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Research Article

EVALUATION OF YARN QUALITY IN FABRIC USING IMAGE PROCESSING TECHNIQUES

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ABSTRACT
The yarn quality estimate is a tough task in textile industries. In most of the cases, the task is accomplished by manual system. However, it is the classical problem in yarn based research where exact yarn quality production is ascertained based on mathematical yarn qualities like yarn diameter and length etc.. In the existing work, it is observed that the yarn quality has been deduced based on yarn length and diameter only. But merely these parameters do not provide much blending permutations and combinations in order to produce different quality variant yarn production. In the presented work, it is proposed to derive more yarn quality parameters like, uniformity of yarn along the axis, thickness profile of yarn along the horizontal axis along with length and diameter. Image processing tools are applied here in order to get the yarn image and extract the yarn features. Further, for yarn quality estimation, a microscopic analysis requires a lot of manual efforts and time and that on compromising on uniformity of quality judgment. The manual analysis does not provide the ease of on-line testing of yarn quality as it is normally off-line and not continuous. Therefore, in order to remove the difficulties in the existing system, a noval on-line testing of yarn quality using statistical analysis is proposed. In the presented work, it is proposed to derive yarn quality parameters like, uniformity of yarn along the axis, thickness profile of yarn along the horizontal axis along with length and diameter. A mathematical model is proposed to be developed that could predict the fabric quality based on yarn quality determination. A global feature vector set of yarn quality is proposed to be compiled that can be standardised for yarn quality determination. By the method, a quantitative evaluation index is proposed for the yarn quality. The proposed work will provide the basis of further studies on quality of yarn evenness and evaluation of yarn appearance.

Keywords: *Yarn Quality Index, Segmentation*

INTRODUCTION
A generic term for a continuous strand of textile fibers, filaments, or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric. Yarn occurs in the following forms: (1) a number of fibers twisted together (spun yarn); (2) a number of filaments laid together without twist (a zero-twist yarn); (3) a number of filaments laid together with a degree of twist; (4) a single filament with or without twist (a monofilament); or (5) a narrow strip of material, such as paper, plastic film, or metal foil, with or without twist, intended for use in a textile construction.

The yarn’s appearance is the one of the most important parameters of the yarn, affecting not only the aesthetic value of textiles, their smoothness, and surface evenness but also the cost of the yarn-to-fabric process. Because of technical limitation in textile industry, the manual test system has been used to test appearance quality of cotton yarn, such as yarn evenness, neps, and impurities, for long time. During the test process, the method has many disadvantages, such as time-consuming and laborious problems, personal fatigue, and operator errors, which would cause unreliability, inaccuracy, and bad repetition of results.

Thus, researchers have been working on replacing the manual inspection method by automatic inspection systems. Since the computer image processing technology has been used in textile field, the computer-related method of inspecting appearance quality of cotton yarn became possible.

Related Works

Yarn diameter is an important determinant of many fabric parameters and properties e.g. cover factor, porosity, thickness, air permeability, fabric appearance, etc. There are many methods based on different types of sensors used for characterization of yarn unevenness. These instruments differ in the principle of measuring and the logic of evaluation of yarn irregularity. It is essential to investigate more deeply which of these methods is more reliable and to establish a relationship between the results obtained from different techniques (Hakan *et al.*, 2008).

Fabric inspection system is important to maintain the quality of fabric. Fabric inspection is carried out manually with human visual inspection for a long time. The work of inspectors is very tedious and consumes time and cost.To reduce the wastage of cost and time, automatic fabric inspection is required. This paper proposes an approach to recognize fabric defects in textile industry for minimizing production cost and time (Bithika and Asit, 1999).

This paper presents a study on the development of a methodology to automatically determine yarn mass parameters using Image Processing (IP) techniques. The sample images were analyzed and processed through a custom made application developed in Lab VIEW from National Instruments using IMAQ Vision Toolkit (Jouko and Erkk, 1995).

