

ARTIFICIAL INTELLIGENCE APPLIED TO MODIFY CONVENTIONAL YARN GRADING SYSTEMS BY IMAGE PROCESSING AND FUZZY LOGIC

MOUSSA BARMOU ABOUBACAR

SHARDA UNIVERSITY

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
GREATER NOIDA-201306

Abstract— The paper focuses on the use of artificial intelligence With Fuzzy image processing and logic, conventional yarn grading systems can be updated. In the entire arrangement of this study, there is the use of MATLAB graphing toolbox to promote investment in algorithms during image processing and yarn quality assessment. The digital camera to sample imaging, a computer to process, and a sample quality assessment are provided. Since yarn grading assessment is typically based on labor intensive assessment in the textile industry. This test solved the inherent limitations of human visual inspection. The graphical user toolbox processing in MATLAB. MATLAB image processing is dependent on the samples of yarn count and the regular Yarn image numbers ASTM (D-2255) of a number of pixels. MATLAB image processing is provided for the picture acquisition and digital image extractions. This article introduces the modern yarn aspect grading system approach for the use of matlab image processing techniques and fluctuating logical structures to change the traditional appearance grading system.

IndexTerm—ArtificialIntelligence, Yarn Appearance Grading, Yarn image Processing, Graphical User Interface, Fuzzy logicssystem

I. INTRODUCTION

Yarns are used for the production of a variety of clothes and fabrics around the world. They are a fundamental raw material for the manufacture of textiles and textiles. The method of yarn production involves the production of nep, sneezing, thick and thin spots, soft yarn, oil-stuffed yarn, spin-offs, bad bits, oily slub, kitty yarn, fairness, diplomatic matters, slub and other abnormalities. Neps, created by the deposition of the fly and fluff on machine parts or by insufficient control, wreak havoc on the appearance of the cloth and cause the hue of colourful materials to change. Snarles, due to a twist of too large a thin spots in the thread, frequently degrade the appearance of the cloth and induce shade difference in coloured textiles and a break in the snare, with adjacent ends. Wear and tear on the tab as well as improper alignment of the tab, excentric rollers on the top and the bottom and insufficient pressure on the high rolls trigger thick spots. The appearance of the towel is degraded and cracked. Another typical defect in yarn is foreign matter that causes splitting, damages the appearance of the fabric and causes trouser in the tissue. Slubs are a defect that may arise from an insufficient drafting and parts of the ring frame, the deposition of fly and fluff on parts of the machine, incorrectly drawn top roller clearers or improper carding. In the next stage, the bandages produce additional end breaks in coloured materials and diminish the look of the cloth. As mentioned earlier, the yarn defects would rapidly decrease textile quality and lead to a substantial sell decline. (H.Y.T. Negan and his associates, 2011)

Since quality is the most important factor in textile yarn production, all manufacturers promote quality as a primary customer value and consider it to be the most important factor in achieving efficiency and customer satisfaction. Yarns are commonly used as a staple in the production of woven and knitted garments, as well as sewing threads and a variety of ropes. The appearance of yarn has a strong impact on the sturdiness and durability of end goods, in addition to its commercial importance. Yarns are used to make technical textiles that are used in the manufacture of different interior parts for automobiles. As a result, inspecting and measuring yarn consistency is the most important aspect in ensuring serviceability, smoothness, and a sense of comfort, among other assets. The aim of this paper is to show how to change the yarn grading scheme using image processing and symbolic logic in MATLAB Software to render the white pixel of the yarn from the yarn sample surface.

The ASTM D2255 has developed a simple yarn surface assessment test methodology (ASTM D 2255-02, 2007). In this conventional technique a specimen of yarn is wound over and over again on a trapezoidal or rectangular black surface. The wound yarn board is then checked and visually inspected. This is done. The test traditionally is carried out by the direct perception of the wound table and the photographic standards in grades A, B, C and D, in which a trained technician compares the wound table and gives the yarn sample a score. Grade A reflects the highest photographic output, while the others are dynamically smaller. Yarn fuzziness, neps, unevenness, and noticeable foreign matter can all be defined in general terms for each grade (ASTM D 2255-02, 2007):

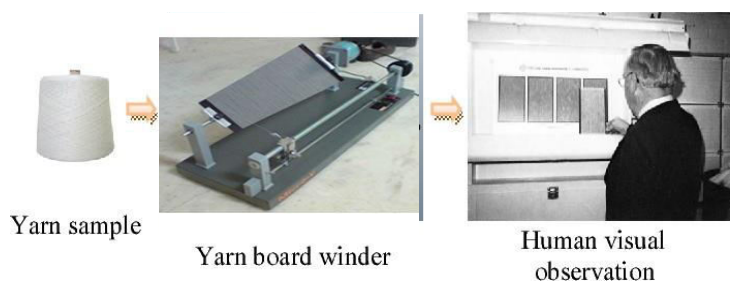


Figure 1: Manual Evaluation; (a) Yarn cone (b) Yarn board winder (c) Human visual observation

II. Methods and Methodology

The methodology of this paper, application of artificial intelligence using image processing and fuzzy logic to modify conventional yarn grading system, image acquirement with the utilization of digital camera. To determine the number of white and dark pixels in a yarn image, it must be transformed to a binary image. The image processing and yarn evaluation technique is schematically illustrated in the following diagram.

