Study on Yarn Blackboard by Digital Image Processing Method

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Abstract

This article introduces a method which adopts the computer image manipulation to process the collected images of yarn black. Aiming at the hairiness and scratches existing in the yarn blackboard, we adopt the methods such as smoothness processing, threshold value division and image repairing to obtain a clear digital image without yawp points and exactly measure the yarn diameter. Comparing with the actual yarn diameter, the computed yarn diameter accords with the actual diameter, which proves that the yarn diameter measured by image processing method is accurate, exactly reflects the appearance features of the yarn such as slubs, neps and nips, and establishes the foundation for the automatic assessment of the yarn blackboard.

Keywords: Image processing, Yarn blackboard, Yarn evenness, Yarn diameter

1. Introduction

For a long time, the grade assessment of yarn appearance quality is to adopt the visualization inspection of manual blackboard, but because of the abuses of this method brought in the inspection such as waste time, hard sledding, personnel fatigue, uncertain results and bad precision and repetition produced by the subjectivity of the inspection personnel (He, 2002, p.59-60), people is taking up with using the automatic inspection system to replace the manual inspection all the while. With the development of computer and image processing technologies, the digital image processing technology has been abroad applied in the domain of textile inspection, and it has been an important research task at present and has important meanings for enhancing the yarn quality to actualize the objective assessment to the yarn blackboard evenness through computer image processing technology.

To inspect the yarn appearance quality through computer image processing technology, can not only overcome the abuses of inaccurate data results produced by the personnel subjectivity but also avoid the influences from measured condition, exactly inspect the slubs and nips of the yarn and the length and number of the neps and compute the variation coefficients of various yarn stain length, accordingly make the objective assessment of the yarn blackboard become possible. In the objective assessment process, the key is the image processing to the yarn blackboard.

Aiming at the characters of the yarn blackboard digital image, this article establishes a sort of processing method for the digital image of the yarn blackboard, obtains clear blackboard digital image, figure out the yarn diameters in the blackboard and compare them with the actual yarn diameters measured by CTT. This method establishes important bases for further studying the evenness quality of the yarn and objective assessment of yarn appearance.

2. Image collection of yarn blackboard

The image collection system adopted in this article is composed of steroscopic microscope, CCD camera, image card and computer. First adopt the Y381A blackboard machine to coil the yarn blackboard, magnify the yarn blackboard ten times through the microscope, and transform the optics signals into analog signals through CCD camera to input into the image collection card of the computer, finally transform them into the digital image. Figure 1 is the typical blackboard image of collected 40^s pure cotton fancy grade yarn and first grade yarn. From the figure we can see that, the blackboard includes important information of yarn appearance quality such as slubs, nips and neps, and yarn evenness in the image attach many filoplumes, interleaving with the nicks of the blackboard background. Therefore, to actualize the complete separation of yarn and blackboard background, we need establish a reasonable image processing method which can reserve the important characters such as the slubs, nips and neps when eliminating the filoplumes, and ensure the yarn diameter has no distortions.

3. Processing process of yarn blackboard image

To actualize the complete separation of yarn and blackboard, this article adopts the image processing method as follows: smoothness processing, threshold value division, and image repairing.

3.1 Smoothness processing

The yarn blackboard collected in this article has many filoplumes, and the filoplumes can not separate with the yarn, there are many nicks on the blackboard and the blackboard can not separate with the yarn well. These disadvantages bring many inconveniences for the following processing. So we adopt the neighborhood average method in smoothness smoothing to process the image.

This method is to utilize the average value of several pixel gray values to replace the gray value of every pixel. Supposed that there is an image f (x, y) with n × n pixels, we can get an image g (x, y) through smoothness processing, so we have (Liu, 2006)

$$g(x, y) = \frac{1}{M} \sum_{(m,n) \in s} f(m, n).$$

This smoothness filter can weaken or eliminate the high frequency component in the Fourier space, but doesn't influence the low frequency component, and the high frequency component corresponds with the part which has big changes of equal gray values in the area edge of the image, that is the parts with filoplumes and nicks in the image of yarn blackboard, after the filter sieves these components, the gray values of filoplumes and nicks parts will be lower than the yarn's, which will convenient for the following threshold values selection and image division to achieve the final purpose of processing.

