Evaluation of Optimal Edge Detection Method For Wool Fiber

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الخلاصة

تدرس الورقة بصورة اساسية خصائص صورة ليف الصوف المنتزعة باستخدام مجهر ضوئي متصل بالحاسوب الذي يلتقط صورة ثابتة لليف الصوف ثم معالجتها باستخدام برنامج الماتلاب وتطبيق طرق كشف حافات مختلفة. تمت مقارنة طرق (بروت، كندي، سوبل، روبرت، لابلاس - كاوس و التقاطع الصفري) خلال التجارب وتم تحديد الطريقة المثلى بالاعتماد على معايير احصائية كـــ معدل مربع الخطأ (MSE) التي تعتبر واحدة من معايير تحديد جودة الصورة، وتقييمنا ان طريقة كندي هي مناسبة لأنتزاع حافات الياف الصوف.

ABSTRACT

This paper mainly studies characteristic of wool fiber image were extracted by using Optical microscope attached to a computer which capture still images of wool fiber and then pre-processed using MATLAB software and then was applied different edge detection methods have been applied. The Prewitt, Canny, Sobel, Roberts, Laplacian of Gaussian (LOG) and zero-cross methods of edge detection are compared through the experiments and determine of optimal method based on statistical parameters as Mean Square Error (MSE) is considered as one of the criterion that identifies image quality, we evaluated that canny method is suitable for extracting the edge of the wool fibers.

***Keywords*:** Edge detection; digital Image processing; wool; Fiber identify

INTRODUCTION

The language of today's wool industry employs the term diameter to describe a characteristic once described as fineness. In geometry the term "diameter" is exclusively used to describe the maximum transverse dimension of a circle or a sphere. Wool fibers are not circular in cross-section. The cross sectional shape is irregular. Some fibers are nearly circular, some are roughly elliptical, some are ovoid, and some can be visualized as elongated ovals or shapes that approximate ovals with concavities [1]. Traditional methods to identify wool fiber, such as optical microscopic method, scanning electron microscope, solution analytical method, etc [2]. They all have their own advantages and shortages and there are not applied in a wide range. With the development of digital image processing technique has been applied in the fiber detection field. As image processing method has the advantages of high accuracy, reliability, and high speed etc, it has great potential for development [3]. In this paper, we take the optical microscope image of more than 50 wool fibers images with the same kind are used in this research. The JPEG format is took as the storage format, in order to reduce the proportion of storage space. The identification wool fibers are usually by distinguishing the surface morphological features, the edge detection is an important process to extract the features. The Prewitt, Canny, Sobel, Roberts, Laplacian of Gaussian (LOG) and zero-cross methods of edge detection are compared through the experiments and determine of optimal method based on statistical parameters.

PRE-PROCESSING OF WOOL FIBER IMAGE

First of all, the digital images of wool fibers are captured by CCD camera emplaced upon optical microscopy have been used Matlab 7.3 in this work. In order to achieve the computer automatic of edge detection method for wool fiber, image pre-processing for wool fibers is needed. Image pre-processing effect on the final evaluation. In this paper, the optimal pre-processing steps included grayscale image transformation, convert image to binary image based on threshold, image contrast enhancement. These operations were designed to make the input image with clear quality, obvious edge [4]. Fig. 1 is the original wool fiber image. The final image after pre-processing was shown in Fig.2:

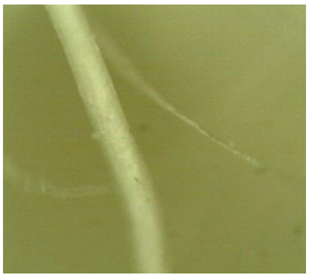

Figure-1: Original wool image.

Figure-2: Wool image after pre-processing.

Edge detection methods

Several edge detections have been proposed with different goals and mathematical and algorithmic properties. Consequently, one problem is encountered by vision systems developers which are the selection of an edge detector to be used in a given application. This selection is primarily based on the definition of the influence of the image characteristics and the properties of the detectors on their performance [5]. There are many edge detection methods, but here we study the common methods.