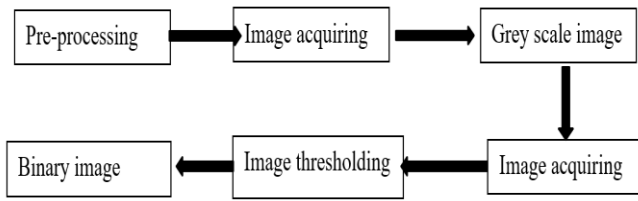


Figure 2: Elements for yarn image processing and grading method

The whole procedure in this study consists of pre-processing to collect and prepare yarn samples, digital camera image capture, and tools for image processing and investigation to determine yarn appearance. The requisite material for this investigation is a yarn wound board, a digital camera, and a computer with Matlab software.

PRE-PROCESSING

This tread depicts the picture arrangement process, which includes sample preparing using either a manually operated or an engine-driven system for winding yarn tests on thermosetting resin bonded laminate trapezium form boards. The apparatus is also shaped with the navigating manual for advance the yarn no matter how you look at it as it is wound. To wind the yarn sample on the surface of the board tray, the quality analyzer ought to adhere to the ASTM standard example arrangement prerequisites and methods dependent on the example yarn count. As per ASTM (D-2255) standard, here in the table underneath given portrays the yarn count details that is vital for board yarn winding example arrangement and ought to be viewed as good for the acceptance grading of universal exchanging among suppliers and customers.

Series	Range of Yarn Numbers		Wraps	
	Single count	Tex	Per inch	Per cm
1	1 – 12	590 – 50+	20	8
2	12 – 24	50 – 25+	22	9
3	24+ – 36	25 – 16+	26	10
4	36+ – 50	16 – 12+	32	13
5	50+ – 75	12 – 8+	38	15
6	75+ – 135	8 – 4+	48	19

Table 1: Requirements and standards for specimen preparation

In yarn fabricating industry, there are diverse universal standards and determinations that the manufacturer should applied at the time of assembling and item quality testing. Structure those, the parameters and strategies for yarn twisting on board region is the one and this example planning technique is appropriate at the time of yarn surface appearance and evaluating system. In this system, to choose and measure the yarn quality evaluation, the preparation of board yarn specimen is accomplished dependent on the global parameters and determinations as appeared in the above table. As indicated by ASTM standard, for each yarn count test has its own specimen preparation specifications.

For this study to fulfil the investigation, we got the yarn sample from the market. The yarn images samples are shown in the following figures.

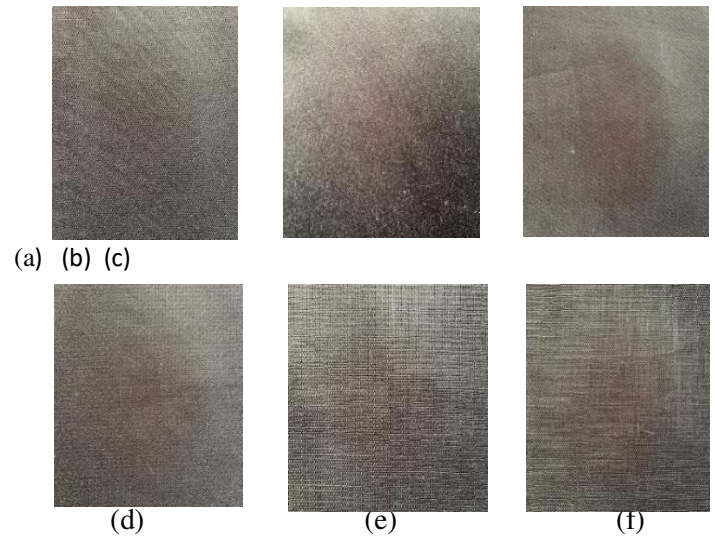


Figure3:Yarn samplein (Tex):(a)25, (b) 23,(c) 21.5, (d)19.5, (e) 18,(f) 16

IMAGEACQUIRING

Using a digital camera, the image capturing process is prepared after yarn wrap on the cardboard surface. The picture capture was done on both sides of the cardboard surface in order to get a standard grade assessment of one single yarn count example. During the image capture process, it's important to utilize an appropriate goal and zooming out image taking procedure so as to acquire the necessary image quality. At that point after capturing, it is conceivable to include and to show the sample picture by utilizing a MATLAB function of `Image=imread('yarn.jpg');`

GRAY SCALE IMAGE CONVERSION

The image captured here is transformed to a grey-scale with the graphical user interface with the MATLAB command 'rgb2gray' It is also known as an intense or grey pixel which comes in the range between [0, 255] and 8bit units in three distinct intensities.