Yarn hairiness is one of the key parameters influencing fabric quality. In this paper image processing and analysis algorithms developed for an automatic determination of yarn hairiness are presented. The main steps of the proposed algorithms are as follows: image preprocessing, yarn core extraction using graph cut method, yarn segmentation using high pass filtering based method and fibres extraction (Cohen *et al.*, 1991).

The proposed algorithms are compared with computer methods previously used for yarn properties assessment. Statistical parameters of the hair length index (mean absolute deviation, standard deviation and coefficient of variation) are calculated. Finally, the obtained results are analyzed and discussed. The proposed approach of yarn hairiness measurement is universal and the presented algorithms can be successfully applied in different vision systems for yarn quantitative analysis (Kang *et al.*, 1999).

Due to the high computation in the market, the weaving factory had to attain the customers' demands based on samples or fabric performance at minimum time. The fabric performance is mostly determined on theoretical bases, which need experiments to meet the factory working conditions; this tends to loss of time and high expensive recycled wastes (Chen, 1998).

The fabric performance was based on fabric tearing, bursting, and tensile strength, elongation, abrasion, thickness, porosity. Fabric porosity was obtained theoretically, by air permeability and image processing. Significant regression equations were determined to predict various fabric properties, and identify the most significant factors influencing the fabric properties (Jianfeng and Zhang, 2003).

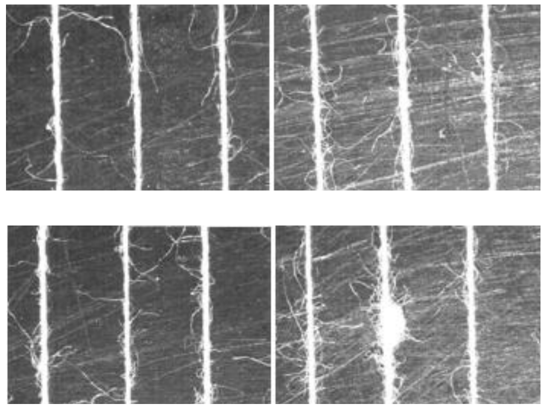
Several tests were performed and compared with other methodologies of yarn parameterization validating the proposed solution. With the results one can support that this can be an alternative solution to the traditional yarn testers, with several advantages (among others, low cost, weight, volume, easy maintenance and reduced hardware). Moreover, this yarn parameterization can be used to assess the quality of the fabrics resultant (Tang *et al.*, 2003).

Algorithm

In the proposed work, a digital method is established to inspect the images of cotton yarn based on the characteristics of the yarn images. Following steps are involved in the presented work:

- Yarn Image Acquisition
- Image Thresholding

- Segmentation
- Feature Extraction
- Feature Vector Set Compilation
- Standards/Reference
- Yarn Quality Determination



The scheme adopted to achieve the goal is summarized as: very firstly the Image is grabbed using camera and stored in bmp format with 8-bits gray level color scheme. The image is then subjected to noise removal algorithm. The noise free image is brought under threshold mode where the background is made white and object/patterns of interest are made black. This is termed as binarization of the image. The acquired image is normally in jpeg format. It is then converted to gray scale image using the rgb2gray command in matlab.
Further, the image is thresholded using the Otsu algorithm and thereafter the binary image is segmented using the bwlable command in matlab. The segmented yarn images are then brought under the statistical analysis tool for measurement of min. and max. radii in each quadrant, perimeter, area, figure aspect and standard deviation etc.
Following images shows the matlab screen shots of the yarn images and segmented yarn images:

