



ISSN 2278 – 0211 (Online)

## Yarn Diameter Measurement Using Morphological Approach

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### **Abstract:**

*Yarn quality depends upon the physical properties like yarn strength, unevenness, hairiness and geometrical parameters like diameter. This paper focuses on the analysis and implementation for Yarn Diameter Measurement (YDM) using image processing for 100% combed, ring cotton yarn and compares the obtained results with the manual microscopic method. The traditional method for YDM includes rod method and travelling microscope method, whereas the electronic methods used for YDM are optical and capacitive sensor method. The result of these methods shows that they are sensitive to environmental conditions. The proposed work aims to measure the yarn diameter using Morphological Approach (MA) which mainly focuses on separating the core area of yarn from the haired area. Then counting the number of pixels in core area so as to measure the diameter in SI units. This approach was applied on 30, 40 & 50 count of 100% combed, ring cotton yarn consisting of 200 samples of each count. The average diameter obtained on 100 samples of each count was then compared with the Uster standard values and from the values computed Zeiss Microscope manually. The results obtained on 100 samples of each count shows that the proposed image processing method for diameter measurement of yarn lies within the allowed tolerance as per the Textile Standards and is immune to environmental effects.*

**Key words:** Yarn Diameter, Zeiss Microscope, Hairiness, Optical sensor, Capacitive sensor, Image Processing

### **1. Introduction**

The most important and first goal of the textile industry is the quality analysis and control of yarn which decides fabric quality. The correct and accurate evaluation of yarn parameter measurement is a subject of major importance to the textile industry, as the final fabric quality directly depends on the yarn quality. Fabric property is dependent on yarn quality and yarn quality depends upon its certain physical properties like yarn strength, unevenness, hairiness and geometrical parameters like diameter. Yarn diameter is the most important fabric parameter which decides the fabric properties viz., porosity, thickness, air permeability etc [1].

There are two traditional methods used for yarn diameter measurement viz., rod method and traveling microscope method. The electronic methods for this purpose are optical and capacitive sensor method. But the results obtained by these methods are prone to errors due variation in temperature, pressure and humidity. An alternative to these methods is yarn diameter measurement, which uses purely image processing algorithms.

In this direction this paper presents an implementation on yarn diameter measurement using Morphological Approach (MA). A well known traditional method set by Textile Testing Bureau of Indian Standards for yarn diameter measurement is presented in [1], [2], [3]. A current research in YDM using coherent optical signal processing is reported by V.H.Carvalho et al. [4]. A comparative study of yarn diameter measurement using optical and capacitive sensors was reported by the same author in [5]. There are still very few researches reported on YDM using image processing using morphological approach. Thus the objective of this proposed work is to develop an efficient method of automatic recognition of yarn diameter based on image processing technique. For the implementation of YDM using image processing technique the sample data collection required is presented in the next section.

### **2. Theory on Yarn**

A yarn consists of number of fibres which are spun into a single strand [3]. The basic property of yarn is variation in mass per unit length along the yarn. The yarn configuration is as shown in figure 1.

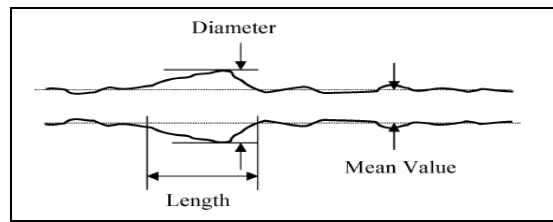


Figure 1: Yarn Configuration Example

**3. Methodology of the Proposed Work**

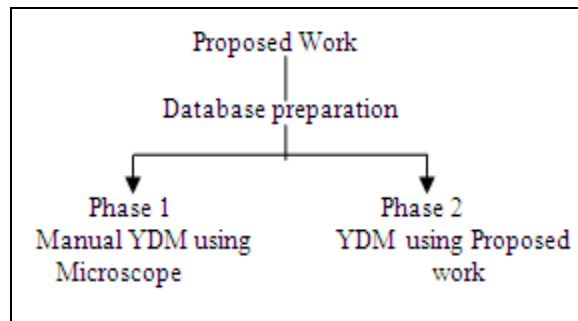


Figure 2: Workflow of Proposed Work

We have divided our work in two parts as shown in figure 2. Phase-1 includes experimentation of manual YDM using microscope whereas in Phase-2 actual covers experimentation of YDM using morphological approach. The image database required for both the phases of experiment is as explained further.

