

Recognition the Parameters of Slub-yarn Based on Image Analysis

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ABSTRACT

In this study, a new method for recognizing the parameters of slub-yarn based on image analysis has been proposed. The slub yarn was wrapped on the surface of the black board by YG381 Yarn Evenness Tester. A high resolution scanner was used to acquire the yarn image. Gray stretching and thresholding were carried out to preprocess the image of slub yarn. By separating the slubs from base yarn with different widths, the slub length, slub distance and slub amplitude can be obtained. With the lists of slub length and slub distance, the periodicity rule of slub yarn can be determined. The period of the slubs then will be identified by 1D-Fourier transform. The experiment indicated that the method can identify the parameters of slub yarn with satisfactory results.

Key words: slub-yarn; slub length; sub distance; periodicity rule of slub yarn; gray stretching; thresholding

INTRODUCTION

As slub-yarn can form special appearance in the surface of fabric, it is widely used in garments and decorative fabrics. The special appearance is determined by the different parameters of the slub-yarn, including the slub length, slub distance, slub amplitude and periodicity rule of the slub. Therefore, the first step for the manufacture of slub-yarn fabric is to analyze the parameters of the slub-yarn.

The traditional method for analyzing the parameters of the slub-yarn is to count slubs in the yarn based on the black boards, which demands special experience for the workers. Generally, the slub will not repeat in a short length, so the parameters of the slub-yarn can not be got until the workers checked enough length of yarn. It is a time-consuming and very complicated task for the workers. In the instrument such as Uster 5 has provided standard techniques of measurement and analysis of slub basis with a special capacitance sensor.

Many researchers have done some contribution to analyze the yarn parameters or evaluate the quality of yarn. Furter R.[1] used Uster Tester to measure the character of the slub-yarn, and evaluation of the yarn was given by the measurement. Bian K. Y. et al [2] described a new method to detect the parameters of slub-yarn with the help of a data acquisition card. The capacitance sensor in Uster Tester was used to get the signals of slub-yarn. By analyzing the signals, slub length, slub distance, slub multiple were obtained.

Both of their work were based on the Uster Tester, and it is confused for people to know the exactly theory of the work. Actually, the change of capacitance results from the amount of fibers in the yarn. But the parameters of slub-yarn are actually geometrical parameters. Therefore, it is proper to obtain the parameters of slub-yarn from the apparent of yarn directly. Image analysis method for detecting the parameters of slub-yarn seems more proper actually. Recent years, with the development of computer, image analysis plays a more important role in fabric industry. People use image analysis to recognize the structure parameters and the defect of the fabric [3-9]. In the paper, a new method base on image analysis is proposed to identify the parameters of slub-yarn. The work is easy to understand and can make the workers obtain the parameters of slub-yarn quickly.

EXPERIMENTS

Theory Of Slub-Yarn

As shown in *Figure 1*, slub-yarn is composed of two part: base yarn part and slub part. In the figure, L_{bi} is the length of base yarn; N_{bi} is the linear density of the base yarn; L_{si} is the slub length with linear density L_{si} ($i = 1, 2, 3, \dots$).

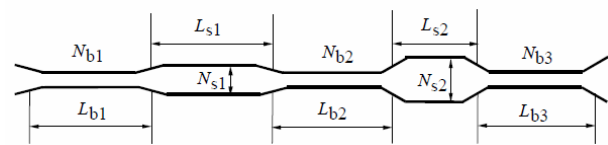


FIGURE 1. Structure of slub-yarn

The appearances of slub-yarn fabric are determined by the parameters of slub-yarn. The purpose of this study is to detect the parameters, including the slub length, slub distance, slub amplitude and periodicity of slub yarn. During the manufacture, there will be a lot of noise signals left in the slub yarn. In order to get the accurate signals of yarn, some pretreatments should be done before the processing.