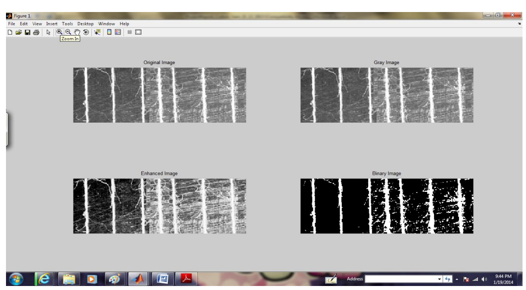


Figure 1

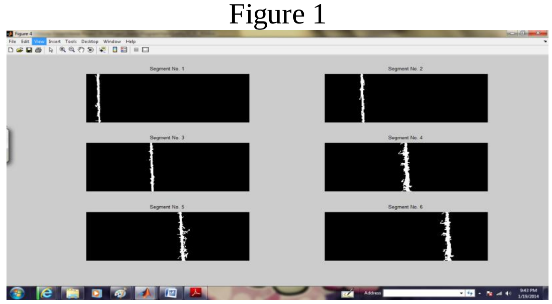


Figure 2

Feature Vector Set Compilation

A feature vector set may be prepared using the above parameters as follows:

- The figure aspect may give the average thickness of the yarn. Or a rough idea about the evenness may be extracted out from the figure aspect.
- The maximum and minimum radii in each quadrant give the estimate of yarn diameter and evenness of the yarn.
- Axis parameters give the length of the yarn.
- Area of the yarn indicates the yarn area.
- Standard Deviation of radii also represents the evenness of yarn thickness.
- High standard deviation represents the non-uniformity of yarn over the entire length

RESULTS AND DISCUSSION

Results

Following figure shows the original image, gray image, enhanced image and binary image using steps discussed in previous sections.

