# Measurement of Diameter and Scale of Cashmere Fibers by Computer Images Analysis

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**Abstract**

This paper mainly studies computer automatic measurement of cashmere diameter and area of cashmere fiber scales. It firstly uses Matlab7.0 to do simulation experiments to determine the appropriate image processing program that is suitable for fiber images obtained under optical microscope. The workflow of image processing includes image format conversion, image denoising, image segmentation, binarization, extraction of fiber edge and modificatory process. After image processing, it obtains the necessary binary image needed by the automatic measurement of parameters. The binary image is the basis of diameter and scale-area measurement of cashmere. This paper designs sub-measurement algorithm to achieve the automatic measurement of fiber diameter and pixel-measurement through pixel-by-point scanning to achieve the automatic measurement of area of cashmere fiber scales. It eliminates the error caused by the influence of man-made factors and improves the accuracy of the measurement, which lays the foundation of automatic identification.

*Keywords*: Image Processing; Cashmere Diameter; Scale Area; Automatic Measurement; Cashmere Fiber

## 1 Introduction

As the production of cashmere is scarce, a variety of clothing made by it is good, beautiful and elegant, so the cashmere price is expensive. In order to reap more benefits, many enterprises often blend wool and cashmere using different proportions. In order to safeguard the legitimate rights and interests of consumers, accurate and rapid identification of cashmere fiber is very important. To identify cashmere wool fiber, extracting its characteristic parameters is needed, and then identify according to characteristic parameters of the differences. In the past, artificial measurements are mostly used to extract the characteristic parameters. Such man-made factors take up relatively large and time-consuming efforts. In order to reduce the influence of human factors, computer automated measurement methods was used to extract the characteristic parameters needed. Diameter is recognized as an identification indicator, and to do such a detailed study of cashmere fiber diameter whilst realizing the computer automatic measurement of cashmere

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fiber diameter can avoid the human factor to impact the measurement results. Subsequently it provides the basis for fiber identification by fiber diameter.

# 2 Pre-processing of Cashmere Fiber Image

In order to achieve the computer automatic measurement of cashmere diameter, image pre-processing for cashmere fibers is needed. This paper studies cashmere fiber images collected under the optical microscope and compares it with images collected under the electron microscopy. Images of this paper contain unfavourable factors, such as the edge of the images being blurred, whilst the fiber and the background gray values do not differ greatly, and the border is fragmented, and so on. Thus, Matlab7.0 is needed to do simulation experiments to determine the appropriate image processing program that is suitable for fiber images obtained under optical microscope. After image processing, it obtains the necessary binary image need for the automatic measurement of diameter. Through simulation experiments, this paper determines the workflow of the image pre-processing shown in Fig. 1.

Fig. 2 is the original cashmere fiber image. The results of using this image processing method obtained by this paper to process Fig. 2 is shown in Fig. 3.
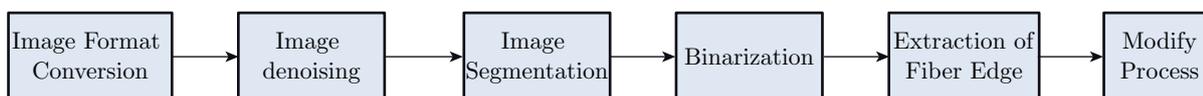


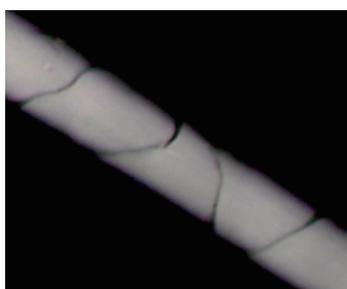Fig. 1: Workflow of image processing
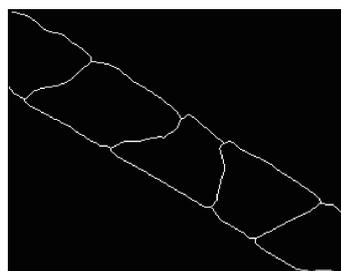


Fig. 2: Original cashmere image



Fig. 3: Image processing result

# 3 Measurement of Parameters of Cashmere

## 3.1 Measurement of Cashmere Fiber Diameter

Methods of fiber diameter measurement commonly used are area method, the main axis method, triangle law, and so on. In this paper, sub-measurement algorithm is designed to achieve the automatic measurement of fiber diameter, and this paper uses the algorithm to achieve the measurement of cashmere fiber diameter. The following section describes the basic principle of sub-measurement.