The most difficult work is to analyze the period of slub yarn. There are two kinds of slub-yarn, which is periodic slub yarn and random slub yarn. The first kind of slub-yarn has its own period during the manufacture. By analyzing certain length of the slub-yarn, the parameters will be obtained. But for the

random slub-yarn, the slub parameters are selected from a certain range of data. It doesn't have exactly period. So the period of slub can't be got by period analyzing method in time domain or frequency domain. To get the exact period of the slubs, the periodicity rule should first be recognized.

Image Acquisition

The slub-yarn was wrapped on the black boards by YG381 Yarn Evenness Tester in the experiment. There are three or four yarns in one centimeter-width of blackboard. Then a high resolution flat scanner was used to capture the image of slub-yarn. The resolution of the image is set at 1200dpi. It means that 1200 points will be sampled in 25.4 millimeter-length yarn.

Threshold Processing

The yarn image got by the scanner has too much noise, for example, the hairiness of the yarn will be left in the space between two yarns. As the gray levels of the pixels in the hairiness is not less than the gray levels of the pixels in the yarn, threshold processing is chosen to preprocess the image. The threshold value is obtained with k-means clustering method based on the histogram of the image. *Figure 2* indicated the local image of yarn. The histogram of the image is shown in *Figure 3*. The threshold is 123 obtained with k-means clustering method automatically. After threshold processing, as shown in *Figure 4*, the influence of the hairiness in the yarn can be mostly eliminated, except some isolated white pixels.

Removing Small Objects

As mentioned in previous paragraph, there are some isolated white pixels in the image. The open process in morphology method is used to remove these pixels. *Figure 5* shows the results after removing the small objects. From the figure, it can be seen that all the hairiness of the yarn has been eliminated. The white pixels indicate the slub yarn while the black pixels represent the background.

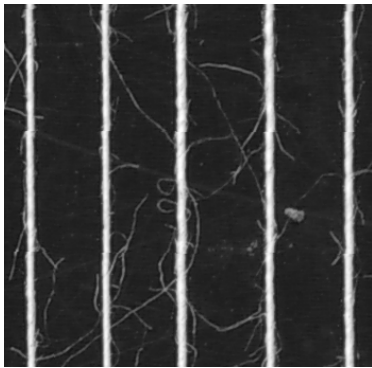


FIGURE 2. Local image of yarn before gray stretching

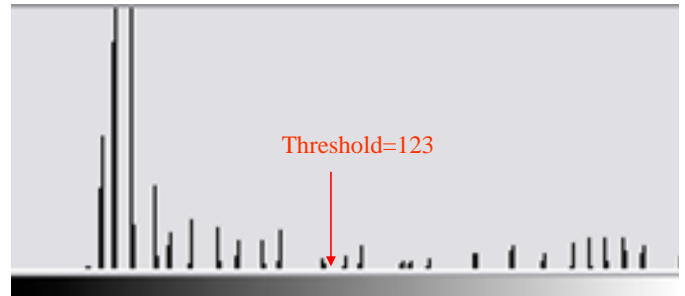


FIGURE 3. The histogram of the local image of yarn



FIGURE 4. Local image of yarn after threshold processing

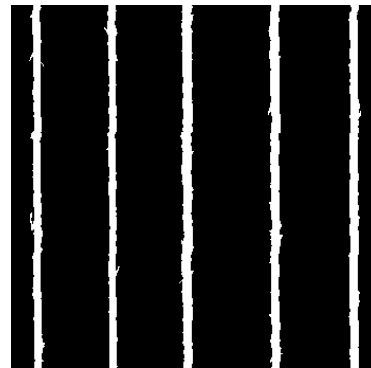


FIGURE 5. Local image of yarn after removing small objects

Separating The Slub From Base Yarn

In order to get the parameters of the slub yarn, signals of the diameters of slub yarn, which are proportion to the line density of the yarn, should be obtained by image analysis. An edge detector is designed for locating the edge of the slub yarn. *Figure 6* shows the result that the detector found in a line in the experiment. The pixels number in one sampling site can be obtained by subtracting the two adjacent edges. By scanning from top to bottom, the width of every point in the yarn will be calculated by the edge detector.