**4. Image Acquisition and Sample Data Collection**

The yarn images were captured by Zeiss Microscope present in Textile Testing Laboratory at T.E.I. Ichalkaranji having the specifications as shown in Table 1 [10]. For our project we have considered a 100% combed ring cotton yarn sample with the count 30, 40 and 50 count.

1.	Camera	1.3Mega-pixel
2.	Image Resolution	1280 × 1024
3.	Aspect Ratio	4:3
4.	Frame Rate	12.7
5.	Lens Mount	C ½
6.	Bit Depth	8 or 10

Table 1 Specifications of Zeiss Microscope

The Zeiss microscope uses AxioVision software for image grabbing. This software works on the Microsoft Windows XP and the software version is 5.1.2600 [10]. The camera used in the microscope is of 1.3 megapixels and with 10X scaling (magnification). The resolution of all images is 1024×1280 taken with optical magnification of 10X.

For the database preparation, six hundred samples of hundred percent combed ring cotton yarn consisting of 30, 40 and 50 count each of 200 samples were imaged using this microscope. These images were then imported into a MATLAB work file for further processing. Table 2 shows the database of yarn sample images for 30, 40, 50 counts and their standard diameter obtained using Uster method [9]. Figure 3 shows the sample image for normal and hairy yarn.

Sr. No	Count	No of Samples	Standard Diameter in µm
1	30	200	166
2	40	200	143
3	50	200	128

Table 2: Yarn Image Database

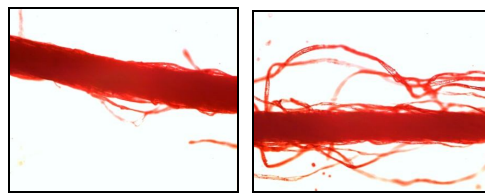


Figure 3: Sample image for normal and hairy yarn  
 a) Normal yarn image    b) Hairy yarn image

Image database is divided into two equal parts. Half of the images were subjected for YDM using manual microscopic method and remaining half images were analyzed for YDM using our proposed approach in MATLAB IDE. Phase I of YDM include manual microscope YDM methods which is explained in the next section.

**5. Phase I: Manual Microscope YDM Method**

This Manual method includes measurement of the diameter with 10X scaling of Zeiss microscope images. Scaled images were then adjusted and focused. Then the diameter was measured manually drawing the line on the microscope image such that line width, exactly covers the width of the core part of the yarn as in figure 4a). The corresponding length proportional to diameter is automatically displayed in terms of mm or  $\mu\text{m}$  of the AxioVision software [10]. In this way we have measured the diameter at ten different widths locations on the core part of yarn and then averaged to obtain a single diameter reading.

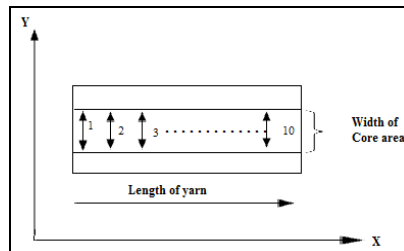


Figure 4 a): Prototype ideal figure model for accurate measurement of yarn diameter

The average of such 10 readings in a single image was computed for 1 sample image. This procedure was repeated for 100 samples thus making hundred diameter observations for one count. Average of hundred observations was obtained to get an accurate final yarn diameter. This procedure was repeated for 40 and 50 count yarn. Figure 4b) depicts manual method adapted for the sample yarn image for diameter measurement using Zeiss Microscope. The average of 300 diameter observations obtained for YDM using manual Zeiss microscope for 30, 40 and 50 counts is listed in table 3.

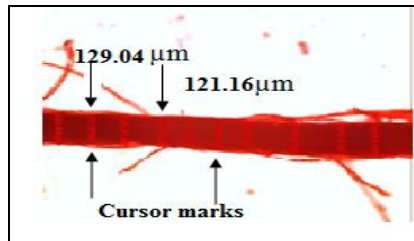


Figure 4 b): Sample yarn image of YDM using Zeiss Microscope

**6. Results of Manual YDM Method Using Microscope**

Table 3 depicts the average diameter of yarn obtained manually for 30, 40 & 50 counts from manual Zeiss microscope method. These results are further used for comparison with yarn diameter measured using proposed image processing algorithm .This is explained as further.