### 3.1.1 Principle of Using Sub-measurement to Measure the Diameter

The so-called sub-measurement method is to divide the cashmere fiber into N segments to obtain the value of each segment, and then take the average of all values is taken to obtain the cashmere fiber diameter. When N is larger, the two edges of the fiber are more similar to a parallel straight line, and the measured data is more accurate. The following section focuses on the implementation process of sub-measurement.

In one image, the lower-left corner of the image is the origin (0, 0), on the assumption that the horizontal direction is the x-axis direction and perpendicular direction is the y-axis direction. Sub-measurement is needed to be discussed on the two cases.

1) When the fiber is in the position shown in Fig. 4, namely, the tilted degree of the fiber is closer to the vertical, it is needed firstly to divide the Y-axis, according to the sub-situation of Y-axis to divide the cashmere fibers. Specific implementation steps are as follows:
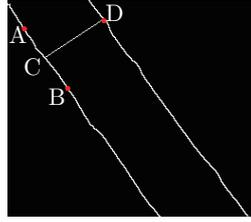


Fig. 4: Tilted degree is closer to the vertical

① The value of y coordinate is initialized to y1 and acts asa certain number of pixels as a unit. According to the order of increasing coordinate values, this paper divides the Y-axis into sections, and obtains the two endpoints of each section, then saves all the coordinates into an array Y [m] (m = 1, 2, 3, . . . ), y1 = Y [1];

② Along the y = Y [m] direction, to search the edge point of the fiber rightwards, and to stop searching after obtaining an edge point, the abscissa value X [m] of this point must be returned to. Similarly, along the y = Y [m +1] direction to search and return the edge point coordinates value X [m +1]. Thus, one boundary of the fiber is divided into m segments, and the endpoint coordinates of every section is obtained.

③ Assume that A and B are two endpoints of the nth section, as shown in Fig. 4, coordinate of point A is $(x_A, y_A)$, coordinate of point B is $(x_B, y_B)$.

Calculating the midpoint coordinates of segment AB is C $(x_C, y_C)$: where:

$$x_C = (x_A + x_B)/2,$$
$$y_C = (y_A + y_B)/2;$$

④ Calculating the slope of the straight line that goes through the midpoint of AB segment and plumbs AB segment is

$$K = \frac{x_A - x_B}{y_B - y_A};$$

⑤ Confirming the straight line that goes through C and plumbs AB segment is as follows:

$$x = \frac{(y_B - y_A)(y - y_C)}{x_A - x_B} + x_C = \frac{(y_B - y_A)(2y - y_A - y_B)}{2(x_A - x_B)} + \frac{x_A + x_B}{2}$$

⑥ Along the straight line equation of search, after finding the intersection of the straight line and the other boundary of the fiber, the intersection is D $(x_D, y_D)$;

⑦ The distance between C and D points is the fiber diameter, according to the distance formula between the two points, and this paper can obtain fiber diameter of the AB segment by:

$$d_{AB} = \sqrt{(x_D - x_C)^2 + (y_D - y_C)^2}$$

⑧ In accordance with the above-mentioned method, to obtain the fiber diameter value of each segment the average is taken, in which then a final value of the cashmere fiber diameter is determined.

2) When the fiber is in the position shown in Fig. 5, namely, the tilted degree of the fiber is closer to the level, it is firstly needed to divide the X-axis according to the sub-situation of X-axis to divide the cashmere fibers. Specific implementation steps are as follows.

① The value of x coordinate is initialized to x1, which acts as a certain number of pixels as a unit, and according to the order of increasing coordinate values, this paper divides the X-axis into sections, and obtains the two endpoints of each section, then saves all the coordinates into an array X [m] (m = 1, 2, 3, . . . ), x1 = X [1];

② Along the x = X [m] direction, search upwards for the edge point of the fiber, and stop searching after obtaining an edge point, then return the abscissa value Y [m] of this point. Similarly, along the x = X [m +1] direction search and return the edge point coordinates value X [m +1]. Thus, one boundary of the fiber is divided into m segments, and the endpoint coordinates of every section is obtained.