As the slub yarn is composed by two parts, which are base yarn part and slub part. To get the parameters of slub yarn, the most important step is to separate the slubs from base yarn. In order to determine the width of base yarn, yarn line density of all the sampling points in one yarn is inspected and indicated in *Figure 7*. For the base yarn is thinner than slubs, the first peak in the histogram corresponds to the base yarn. The other peak in the figure indicates the slubs. The valley value, “10” indicates the separating value of base yarn and slub. If the value is less than 10, it will be considered as base yarn, and if the value is more than 10 pixels, it will be set as slub. During the yarn manufacture, there is lots of unevenness, so the pixels of the sampling sites will disperse in a round range. To judge a sampling point belongs to base yarn part or slub part, the mean value of 100 points around it is calculated. When the mean value is larger than 10, the part of the yarn is then considered as slub part.

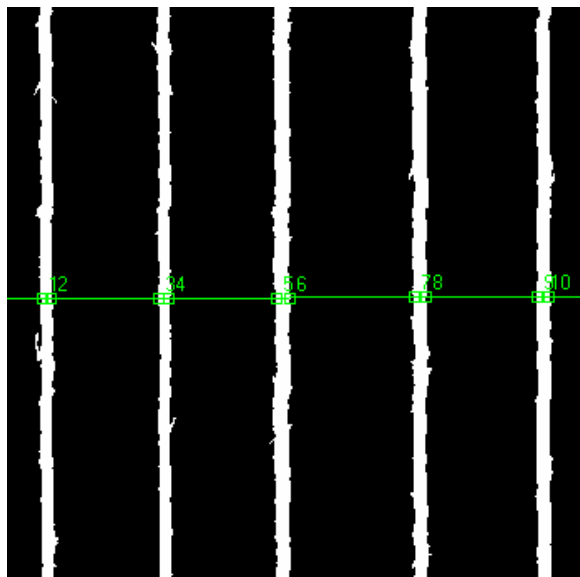


FIGURE 6. Edges of slub-yarn

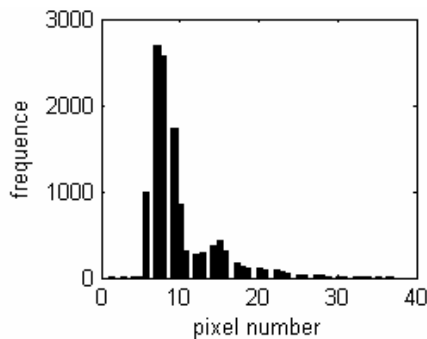


FIGURE 7. Statistical of width for sample points in one yarn

Condition Filtration

During the manufacture of yarn, the unevenness of the line density of the yarn can't be avoided. Some parts in the yarn are wider than others. In the processing, these parts may be detected as slubs. To eliminate the influence of them, a condition filtration is set to correct that. In the experiment, the slub length will be not shorter than 20 millimeters during the yarn production. Therefore, if the slubs are shorter than 20 millimeters, they were considered as base yarn part. By this process, the yarn has been divided into two parts, base yarn part and slub part. The parameters of slub yarn, including the slub length, slub distance and the slub amplitude can be identified.

To describe the recognition process, we list the schematic diagram of the recognition system in *Figure 8*.

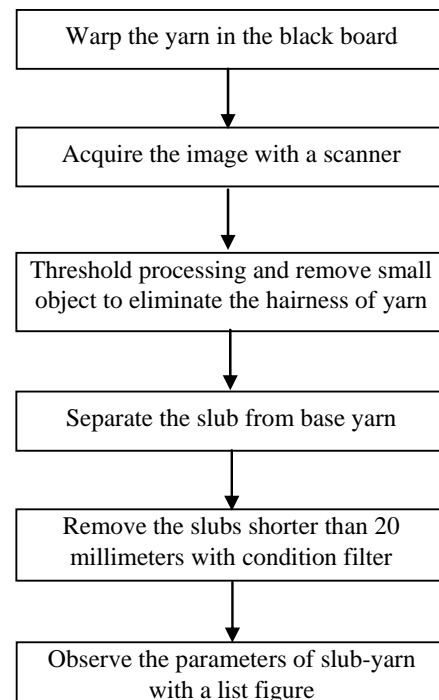


FIGURE 8. Schematic diagram of the recognition system

RESULTS and DISCUSSION

The parameters of the sample yarns are shown in *Table I-III*, all of them were spun from the same roving to avoid the influence by the machine.