A- Robert Operator

The Robert operator marks edge points only; it does not return any information about the edge orientation [6]. The Robert cross operator performs a simple and quick to computer 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of (2x2) convolution kernel. One kernel is simply the other rotated by 90°. Robert's gradient operators can be put in two forms; these are given by[7]:

$$G(x,y)=\sqrt{\left[I(x,y)-I(x-1,y-1)\right]^2+\left[I(x,y-1)-I(x-1,y)\right]^2} \quad (1)$$

OR

$$G(x,y)=\left|I(x,y)-I(x-1,y-1)\right|+\left|I(x,y-1)-I(x-1,y)\right| \quad (2)$$

The main reason for using the Roberts operator is that it is very fast implementation, comparing with the other edge detection operators. Only four input pixels are need to be examined to determine the value of each output pixel, and only subtractions and additions are used in the calculation [8]. Roberts operator is very sensitive to noise and only gives a strong response to very sharp edges [9]

1	0
0	-1

G_X

0	1
-1	0

G_y

B- Sobel Operator

The Sobel edge detection masks look for edges in both the horizontal and vertical direction and then combine this information into single metric [6]. The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that corresponds to edges. The operator consists of a pair of (3x3) convolution kernel.

1	2	1
0	0	0
-1	-2	-1

G_X

-1	0	1
-2	0	2
-1	0	1

G_y

Sobel operator is slower than the Robert Cross operator, but its larger convolution kernel that smoothers the input image to a greater extent and so makes the operator less sensitive to noise. Generally, the operator also produces a considerably higher output values for similar edges compared with the Roberts Cross. Sobel and Robert operators are not the best, but they are reasonably effective, simple, and so useful [9].

C- Prewitt Operator

The Prewitt operator has two masks given as follows [10]:

-1	-1	-1
0	0	0
1	1	1

Gx

-1	0	1
-1	0	1
-1	0	1

Gy

The Prewitt operator is slightly simpler to implement computationally than the Sobel operator, but it tends to produce somewhat noisier results. It can be shown that the coefficient with value 2 in the Sobel detector provides smoothing.

D- Laplacian of a Gaussian Operator

Consider the Gaussian function

$$f(x,y) = \frac{1}{2\pi\sigma^2}\exp\left(-\frac{r^2}{2\sigma^2}\right) \qquad (3)$$

This is a smoothing function which, if convolved with an image, will blur it. The degree of blurring is determined by the value of σ .The Laplacian of this function (the second derivative with respect to r) is [11]

$$\nabla^2\left\{\exp(\frac{r^2}{2\sigma^2})\right\} = \frac{r^2-\sigma^2}{\sigma^4}\exp\left(\frac{r^2}{2\sigma^2}\right) \qquad (4)$$

For obvious reasons, this function is called the Laplacian of a Gaussian (lOG) knowing that it has two effects: It smoothes the image (thus reducing noise), and it computes the Laplacian, which yields a double-edge image, Locating edges then consists of finding the zero crossings between the double edges.

E- Zero-Crossings operator

This detector is based on the same concept as the LOG method, but the convolution is carried out using a specified filter function.

F- Canny Operator

The Canny operator is the most powerful edge detector provided by function edge. The basic procedure can be summarized in the following steps [11]:

(1) The image is first smoothed using a Gaussian kernel.

(2) Find the edge strength $E(x,y) = |G_x(x,y)| + |G_y(x,y)|$.

(3) Calculate the edge direction: This is easily calculated as $\theta = \tan^{-1} G_y(x,y)/G_x(x,y)$.

(4) Digitize the edge direction.
(5) Nonmaximum suppression.
(6) Hysteresis.

RESULTS AND DISCUSSION

After image pre-processing on more than 50 wool fibers, we get results by applying different operators with different thresholds values on the edge images, where the size of image (941x704) pixels. Figures (3-8) illustrates the results of the edge detector images by using Prewitt, Canny, Sobel, Roberts, Laplacian of Gaussian (LOG) and zero-cross methods respectively.

Figure-3: Edge detection using Prewitt operator.

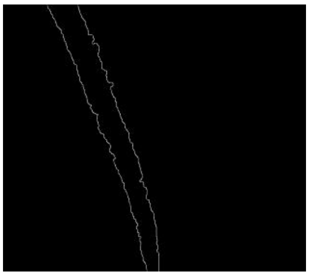

Figure-4: Edge detection using Canny operator.

Figure-5: Edge detection using Sobel operator.

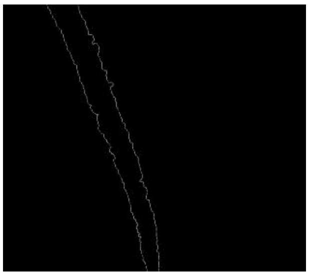

Figure-6: Edge detection using Roberts operator.

Figure-7: Edge detection using LOG operator.

Figure-8: Edge detection using zero-cross operator.