③ Assume that A and B are two endpoints of the nth section, as shown in Fig. 5, coordinate of point A is $(x_A, y_A)$, coordinate of point B is $(x_B, y_B)$. Calculating the midpoint coordinates of segment AB is C $(x_C, y_C)$, where:

$$x_C = (x_A + x_B)/2,$$
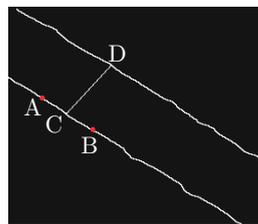$$y_C = (y_A + y_B)/2;$$



Fig. 5: Tilted degree is closer to the level

④ Calculating the slope of the straight line that goes through the midpoint of AB segment and plumbs AB segment is

$$K = \frac{x_A - x_B}{y_B - y_A};$$

⑤ Confirming the straight line that goes through C and plumbs AB segment is as follows:

$$y = \frac{(x_A - x_B)(x - x_C)}{y_B - y_A} + y_C = \frac{(x_A - x_B)(2x - x_A - x_B)}{2(y_B - y_A)} + \frac{y_A + y_B}{2}$$

⑥ After searching along the straight line equation, and finding the intersection of the straight line and the other boundary of the fiber, the intersection is D $(x_D, y_D)$;

⑦ The distance between C and D points is the fiber diameter, and according to the distance formula between two points, this paper can obtain fiber diameter of the AB segment as:

$$d_{AB} = \sqrt{(x_D - x_C)^2 + (y_D - y_C)^2}$$

⑧ In accordance with the above-mentioned method, to obtain the fiber diameter value of each segment the average must be taken, and then a final value of the cashmere fiber diameter will be determined.

### 3.1.2   Error Analysis of Measurement Results

Area method, the triangle law and law in the axis of measurement methods will be subject to fiber boundary bend and the two fibers boundaries are not parallel, bringing the error effect to the measurement results. Using sub-measurements as much as possible to eliminate the error effect mentioned above, improving measurement accuracy. Adopting sub-measurement can use the following two kinds of operations to improve the measurement accuracy.

① Increasing the number of sub-paragraph. According to the limits though, the more the section numbers, the more the fiber is nearer as a straight line, and the fiber diameter measurement accuracy will be higher.

② Removing the measurement values which are too deviated. As there is impact on a number of factors of the image acquisition process and the fiber itself, it is bound to bring great error of measurement results. To solve this problem, we must get rid of measurement results which is too large or too small, and then take an average to be the diameter of cashmere fibers.

## 3.2   Measurement of Cashmere Scale Area

Cashmere fiber scales as much as irregular shapes [7] and direct measurement is not easy, so we design the pixel by pixel-by-point scan measurement to achieve the automatic measurement of fiber size scales.

### 3.2.1   The Principle of Pixels Measurement

The so-called pixel measurement is to deal with good fiber image by row from bottom to top in units of pixel-by-point scanning, recording two boundary points of each row of pixels between the number of scales the image of a scanned records after all the pixel was added. As well, N determines the pixel side length of n-pixel square area of Sn according to the number of pixels in the image area to determine the fiber scale, as shown in Fig. 6.

### 3.2.2   Pixel Characterization of Fiber Scale Area

Pixel adjacent pixel exists only in eight cases, up, down, left, right, left, upper right, lower left, and lower right, as shown in Fig. 7. This pre-treatment method is the use of morphological
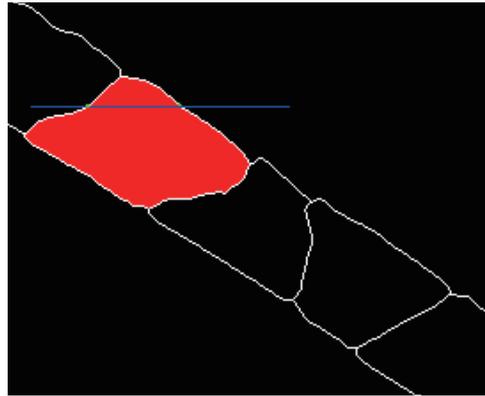
Fig. 6: Schematic diagram of scales area measurement



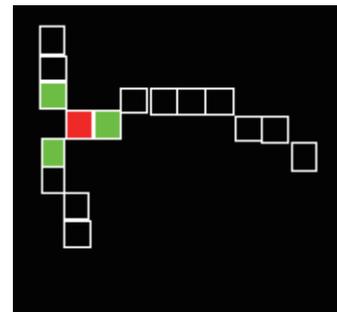Fig. 7: Schematic location of pixels adjacent scales



Fig. 8: Pixel scale diagram of the node

thinning of the image to obtain the edge of the continuous and single-pixel value for the binary image, as measured by pixel area of the Method which provides the basis for fiber scales.