TABLE I. Periodic slub-yarn (Sample 1, base yarn count 14.5tex)

Slub length(mm)	Slub amplitude(%)	Slub distance(mm)
30	250	40
50	250	60

TABLE II. Periodic slub-yarn (Sample 2, base yarn count 20tex)

Slub length(mm)	Slub amplitude(%)	Slub distance(mm)
30	250	40
50	350	60

TABLE III. Random slub-yarn (Sample 3, base yarn count 20tex)

Slub length(mm)	Slub amplitude(%)	Slub distance(mm)
30	350	40
40	350	50
50	350	60

Slub length disperses in a certain range during the yarn manufacture as *Figure 9* shown. All the lengths can be separated into two clusters, and the slub length can be obtained by averaging the lengths in each cluster. Slub distance can be identified as the same method. The most difficult process in the recognition is to identify the period of the slubs. To recognize the period, the periodicity rule of the slub yarn should first be determined.

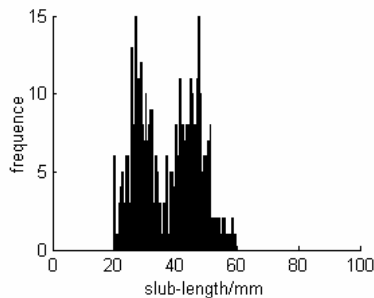
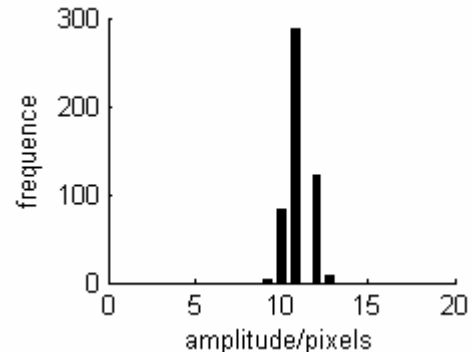
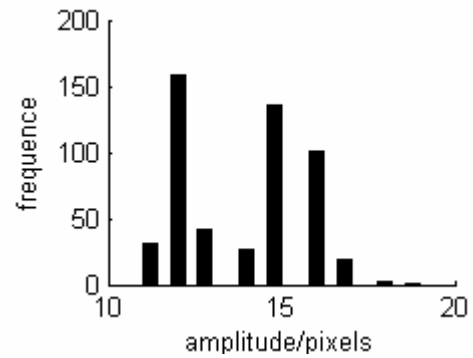


FIGURE 9. Histogram of slub lengths (Sample 1)

In order to detect the periodicity rule, a visualization method is proposed to analyze slub length, slub distance and slub amplitude. The kinds of slub amplitude can be chosen by the number of peak in the histogram as indicated in *Figure 10*. In the histogram of Sample 1, there is one peak. It can be considered that there is one kind of slub amplitude in Sample 1. With the same method, it can be known that there are two kinds of slub amplitude in Sample 2.



