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Yarn Hairiness Determination Using Image Processing

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Abstract: *Yarn hairiness is one of the key parameters influencing the quality of yarn.It is observed that yarn quality has been deduced based on yarn length and diameter only. But these parameters do not provide much information about yarn quality. Thus it is proposed to derive more yarn quality parameters like yarn hairiness, uniformity of yarn and its thickness. In textile industry, image processing is use to determine yarn parameters as well as yarn production characteristics. The main steps of the proposed algorithm are as follows: Image acquisition, Image thresholding, Segmentation, Image analysis*

Keywords: *Yarn, Hairiness, Image acquisition, Image thresholding, Segmentation, Image analysis, Uniformity*

I. Introduction

Yarn is a generic term use for continuous strands of textile fibre, filaments or material in a form suitable forknitting, weaving or otherwise intertwining to form a textile fabric. Yarn occurs in the following forms: 1) a number of fibres twisted together; 2) a number of filaments laidtogether without twist; 3) a number of filaments laid together with a degree of twist; 4) a narrow strip of material, such as paper, plastic film, or metal foil, with or without twist, intended for use in a textile construction.

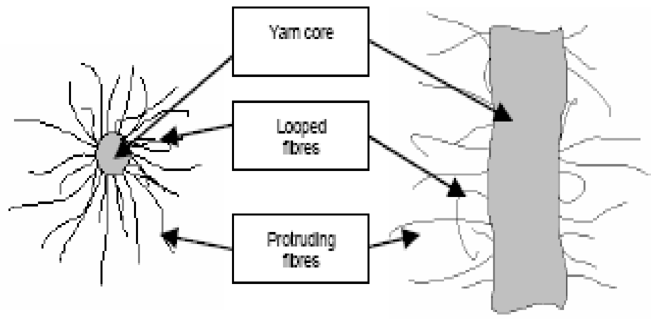

Fig1. Identification of yarn core and yarn hairiness (looped fibres and protruding fibres)

The yarn's appearance is 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.

Computer vision system is commonly used in many branches of science, medicines and industry [4].In modern computer vision systems image processing and analysis algorithms are used for an automatic measurement of important yarn quality parameters, such as:
Hairiness, diameter, twist, thickness, faults, density and bulkiness, surface defects etc.
One of the key parameters defining textile yarn quality is its hairiness. Hairiness arises from protruding fibre ends released from the yarn surface which can be divided into the protruding fibre ends and the looped fibres arched out of the yarn core.

Generally, hairiness is an undesirable yarn feature. It spoils yarn smoothness and negatively influences weaving, knitting and other textile operations following spinning. This in turn degrades fabric quality, negatively impairs its characteristics and causes serious faults in further textile processes. Therefore it is necessary to measure and control yarn hairiness during its production . In some cases, hairiness is a desirable feature, i.e. for fancy yarns, yarns for soft and bulky fabrics, etc.
Although a number of approaches for yarn hairiness determination exist, the methods using image processing and analysis algorithms are still under development. This paper presents application of image processing using MATLAB method for yarn core extraction and filer based method for yarn segmentation.

II. Existing Work

The history of yarn hairiness measurements dates back to the 50's to the pioneering works of Barella and Onions. However, in general they can be classified into one of the following groups:

2.1 Weighting methods: Define hairiness by means of the difference between weight of yarn before and after singeing (i.e. burning the protruding fibres). The main drawback of these methods is averaging of results. Moreover, they do not provide information about the spatial distribution of the protruding fibres. Therefore, recently their significance is mostly historical.

2.2Photoelectric method: Hairiness determined by the number of interruptions to the light beam (which is parallel to the yarn core) caused by the protruding fibres.

III. Proposed Work

Since the hairiness may considerably change along the linear development of a yarn, in the last years a number of works have been carried out in order to introduce more reliable and realistic indexes.

Carvalho et al. [9] introduced an image processing based technique for hairiness index evaluation in order to overcome a number of the main drawbacks identified in the traditional yarn testers (e.g. high cost, large volume, high weight, limited resolution and precision in the yarn mass parameters determination).

In the proposed work, a digital method is established to inspect the images of cotton yarn based on the characteristics of the yarn images.

As per above algorithm, yarn hairiness will be determined by following 3 steps:

1. Image Acquisition.
2. Image Processing.
3. Image Analysis.

This method will overcome all the drawbacks of the existing work and good result will be obtained.