In one image, the image of the lower left corner acts as the origin (0, 0), assuming that the horizontal direction is the x-axis, vertical direction is the y-axis, the image size is M * N, x-axis is the number of pixels in the direction of M and y axis is the number of pixels as N. From the bottom left to right order of units of pixels progressive scan, the coordinates of each scanned point was recorded, and all the coordinates turned into two-dimensional array X [i] [j] (i = 1, 2, 3, ..., M; j = 1, 2, 3, ..., N), which is the image scanned to assign points to 1 point on the non-image assignment to 0.

Scales from the edge of pre-treatment binary image can show that the fibers of each two adjacent scales between two nodes require a scale to determine the size of the first 4 scales of the fiber nodes. Based on morphological thinning method to obtain the edge of the continuous and single-pixel wide binary image, edge pixels in the scale and the nodes around the number of adjacent pixels is 3, instead of nodes around the adjacent pixels being Number two, as shown in Fig. 8.

Assume that any scale edge image coordinates of a pixel A is (m, n), then the A point of the coordinates of the surrounding eight pixels are (m-1, n-1), (m, n-1), (m +1, n-1), (m-1, n), (m +1, n), (m-1, n +1), (m, n +1), (m +1, n + 1). These eight pixels coordinate with the two-dimensional array X [i] [j] in the data comparison. The variable num = 0 for counting, when the eight coordinates of each pixel is once and has two-dimensional array X [i] [j] a value in the same. The count variable num + 1, when compared to the eight pixel coordinates being all finished, and if the num is 3, the array X [m] [n] changes the point value to 3 as a point for the node.

Otherwise it remains unchanged, with A point for non-node. At the same time mustre-assign the variable num to 0 points as the next pixel counts variable.

From the first scan to start node A, from bottom to top, from left to right, sweeps are used to find a closed area. When calculating the number of nodes contained in an area, there are two cases. The first case is if the number of nodes is less than equal to the area of the region then it is invalid and not a full scale and should be abandoned. There should be a second scan to the node B as the first node, and the scan be restarted. The second case is, when the number of nodes equals four, then the effective area of the region is a full scale, and the enclosed area calculates the total number of pixels (including the edge pixels), so that the characterization of scale can be calculated by area. Therefore, how to determine the enclosed area to determine how to calculate the enclosed area of the total number of pixels are two pressing problems. Fig. 9 shows that ABC is an invalid region, whilst regional BCED is a full scale that contains the effective area.
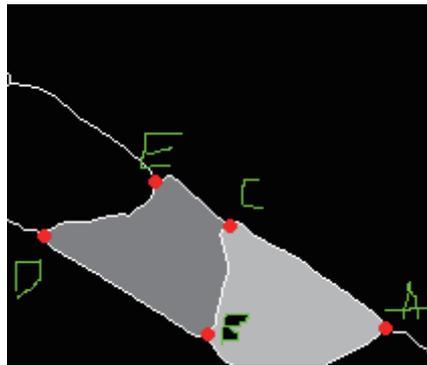


Fig. 9: Schematic invalid region and the effective area

From the first scan to start the line node, there will be a point by point scan from left to right, with edge pixels for M, N two points, and two cases. If the M point A is the left edge of the node, find the point of M adjacent to points M1, M2, M3, M1, M2, M3 to M around eight (m-1, n-1), (m, n-1), (m +1, n-1), (m-1, n), (m +1, n), (m-1, n +1), (m, n +1), (M +1, n +1) in the three points, and respectively, find the M1, M2, M3 non-M adjacent points, and so on, and gradually extend.. N points are also two adjacent points that are gradually extended. If the M's extension points coincide with the extension of N, then the area is a closed area. If the A point is the right edge of the node, then ibid.

The effective area of all pixels was added and N determines the pixel side length of n-pixel square area of Sn according to the number of pixels to determine the fiber scale image size.

This image is used in the optical microscope image collection of cashmere fiber, and sets the microscope magnification as p, in which there is then the characterization of the final area of the fiber scales.