Sr. No	No of Sample Images	Count	Average Diameter in $\mu\text{m}$
1	100	30	191.0922
2	100	40	142.8209
3	100	50	125.1816

Table 3 Results of manual method of yarn diameter measurement using Zeiss Microscope for 30, 40 and 50 count

Phase 2 of proposed work includes YDM using image processing which is explained in further section. We have implemented the YDM analysis algorithm on database images. In the next section YDM analysis in spatial domain using Morphological Approach (MA) [8] is explained.

### 7. Phase II: Morphological Approach (MA) for YDM in Spatial Domain

Here, in pre-processing the image acquisition and its conversion from color to binary image is carried out. The yarn diameter is counted in terms of number of pixels. Then, these pixels are converted into length unit (micrometer) referring to the set calibration of imaged area of yarn. This help to give yarn diameter in length units. This diameter is then displayed.

The experimental flowchart designed for proposed YDM using morphological processing [8] is presented in figure 5.

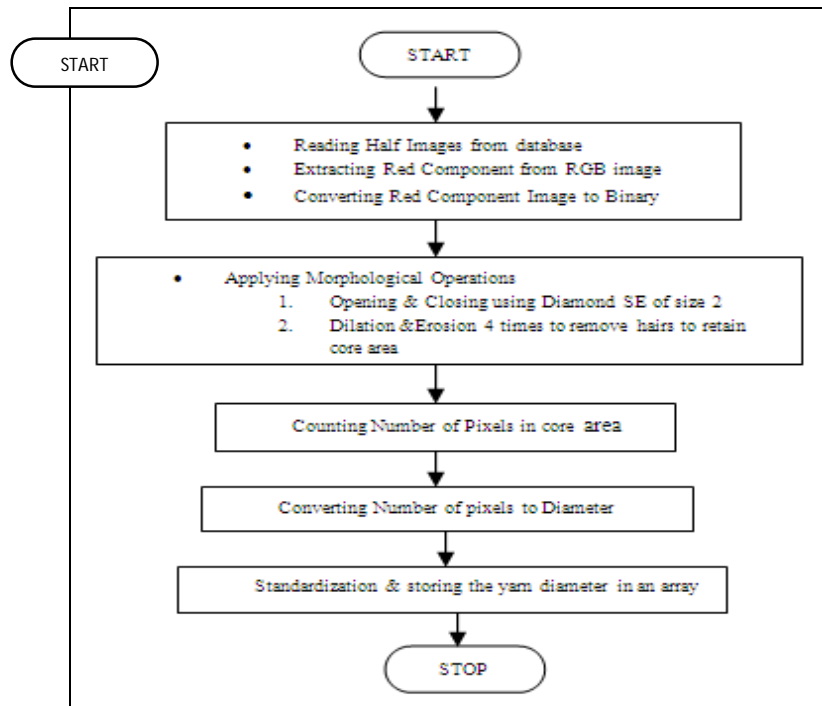


Figure 5 Proposed flowcharts for YDM using Image Processing

In this proposed flowchart the focus is on separating the core area of yarn from the haired yarn. This is established by carrying out morphological operations on extracted red yarn image obtained from RGB image. The experimental procedure designed for this objective is presented in next point.

### 8. Experimental Procedure

Detailed experimental steps involved for experimentation are as below of which main objective is to separate core area from haired yarn image to obtain YDM.

- Take yarn image from database.
- Extract red component from RGB image
- Convert red component image to binary image.
- Invert the binary image.
- Apply opening and closing operation using diamond Structuring Element (SE) of size 2.
- Apply closing operation using diamond Structuring Element (SE) of size 2.
- Apply dilation operation using diamond Structuring Element (SE) of size 2.
- Apply erosion operation 4 times using diamond Structuring Element (SE) of size 2 to retain only core area of yarn image.
- Count the no of pixels in core area of yarn.
- Convert pixels to diameter using standardization factor.
- Repeat steps from 1 to 10 on all sample yarn images of 30 count in database.
- Store the result in an array.
- Obtain average of all the YDM readings.
- Repeat the above experimental procedure on 40 and 50 counts for all the images.

