.

Known by the principle block diagram, first we preprocessing the RGB image which recorded by a CCD camera. Although CCD camera can get high quality, high resolution image, however, due to the influence of the external environment image may have many noise, if make the direct detection and analysis on the acquired images, will unable to get accurate result, so prior to the detection and analysis, need to preprocessing the image, aims to improve image quality.

Here, we pretreat the RGB image obtained by the camera into the gray image. Gray image means divided black to white into 256-order according to the logarithmic relationship, and correspond each pixel of the original RGB image to a gray scale. Due to

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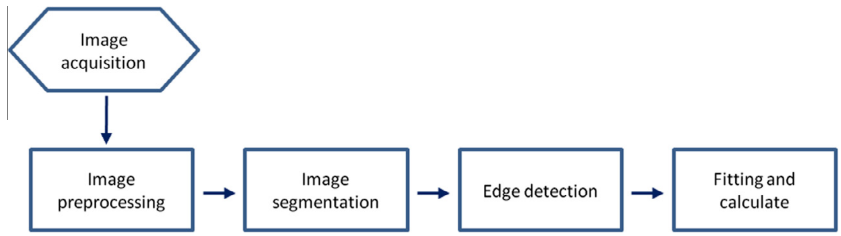

Fig. 1. Principle block diagram.

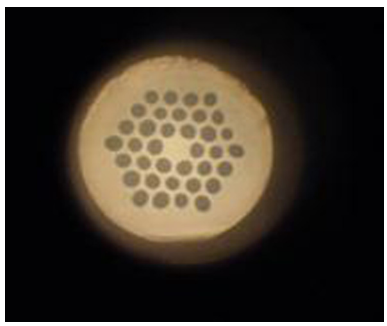

Fig. 2. RGB image of MCF collected by camera.

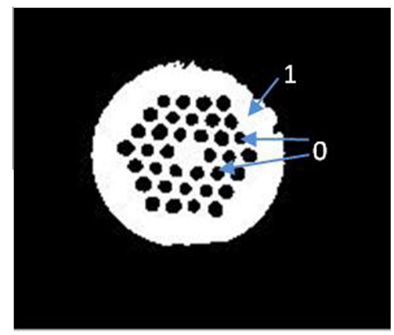

Fig. 5. Binary image.

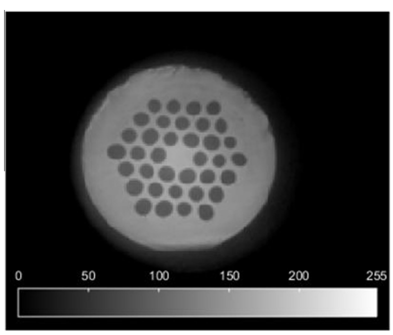

Fig. 3. Gray image.

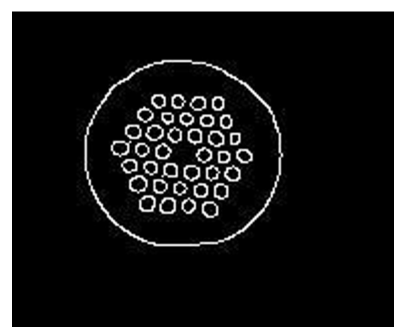

Fig. 6. Detect edges from the fiber end-face with Canny operator.

its protection of edge information, we use Median Filter to filt Gaussian white noise. RGB image and gray image after preprocessing as shown in Figs. 2 and 3, respectively.

After image preprocessing, then second step is segmentation the image, mainly include binarization processing. Image segmentation is to separate the target image from the background. Defined the gray image as $f(x,y)$, the gray scale ranged is $[0, L-1]$, then choose a suitable threshold '*T*', and the image segmentation can be described by the following formula,

$$g(x,y) = \begin{cases} 1 \; f(x,y) \geqslant T \\ 0 \; f(x,y) < T \end{cases} \tag{1}$$

where g(x,y) is a binary image. In the process of segmentation, the key is the selection of threshold '*T*'. Here we defined n_k as the pixels of gray scale for *k*, so the total pixels '*N*' can be described by,

$$N = \sum_{i=0}^{L-1} n_i = n_0 + n_1 + \ldots + n_{L-1} \tag{2}$$

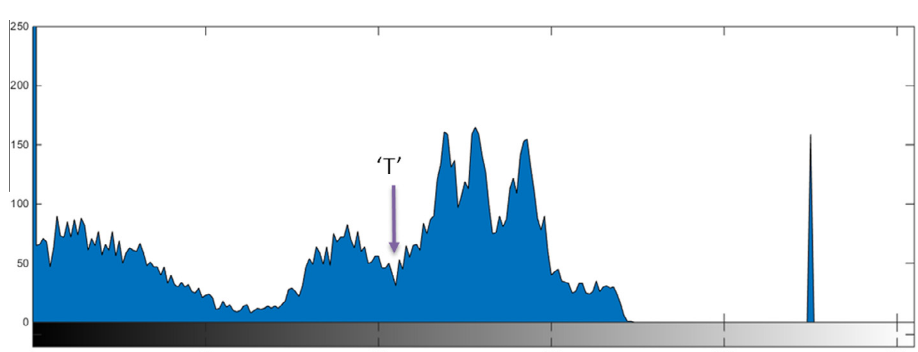

Fig. 4. Gradation histogram.