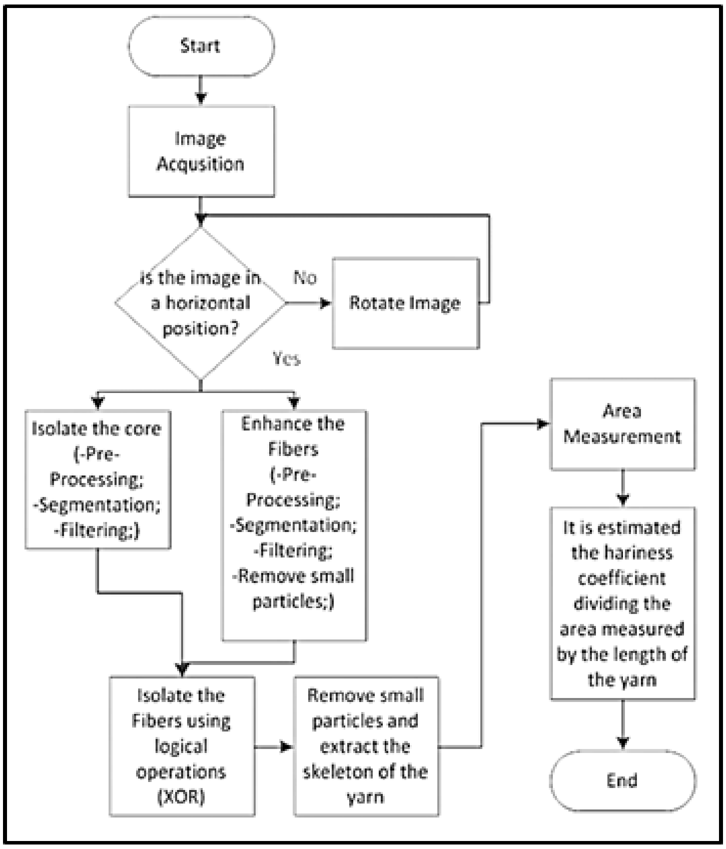

Fig 2: Yarn Hairiness Algorithm For Software

The detail analysis of steps are as follows:

1.Image Acquisition:

Planar still images of yarns of various hairiness magnified 45 times were considered in this work. The images were acquired with 8-bit resolution and stored as monochromatic images of resolution M×N equal to 480×640pixel.

2. Image Processing-

a. Image Conversion & Filtering-

- The magnified image is usually in the RGB format.
- This image is then subjected to Noise removal algorithm which uses two filters. Weiner filter removes the blurriness of the image whereas the Median filter removes the 'salt-&-pepper' noise.


Fig. 3.(a) **Fig. 3.(b)**

b.Thresholding & Segmentation:

The noise-free image is then converted to grayscale image. The gray level threshold is set by using Otsu's algorithm. Thereafter the image is subjected to segmentation. High pass filtering is applied in this step. In the resulting image all values above 0 are set to 1. Others are set to 0. In consequence binary image of yarn is obtained. The extracted fibres are disjoint and well-defined while fibres segmented by the thresholding methods are often discontinuous and merged into one region.


Fig.4(a) **Fig. 4(b)**

c. Feature Extraction:

In the final image processing step the protruding and looped fibres are separated from the yarn. It is done simply by subtracting the core obtained in the first processing step from the image of yarn.

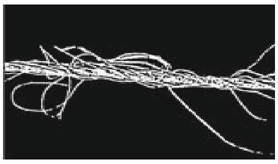
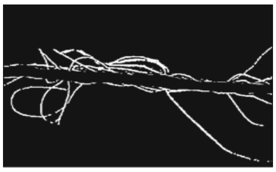

Fig. 5(a) **Fig. 5(b)**

The image before and after conversion.-

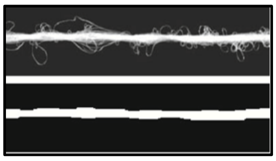
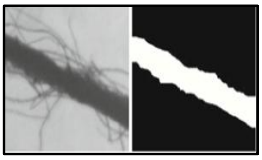

Fig. 6(a) **Fig. 6(b)**

IV. Image analysis

Image analysis aims at determining yarn properties based on results provided by image processing steps. The considered application determines fundamental statistical yarn parameters which are the following: hair length index *HL*. The definitions of these parameters and the proposed algorithms for their determination are presented in the following subsections.

4.1 Determination of hair length index

Hair length index *HL* (known also as hairiness index) is a unit-less parameter defined as a ratio between the total length of single (i.e. looped and protruding) fibres *L*F and the total length of core *L*C [12]. It can be expressed by Eq. (1).

$$HL = 10*\frac{Lf}{Lc} \quad (1)$$

Hairiness index *HL* as defined in Eq. (1) for the sensing length *L*C of 1 cm is used, as a measure defined in Uster Tester 3 apparatus. It is valid for cotton yarns with average fibre finesses. Due to the method used in this apparatus the measured intensity of light scattered by the protruding fibres is proportional to the total length of protruding fibres. This assumption is correct only, if the fibres cross-section is approximately symmetric. Application of image processing and analysis methods allows for hair length index calculation.