The average measured yarn diameter results obtained were then compared with the diameter obtained manually as shown in Table 3. [10].

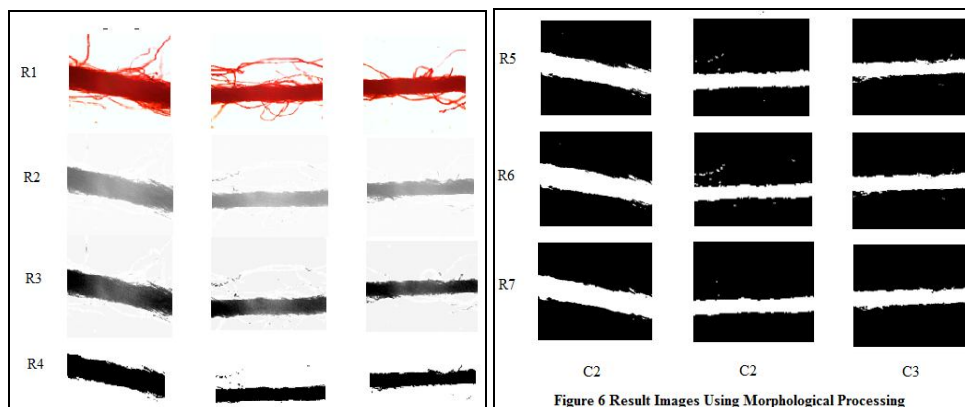


Figure 6

Figure 6 Result Images Using Morphological Processing

Figure 6 illustrates the result images of our proposed algorithm corresponding to different operations performed using morphological processing on yarn images. Table 4 explains the actual operations performed on the images in different rows of Figure 6. Columns C1, C2 and C3 of Figure 6 indicates the results images for 30, 40 and 50 count.

Count			Operations Carried out
30	40	50	R1: Original Image
			R2: Red Part Extracted Image
			R3: Intensity Adjusted Image
			R4: Binary Image Obtained After Thresholding
			R5: Binary Inverted Image
			R6: Eroded Image
			R7: Final Eroded Image Obtained After 4 Erosions

Table 4: Operations performed for Result Images

Row R2 shows the red component extracted images from original images present in row R1. The binary images in row R4 were obtained after intensity adjustment of images in row R3. Row R5 images were obtained after binary inversion of binary image in R4. These images in Row R5 were then subjected to erosion operation and the resulting images of this are as presented present in row R6. Row R7 shows the final images obtained after four erosion operations which contains only core area of yarn.

**9. Procedure to Find the Diameter of the Core Yarn Area**

The resulting final images obtained after 4 erosion operations are as shown in row R7 of Figure 6, where only core part of the yarn was retained. The number of binary image pixels widthwise in vertical direction of core part of yarn were counted at an interval of every 10 pixels along X-axis as in Figure 4a). The yarn diameter in terms pixels were then averaged and multiplied using standard for conversion of pixels to SI unit. The computed values of diameter were then compared with the manual microscopic method that are depicted in Table 5. The next part includes numerical results obtained for YDM using proposed morphological processing.

**10. Results and Observation**

In the previous section we have seen that different operations involved in morphological processing have separated the core area of yarn from the hairy part. So counting the number of pixels in the core area of yarn as a diameter in pixels and converting to SI unit i.e. to micrometer and is tabulated in Table 5 for 30, 40 and 50 counts. The absolute difference between the results of manual microscope YDM method and that of proposed YDM algorithm using morphological approach is computed using (1) as below,

$$ADD = DZM - DPIPA \tag{1}$$

Where, ADD is Absolute Difference, DZM is Diameter Observed by Zeiss Microscope, and DPIPA is Diameter Observed by Proposed by IP Algorithm.

Sr. No	Count	Sample Images	Diameter Observed By Zeiss Microscope in $\mu\text{m}$	Diameter Observed By Proposed IP Algorithm in $\mu\text{m}$	Absolute Difference
1	30	100	191.0922	191.5344	0.44222
2	40	100	142.8209	133.8348	8.98608
3	50	100	125.1816	120.1602	5.02138

Table 5: Results Comparison of Manual Microscope Method and Proposed IP Algorithm Method

### 11. Performance Parameters of YDM

Table 6 presents the comparison results obtained for yarn diameter by Uster standard, manual Zeiss method and our proposed morphological approach.