### 3.2.3 Error Analysis of Measurement Results

As the fiber boundary consists of irregular scales graphics, the direct measurement error is large and it is difficult to find a reasonable common measurement algorithm, so we use the pixel-by-point scanning method to measure, because by morphological thinning algorithm, the edge of the image processing can be turned into a continuous and single-pixel width, and point by point to the image contour tracking to measure the area of fiber scales provide a theoretical basis.

Because in pixels, the error is small, so the measurement accuracy scales for the latter part of fiber establishes the foundation for automatic identification.

# 4    Results and Analysis

In this paper, the measurement algorithm, in Visual C ++6.0 development platform, uses MFC programming application framework and scale of cashmere fiber diameter automatic measurement of the area. This measurement method uses measurements obtained by sub-cashmere fiber diameter with the average of 13.4440, and the use of fiber-recognition software have more than 200 fibers measured indicator data, resulting [1] in: The average diameter of 14.10 μm. Pixel-by-point scanning method according to the measured size distribution of the fiber scales is shown in Fig. 10. Observed fiber size distribution shows scale, from the shape of the graphic point of view, and in the approximate normal distribution, the follow-up provides the basis for the identification of fibers, whilst the cashmere fiber scales have the average area of $1.944 \times 10^{-10}\,\mathrm{m}^2$, as shown in Fig. 11.
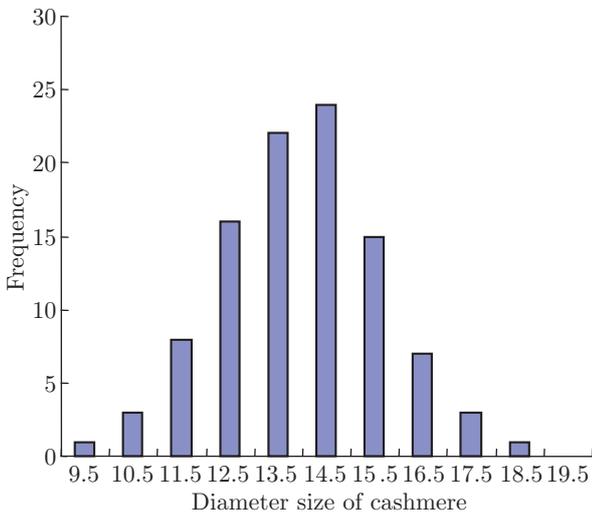


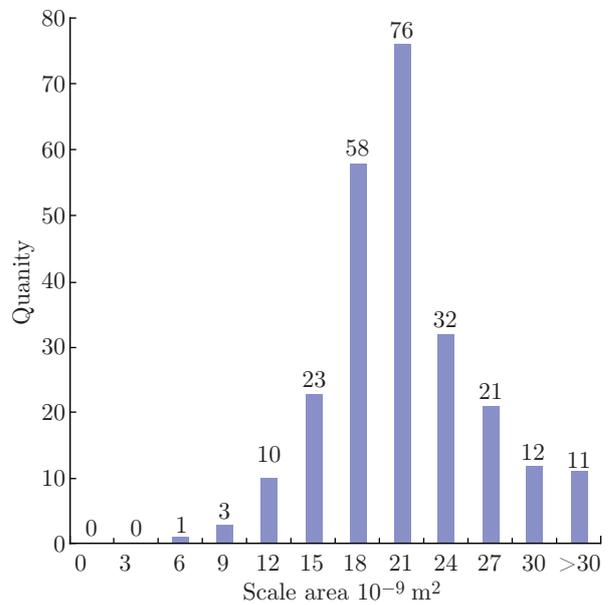Fig. 10: Distribution of the diameter of cashmere



Fig. 11: Distribution of Scale area

# 5    Conclusions

A method of measuring cashmere fiber diameter and area of scale is developed on the basis ofimage processing technique, by usingMatlab7.0 simu. The optical microscope is used for collection of cashmere images. Processing program with the treatment options of binary image processing are used to achieve sub-automatic measurement of the fiber diameter and scale area ofcashmere. This method can eliminatethe conventional manual measurement error caused by human factors. The results showed that: the proposed image processing program is effective, and the use of sub-measurement algorithm to measure fiber diameter road using pixel area of measurement scales to

measure the fiber can improve the accuracy of measurement, based on fiber optical microscope image acquisition Automatic identification of the foundation.

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