3.2 Threshold value division

In the image of yarn blackboard through smoothness processing, the gray values of filoplumes on the yarn and the nicks on the blackboard would reduce. In addition, because the yarn blackboard is a good black and white image itself, if we want to well separate the yarn and blackboard and stand out the outline characters of the yarn, and the processed image should be easy to compute, the binary image processing is the best choice for the yarn blackboard. This article adopts the gray threshold method to perform the binary processing to the image. This method mainly selects one proper grade threshold value T, compares every pixel gray g (x, y) with it, and redistributes the pixel points that the gray point exceeds T with the maximal gray (such as 255), the pixel points that the gray point is below T with the minimal gray (such as 0), so the image after threshold value processing is (Liu, 2005)

$$g(x, y) = \begin{cases} 255 & if \quad g(x, y) \geq T \\ 0 & others \end{cases}.$$

In the binary image processing, the selection of the threshold value is the key step, and the threshold value selected by the type differentiation analysis method can achieve the best effect. First, compute and input the gray direct block diagram (Phs (i)) of the image, second, compute the gray average value (Ave), gray type average value (Aver (k)) and type direct block diagram sum (W (k)).

$$Ave = \sum_{i=0}^{255} (i-1) Phs(i), \quad Aver(k) = \sum_{0}^{k} (i+1) Phs(i), \quad W(k) = \sum_{i=1}^{k} Phs(i).$$

Then, compute type separation index (Q (k))

$$Q(k) = \frac{\{[Ave * W(k) - Aver(k)]^2\}}{W(k) * (1 - W(k))}.$$

So we can get the maximal value K of Q, and the best threshold value T = K -1 (Li, 1999).

Figure 2 is the yarn blackboard thorough processing.

3.3 Image repairing

Because of threshold value selection, the binary image through image division still has remains of small filoplumes, and many nicks on the blackboard surface have not been completely eliminated, so we need repair the yarn blackboard image divided after image division processing.

This article adopts the eight neighborhoods shrinking method and eight neighborhoods inflating method to process the image through threshold value division for eliminating the noise points on the background and the filoplumes on the yarn, staying useful information what we need to convenient for the yarn diameter computation.

The eight neighborhoods shrinking means that in an eight neighborhood image block with 3*3, if the gray value of the processing pixel is 0, so the gray values of other eight neighborhood pixels are 0 too. After that processing the background noise and the filoplumes on the yarn have been basically eliminated, but the thin-degree of the yarn would be thinner obviously, which will bring errors for the final experimental results, so we need inflate the yarn to recover the former useful information.

The eight neighborhoods inflating means that in an eight neighborhood image block with 3*3, if the gray value of the processing pixel is 255, so the gray values of other eight neighborhood pixels are 255 too. The repaired yarn blackboard image is seen in Figure 3.

Through the above image processing methods, we get clear binary image of the yarn blackboard without noise points. Form Figure 3, we can see that the yarn filoplumes and background nicks in the image have been completely eliminated and useful characteristic information such as slubs, nips and neps are hold.

4. Inspection and comparison of yarn diameter

The yarn blackboard after image processing is an excellent digital image, and we test the yarn evenness on the blackboard through quantitative analysis, and compare it with the actual yarn diameter measured by the yarn performance testing instrument.

4.1 Inspection of yarn diameter

Before the yarn image is analyzed, this article first uses the CTT yarn performance testing instrument made by American Lawson Hemphill Company measure the diameters of the used 40^s pure cotton fancy grade yarn and first grade yarn sample, and the testing results are seen in Table 1.

4.2 Computation of yarn diameter in digital image and comparison with measured yarn diameter

Scan the image in Figure 3 from the left to the right and from the up to the down, define the minimal unit in the image frame is pixel, and utilize the nether formula to converse the pixel number into millimeter, so the diameter of every yarn can be calculated.

$$1\,pixel \approx \frac{15}{1440} \times 25.4\,mm$$

Table 2 and Table 3 list the diameters of various yarns and corresponding yarn stains in the digital image.

Table 2 lists the diameters measured by the image processing method and the differences comparing with the actual measured yarn diameters in Table 1 for the fancy grade yarns and first grade yarns with normal appearance quality through eye inspection. From Table 2, we can see that the differences between the yarn diameters measured by the computer image processing method and actual yarn diameters are very small, which indicates that the yarn diameter measured by the image processing method has no distortions, basically accords with the actual measured results. In addition, according to the yarn diameter variation coefficient measured by CTT, the yarn has asymmetry of the appearance itself, which will induce data fluctuation in the image measure process. From data in Table 1 and Table 2, we also can see that the average diameter measured by the computer basically is smaller than the actual diameters, because the image processing process eliminates the filoplumes of the yarn, which means the testing results obtained by the computer image process method more accord with the objective requirements.

4.3 Inspection of yarn stains

Table 3 lists the diameters of the stains which the people think the blackboards in the Figure 3 contain yarn stains (2# yarn), and the diametrical deviations comparing with the actual diameter in Table 1.

In addition, according to American standards of ASTM-D2255-90 (Li, 1999) which institutes the diametrical deviations for the cotton yarn appearance stains, we can obtain the following results.

(1) The deviation of the slubs diametrical section is confirmed as +25%.

(2) The deviation of the nips diametrical section is confirmed as -40%.

(3) The deviation of the neps diametrical section is confirmed as +200%.

Through the comparison, we can see that after the slubs, nips and neps in people's eye are implemented quantitative processing through this image processing method, and the obtained stain diametrical deviations accord with the CTT standards, which indicates this image processing method can stay the character information of the yarn and further prove that the results utilizing computer image processing method accord with the inspection by the people's eye.