Criteria quantifying the performances of these edge detectors are desired. Two general classes of criteria are used as the basis for such evaluations: (a) Objective fidelity criteria: In this different images are evaluated on the basis of quantitative parameters. (b) Subjective fidelity criteria: human observers visually evaluate different images. Six types of errors define the performance of edge detector: (1) Omission: this error occurs when the detector fails to find an ideal edge. (2) Localization: this error occurs when the location of the unambiguous edge is different from the location of the ideal edge. (3) Multiple-Response: this error occurs when multiple edges are detected in the vicinity of an ideal edge. (4) Sensitivity: this error occurs when the detector localizes edges which do not belong to the support region of the ideal edge. (5) Suppression: Usually false-edge suppression is done by a thresholding operation. Suppression error occurs when there is a suppression of unambiguous edge while false edge persists. (6) Orientation: This error occurs when the estimated orientation of the detected edge is not equal to the given orientation.

The statistics measures are used to give the quality of image, and it is related to the principle of probability of gray level distribution in the image. Mean Square Error (MSE) is considered as one of the criterion that identifies image quality. It can be calculated from the equation [12]:

$$MSE = \frac{1}{\mathrm{MN}} \sum_{\mathrm{X}=1}^{M} \sum_{\mathrm{Y}=1}^{\mathrm{N}} (\mathrm{f}(\mathrm{x},\mathrm{y}) - \mathrm{f}'(\mathrm{x},\mathrm{y}))^2 \qquad (5)$$

where f(x,y) and f'(x,y) represent the noisy and original images in succession.

Tables (1) contain results of the optimal thresholds for dependent operators with errors values of (MSE). Figure (9) show the relation between thresholds values and Mean Square Error (MSE). This figure helps us in choosing optimal edge detection method and threshold which has the lower error value for edge detectors.

Table-1: results of edge detection method and thresholds with errors values.

Method	*Th.*	*MSE*	*Method*	*Th.*	*MSE*
	0.1	0.0031		0.1	0.0042
	0.2	0.0031		0.2	0.0042
Prewitt	0.3	0.0030	*Roberts*	0.3	0.0042
	0.4	0.0030		0.4	0.0042
	0.5	0.0007		0.5	0.0029
	0.1	0.0040		0.1	0.0035
	0.2	0.0040		0.2	0.0034
Canny	0.3	0.0040	*Laplacian of Gaussian*	0.3	0.0033
	0.4	0.0040		0.4	0.0025
	0.5	0.0040		0.5	0.0010
	0.1	0.0033		0.1	0.0035
	0.2	0.0033		0.2	0.0034
Sobel	0.3	0.0033	*zero-cross*	0.3	0.0033
	0.4	0.0033		0.4	0.0025
	0.5	0.0013		0.5	0.0010

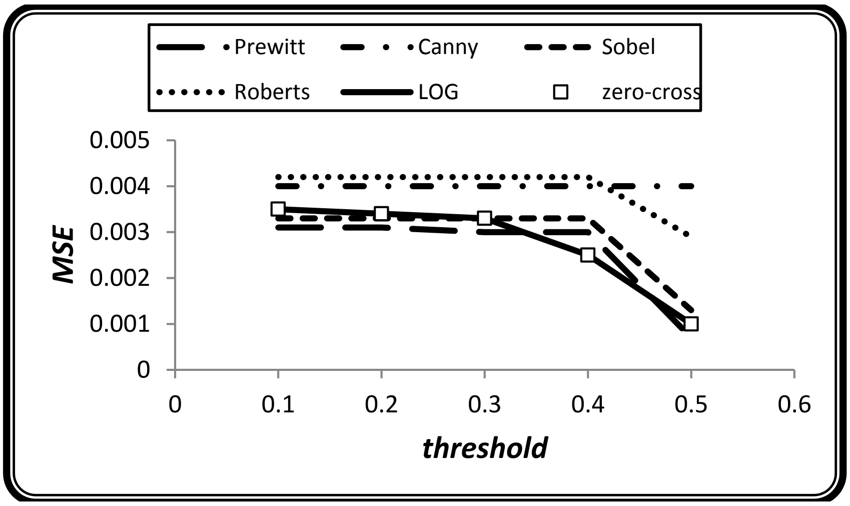

Figure-9: shows the threshold selection for edge detection method.

CONCLUSIONS

By using statistical criteria that thresholds effect on edge detection methods seem clearly at value (0.5) except canny method, that is constant for all Mean Square Error values. From the results we can see that for wool fiber images using canny operator can get good edge detection results, while other operators will result in loss of edge information. Therefore, gives us evaluate that canny operator is the best methods used to edge detect for wool fiber. Furthermore, using the criteria of human vision we get a clear image of the wool fiber, which helps us to determine the parameters and characteristics important to it.

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