Analogously, for *HL* index calculation both lengths aredetermined from binary images of fibres and core. However, the parameters cannot be determined directly. Therefore in order to determine desirable lengths, image skeletonization is applied to both the binary images (i.e. images of core and fibres). Skeletonization produces line representation of both theyarn core and the fibres. In particular, it provides skeletonsi.e. set of white (with 1's assigned) points equi-distant toborders of objects.Obtained skeletons retain topology of objects, thereforethey can be successfully used for determination of total lengthof the core and the protruding fibres. Specifically, the lengthsare calculated by counting number of pixels belonging to the skeleton of the core and the fibres in accordance with Eqs. (2) and (3) respectively.

$L_f = \sum_{i=1}^{M}\sum_{j=1}^{N} SK\big(f\,(\mathbf{x}i\,j\,)\big)z$ (2)

$Lc = \sum_{i=1}^{M}\sum_{j=1}^{N} SK(\,c(\mathbf{x}i\,j\,))z$ (3)

Where *SK* denotes skeletonization by thinning performed onthe binary image given as a parameter and *z* is parameterwhich equals 1 when two neighbouring pixels are horizontalor vertical and √2 when neighbouring pixels are diagonal.

4.2 Diameter:

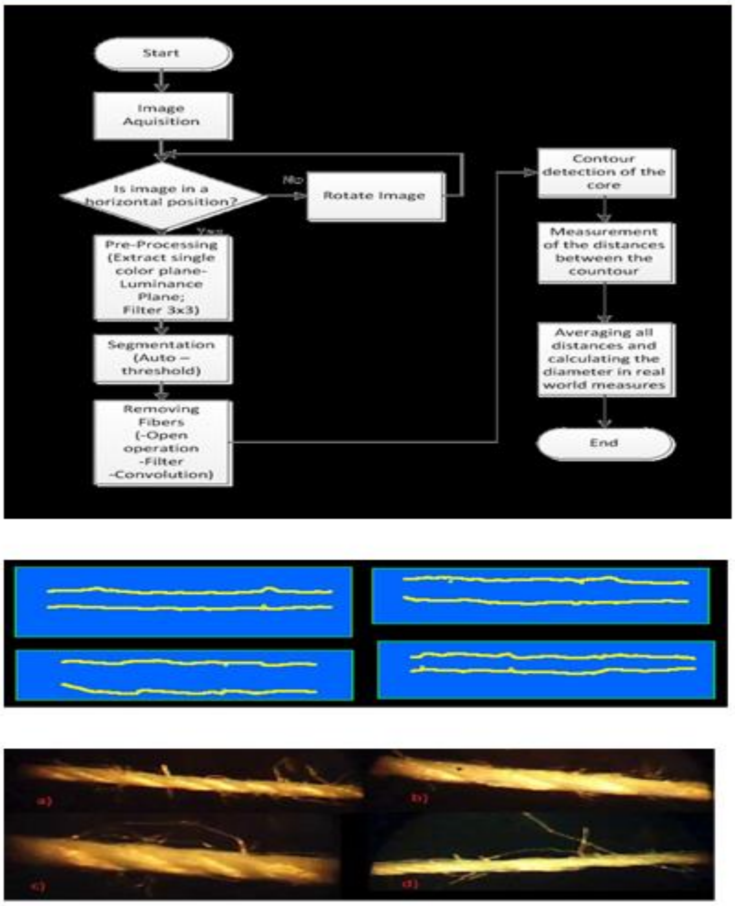

Fig. 7

Diameter is determined by segmenting the core from the fibre. The thickness of the core is then measured at various points. The average of this is taken and this is the average diameter of the yarn.
By determining the diameter of the yarn result will come to know whether the thread or yarn is thick or thin.

V. Conclusion

The main goal of this project is to describe a technological solution to automatically characterize yarns properties and predict the visual appearance in fabrics, using primarily Image Processing (IP) and artificial intelligence based techniques.

Regarding the results obtained for each of the parameterizations performed (yarn production characteristics, yarn diameter and imperfections and yarn hairiness determination) it can be concluded that the reliability of the image processing system option is competitive with traditional systems based on capacitive and optical sensors.

Apart from other benefits, its low cost, portability and reduced maintenance give proper indicators in order to justify its adoption for offline yarn analysis systems.

VI. Future Work

Future work will consider artificial intelligence algorithms to improve the detection and to enable a distinction between the loop and protruding fibers.

It will also involve simultaneous processing two orthogonal images of the yarn as proposed in or analysing data composed from images provided by two cameras located at different views.

Additionally, it is planned to focus on developing on-line algorithms for yarn quality assessment and image analysis algorithms for distinguishing between the looped and free fibre sends, and also calculation of their number and length.

Furthermore it would be particularly interesting to extend the developed methodologies to the characterization of different types of yarns, such as fancy yarns.

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