Sr. No	Samples	Standard Diameter in $\mu\text{m}$	Yarn Diameter measured in $\mu\text{m}$ by	
			Manual Microscope Method	Our IP Approach
1	30	166	191.0922	191.5344
2	40	143	142.8209	133.8348
3	50	128	125.1816	120.1602

Table 6: Results Comparison of Diameter obtained by Standard, Manual Microscope Method and Proposed IP Algorithm Method

This table shows that the obtained values for diameter for three different counts are nearly equal to the values obtained by manual method and the standard values. But for the comparison of results obtained for diameter measurement, performance parameters such as Standard Deviation and Coefficient of Variation were computed as per Textile Standards so as to find the allowed tolerance for the YDM. Hence we have also found out these performance parameters for our MA method by using the following equations.

The performance parameters for proposed algorithm such as Standard Deviation (S.D) and Coefficient of Variation (C.V) were computed with the help of (2) and (3) [1].

$$(2) S.D\% = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$$

Where. X is No of observations,  $\bar{X}$  is Mean of no. of observations, n is No. of images.

$$C.V\% = \frac{S.D}{\bar{X}} \times 100 \quad (3)$$

Where. C.V is Coefficient of Variation, S.D is Standard Deviation,  $\bar{X}$  is Mean of no. of observations. These computed parameters were then further compared with the allowed tolerance [1].

### 12. Comparison of Diameter Measurement and Performance Parameters

Table 7 and Table 8 give the comparison of the results obtained with the allowed tolerance of C.V. %.

Sr. No	Count	Sample Images	Manual Method			
			Diameter in $\mu\text{m}$	S.D in %	% C.V.	
					% C.V. Allowed	% C.V. Obtained
1	30	100	191.092	21.3	± 15	11.178
2	40	100	142.820	7.08		4.9611
3	50	100	125.181	7.13		5.7014

Table 7: Results Obtained By Manual Microscope Method

Sr. No	Count	Sample Images	Manual Method			
			Diameter in $\mu\text{m}$	S.D in %	% C.V.	
					% C.V. Allowed	% C.V. Obtained
1	30	100	191.534	30.9	± 15	16.0751
2	40	100	133.834	12.6		9.47292
3	50	100	120.160	10.6		8.82600

Table 8: Results Obtained By Proposed IP Algorithm

Following observations can be made from Tables 7 and 8.

It is seen that measured yarn diameter using manual method for 30, 40 and 50 count is 191.0922, 142.82 and 125.18  $\mu\text{m}$  respectively, whereas YDM computed by proposed algorithm for 30, 40 and 50 count is 191.53, 133.834, 120.160  $\mu\text{m}$  respectively.

It is seen that standard deviation for measured yarn diameter using manual method for 30, 40 and 50 count is 21.3, 7.08 and 7.13 % respectively, whereas standard deviation for measured yarn diameter using proposed algorithm computed is 30.9, 12.6 and 10.6 % respectively.

For count 30, 40 and 50 C.V for YDM using manual method is 11.171, 4.961 and 5.7014 % respectively, whereas C.V for YDM using proposed algorithm is 16.0751, 9.47292 and 8.82600 % respectively.

Thus the YDM results are within allowed tolerance & agree with manual measurement.

### 13. Conclusion and Future Work

We have presented 100 % combed, ring cotton yarn diameter measurement using Morphological Approach. From the observations we can conclude that for the 100% cotton yarn, as the count goes on increasing Standard deviation and Coefficient of Variation go on decreasing. It is found that CV % for measured yarn diameter is well within the allowed tolerance limit of 15% as per Textile standards for YDM.

So we authentically claim that our proposed IP algorithm based on morphological approach is capable of measuring diameter of yarn which confirms with the traditional method and microscopic method. Thus we incorporated complete automation for YDM using morphological approach.

This morphological approach can be further extended to measure the hairiness of yarn using morphological processing.

### 14. Acknowledgement

We are thankful to Textile department of TEI for providing the useful information and instruments.

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