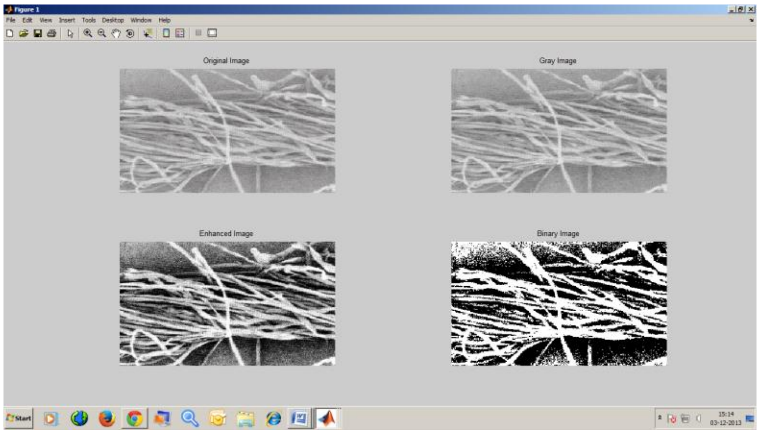


Figure 3

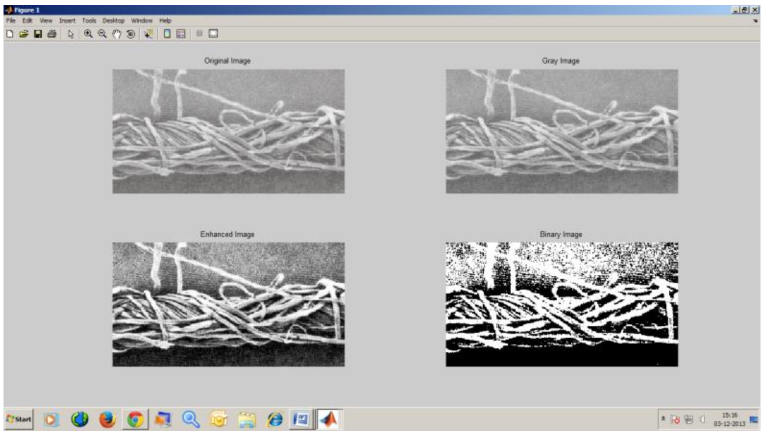


Figure 4

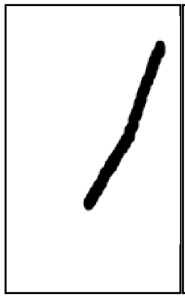


Figure 5

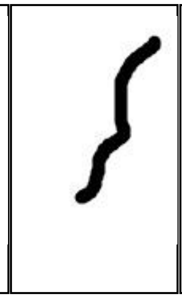


Figure 6

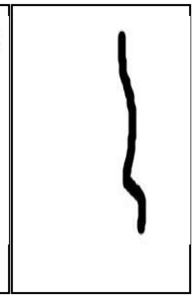
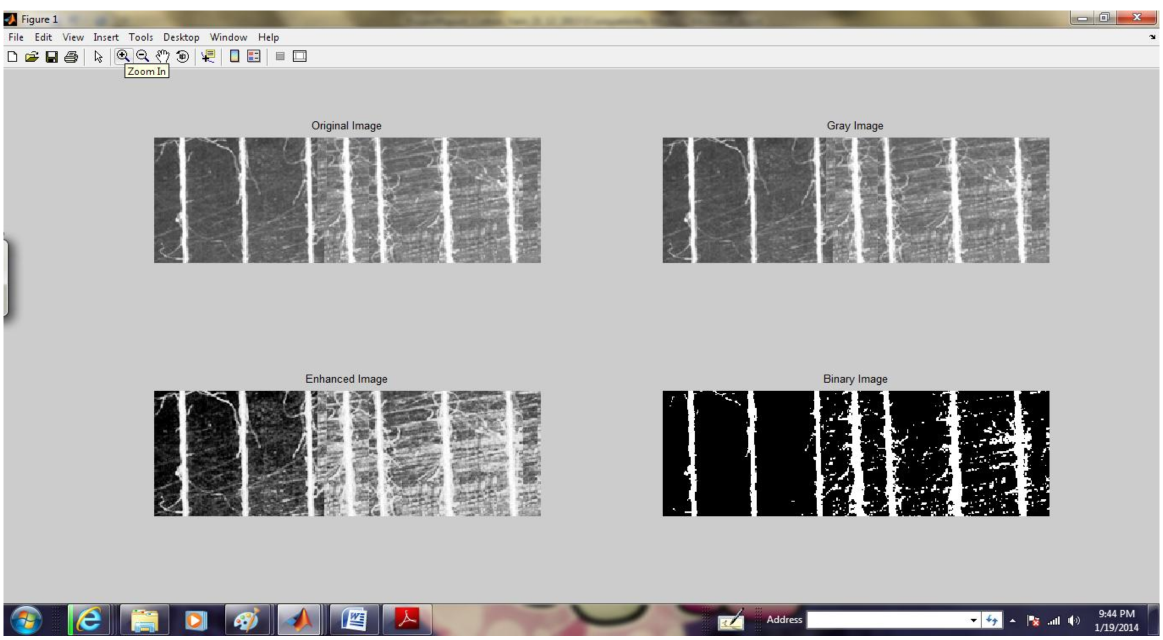


Figure 7

Following table shows the yarn features as extracted using the algorithm discussed in previous sections:

Figure No.	**Mean Dia. Pixel Units**	**Std. Sev.**
5	5	0.0034
6	7	0.0023
7	8	0.0017

The yarn diameters are in pixel units and may be validated or calibrated with actual scale i.e. size of pixels in mm. In the earlier work, the standard deviation has been computed to the first place of decimal. However, we could compute the standard deviation upto second place of decimal thereby improving the accuracy in the computation part. However, the values will depend primarily on the yarn quality. Still, we could get better accuracy by using the machine vision and statistical analysis technique.
Following screen shots shows the segmented yarn/fibres images for which the proposed algorithm has been worked out and results are given in the table:



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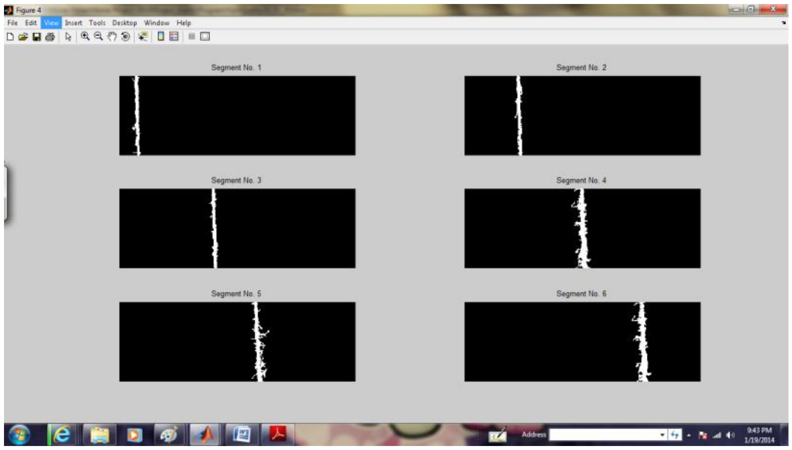

The coefficient of variation (CV) is defined as the ratio of the standard deviation σ to the mean μ:

$$c_v = \frac{\sigma}{\mu}$$

which is the inverse of one definition of the signal-to-noise ratio. It shows the extent of variability in relation to mean of the population

Table

Seg. No.	Max. Radii in each Quadrant				Min. Radii in each quadrant				Intercepts in Each Quadrant			
	R_1	**R_2**	**R_3**	**R_4**	**R_1**	**R_2**	**R_3**	**R_4**	**X_1**	**X_2**	**Y_1**	**Y_2**
1	120	119	123	121	10	12	11	12	5	5	114	112
2	121	123	121	123	9	11	11	12	5	5	112	100
3	126	127	125	124	11	10	10	11	5	5	111	101
4	127	124	120	120	10	10	13	15	5	5	113	100
5	115	119	123	125	9	9	9	12	5	5	112	100
6	123	121	120	126	12	11	11	10	5	5	113	109
CV	0.0359	0.0255	0.016	0.018	0.114	0.099	0.12	0.13	0	0	0.009	0.052

All measurements are in Pixel units

Table

Seg. No.	Figure Aspect = Y_1+Y_2/X_1+X_2	Standard Dev. of Radii (Pixel Unit)	Area of Yarn (Sq. Pixels)	Mean Radius
1	22.6	54.13	547	63.66
2	21.2	54.27	567	62.75
3	21.2	55.62	534	63.83
4	21.3	54.26	543	63.50
5	21.2	54.09	556	61.91
6	21.2	55.03	552	63.81
CV	0.0263	0.01136	0.02062	0.01209

All measurements are in Pixel units

Conclusion

The above table shows the results for the six yarns shown in above figure. The yarn shown above are of reasonable good quality and importantly are of same quality as the figure aspect and standard deviation are in a very near range i.e. 21 and 54 respectively.

A lower CV as shown in above tables indicates the uniform measurement of yarns diameter over the longitudinal profile.

The area and mean radius are also in the same range for the blend of yarns under study here. This shows a uniform blend of yarn used in the knitting of cloth material and thereby a quality index may be formed using the yarn quality as discussed above.

A quality index for cloth material based on yarn features may be given as Yarn Quality Index (YQI):

YQI = f(FA, SD, MR, Area):

Where FA, SD, MR and Area are the average figure aspect, standard deviation, means radius and Area of the yarn under study. Different features may be given different weightage as per the application requirement of the knitting/spinning process.

Or

YQI = w1. FA + w2. SD + w3. MR + w4. Area

Where w1, w2, w3, and w4 are the weights and can be adjusted for different grades of yarns there by making different yarn quality indexes

In the proposed work, we have computed the mean diameter and standard deviation of radii of yarn images in different quadrants. The low values of standard deviation indicate the uniformity of yarn dia. Throughout its length. Higher is the standard deviation, more the non-uniformity in yarn dia along its length and poor is the yarn quality. The proposed work may be used to generate an index for the quality estimation of yarn and can be used as standard for yarn quality. Then yarn quality may be indexed using this quality index and can be categorized according to different blends of the yarn.

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