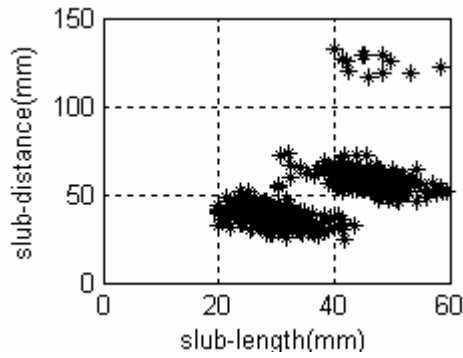
(a)Sample 1



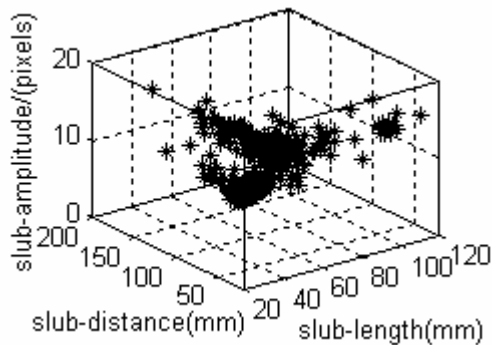
(b)Sample 2

FIGURE.10 Histogram of slub amplitude

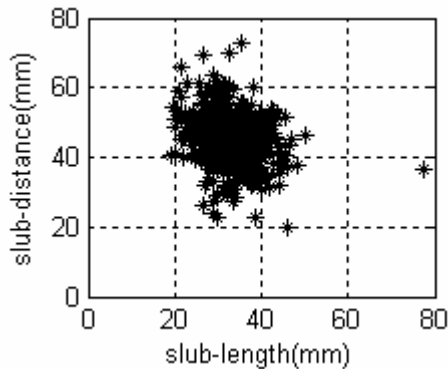
A list figure is designed to observe the slub length, distance and amplitude. By analyzing the kinds of slub amplitude in the yarn as mentioned, two kinds of list are used to analyze the distribution of slubs. If the yarn has just one kind of slub amplitude, a two-dimensional list is used to watch the slub length and the slub distance in the yarn. And if there are more than two kinds of slub amplitude in the yarn, a three-dimensional list is designed to observe the distribution of the slub length and slub distance. The lists of the three samples can be seen in *Figure 11*.



(a) Sample 1



(b) Sample 2



(c) Sample 3

FIGURE 11. List of slub yarn' parameters

The periodicity rule of the slub yarn now can be identified from these lists. In the lists of Sample 1 and Sample 2, there are two clusters which represent the two kinds of slubs as shown in *Table I* and *Table II*. They now can be considered as periodic slub-yarn. In the list of Sample 3, there is just one cluster. It can not be divided into three kinds of slubs as *Table III* shows. By the experiences from the manufacture, its periodicity rule must be random slub.

The period will be easily recognized from the lists. If the yarn is periodic slub yarn, the slubs in the yarn can be divided into two kinds, and then the period can be analyzed by 1D Fourier transform. The results of the parameters of Sample 1 and Sample 2 can be seen in *Table IV* and *Table V*. They are not same as the designed parameters of slub-yarn, but with the experiences of the workers, these parameters can be adjusted to satisfy the need for the production of slub yarn.

TABLE IV. Recognized parameters of Sample 1

Periodicity rule of the slub	Slub length(mm)	Slub amplitude (%)	Slub distance(mm)
Periodic slub	31.2	225	39.5
	49.5	225	62

TABLE V. Recognized parameters of Sample 2

Periodicity rule of the slub	Slub length(mm)	Slub amplitude (%)	Slub distance(mm)
Periodic slub	33.2	225	41.5
	49.5	330	63.5

In the practical method for recognizing the parameters of slub yarns, the most difficult process is to analyze the random slub. While the parameters of random slub is chosen from a setting range of data, the workers can not get the parameters until they check enough length of yarn. The method in this study can keep workers from the tired task. The list of Sample 3 shows the range of the slub length and distance. By the range data, the workers can produce the same slub-yarn as the sample yarn. *Table VI* shows the recognition parameters of Sample 3.

TABLE VI!. Recognized parameters of Sample 3

Periodicity rule of the slub	Slub length(mm)	Slub amplitude (%)	Slub distance(mm)
Random slub	22-53	340	32-61

CONCLUSION

Recognition of the parameters of slub yarn in the manufacture was addressed as a specific problem. An automatic identification system was proposed and implemented in this study. A description of the image acquisition and image preprocessing was given in the

paper. A detailed study for the algorithmic employed in the proposed system was carried out. By separating the slub from base yarn, the slub length, slub distance and slub amplitude can be obtained. The periodicity rule and period of slub-yarn were recognized by listing the slub length and distance in a visualization plot. The method can get reliable results while the manufacture of slub-yarn does not require complete standard measurement parameters. The problem of fault detection for slubs and a complete recognition system will be proposed in a future study.

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