5. Conclusions

(1) The yarn blackboard image through this image processing method can basically eliminated the yarn filoplumes and blackboard nicks, actualize the effective separation of yarn and blackboard, obtain clear yarn outlines, and keep back useful information what we need, such as slubs, nips, neps of the yarn convenient for the following computation of the yarn diameter and judgments of the yarn evenness.

(2) The yarn blackboard image through this method can exactly obtain normal yarn diameter, and accord with the actual yarn diameter, which indicates that results through computer image measure have no distortions. In addition, this method can clearly reflect the deviations of slubs, nips, neps comparing with the actual yarn diameter, according with the American yarn appearance quality standards. The results indicate the computer image processing method can implement quantitative analysis to the yarn blackboard, more objectively evaluate the uneven sense effect of yarn blackboard, and eliminate the judgment coming from subjective factors.

(3) The image processing method is fit for not only the yarn blackboard image, but also the blackboard sample image, which can unify the processing methods of blackboard sample image and yarn blackboard image, and can offer more evidences for yarn grading, and more objectively evaluate the yarn appearance quality.

Therefore, this image processing method has application values, can completely substitute people's eyes for yarn grading, and obtain more exact and repetitive results than people's eyes. The inspected results can be stored in the computer, which can better evaluate the yarn appearance quality and establish bases for further automatically evaluate yarn

blackboard.

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a. Fancy Grade Yarn Blackboard

b. First-grade Yarn Blackboard with Slubs

c. First-grade Yarn Blackboard with Neps

d. First-grade Yarn Blackboard with Nips
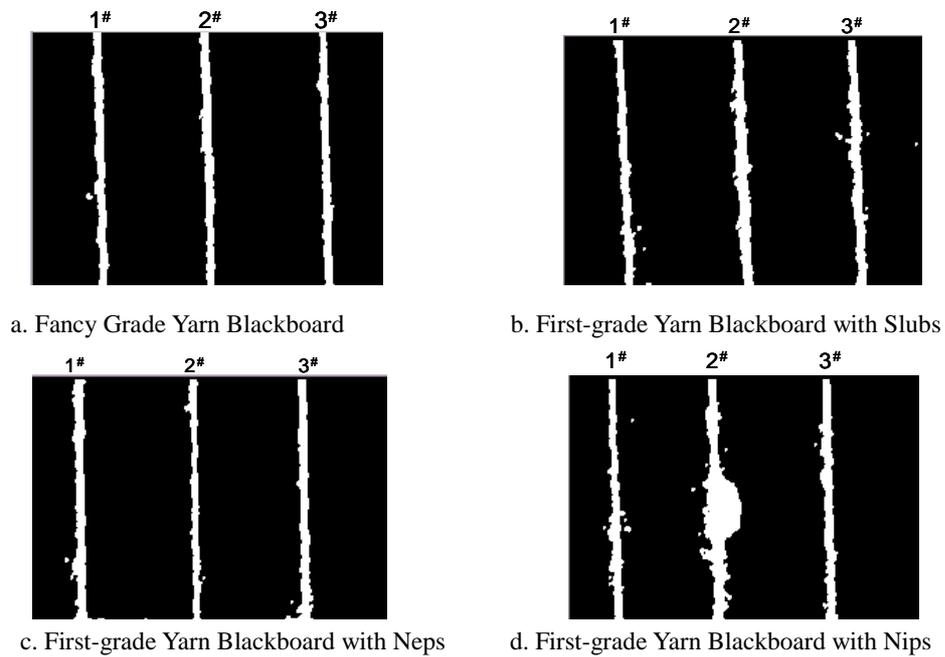
Figure 3. Yarn Blackboard Images through Image Repairing

Table 1. Actual measured yarn diameters

Yarn types	Actual measured diameter / mm	Diameter variation coefficient / %
40s Fancy grade yarn	0.166	14.65
40s First grade yarn	0.172	17.59

Table 2. Average diameter of normal yarn and deviation from actual yarn diameter

No.	Normal Yarns	Average diameter / mm	Deviation / %
1	Fancy grade yarn 1# yarn	0.164	1.2
2	Fancy grade yarn 2# yarn	0.165	0.6
3	Fancy grade yarn 3# yarn	0.158	4.8
4	First grade yarn with slubs 1# yarn	0.157	8.7
5	First grade yarn with slubs 3# yarn	0.175	1.7
6	First grade yarn with nips 1# yarn	0.170	1.2
7	First grade yarn with nips 3# yarn	0.170	1.2
8	First grade yarn with neps 1# yarn	0.157	8.7
9	First grade yarn with neps 3# yarn	0.170	1.2

Table 3. Yarn stain diameter and deviation from actual yarn diameter

No.	Abnormal Yarns	Stain points / mm	Deviation / %
1	First grade yarn with slubs 2# yarn	0.216	+25.58
2	First grade yarn with nips 2# yarn	0.102	-40.70
3	First grade yarn with neps 1# yarn	0.520	+202.33