The MATLAB program that was used to convert the captured yarn image into gray scale image is recorded as follows.

```
gray=rgb2gray(image);
```

IMAGE THRESHOLDING

Picture thresholding is the easiest way to separate an image into a narrower view and base stage that results in a clear, fluctuating image. This kind of image processing is used for division of images that divides objects into binary images by converting grey images. The following is described in this stage of the software MATLAB.

BINARY IMAGE CONVERSION

It only has, as its name suggests, two colours (white and black for example) and two pixel (0 and 1) of 0 marking black and 1 marking white. For MATLAB image processing, the result of white pixel binary image measurement takes on a fundamental task to pick the appearance of the yarn, depending on the pixel value that is assessed of the binary yarn images.

In this phase of yarn image preparing, to produce the forefront and foundation pixel numbers, we figured the accompanying binary image conversion MATLAB program.

```
Bw=im2bw(image);
```

BINARY IMAGE OF BOARD YARN PIXLE VALUE

In the board yarn image processing, a binary image is a computerized image and contains just two colors which are high contrast. These two colors have their own pixel values which represents the sample image stored inside a PC and portrays the physical appearance of the image. Generally, in the easiest case of binary image, the created pixel value is a 1-bit number which showing either the yarn surface or board.

```
threshold=im2bw(image);
Black=sum(threshold(:)==0);
White=size(threshold,1)*size(threshold,2);
```

YARN QUALITY GRADING

It only has, as its name suggests, two colours (white and black for example) and two pixel (0 and 1) of 0 marking black and 1 marking white. For MATLAB image processing, the result of white pixel binary image measurement takes on a fundamental task to pick the appearance of the yarn, depending on the pixel value that is assessed of the binary yarn images. It may deal with ambiguous, imprecise, unclear, partly real, or boundaryless knowledge resulting from computational perception and cognition. By using a fuzzy membership function, it is possible to use ambiguous human judgments in computational problems (S. Princy, 2016).

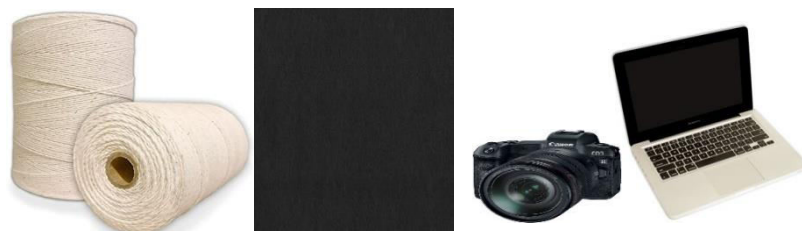
This will work by constructing a fluid group of groups based on their respective similarities to the ideals and the degree of membership that characterizes the true value of the yarn in the given fluorescent set.

A numerical function called the membership function can be used to describe the degree of membership in a fuzzy set (MF). MF is a graphic depiction of each input value or curve that shows how any point in the input area is mapped to a membrane (member level) of anywhere from 1 to 0.. Input space in MF is also called the fluffy set width or universe of expression (O. Ali, A. Ali, B. Sumait, 2015).

Since the visual evaluation of yarn surface grading report results is always in a state of confusion and ambiguity, this project was created to address this problem.

MATERIALS USED

In this study to achieve the investigation, the required materials include; yarn, cardboard, digital camera and computer. So generally, the materials utilized for this analysis are diagrammatically listed below.



(a)(b) (c) (d)

Figure 4: Materials for research: (a) Yarn cone; (b) Cardboard paper; (c) Digital camera; (d) Computer with MATLAB

For image capturing preparation in cardboard surface the number of turns per inch or centimeter of yarn ought to be done dependent on the given ASTM standard specification for the purpose of getting a clear image. Which implies, when the yarn count is coarser, in board surface there is a smaller number of yarns turns per a given length estimation and when its better count, number of yarn turns will be increase. So, in this research, method for preparation yarn sample in cardboard surface has a great factor on the pixel value output of binary image and the final yarn appearance grading result.

GRAPHICAL USER INTERFACE DESIGNING FOR YARN IMAGE PROCESSING

In this investigation, the strategy for yarn image processing and appearance grading, is handled by utilizing image capturing device, MATLAB with image processing toolbox or graphical UI (GUI), and fuzzy logic system for grading choice of yarn quality in rate. The graphical interface contains a wide scope of image processing activities including; open image file which is captured by digital camera, change to gray scale image, conversion to binary image, and image thresholding so as to rectify the image and remove its piece.

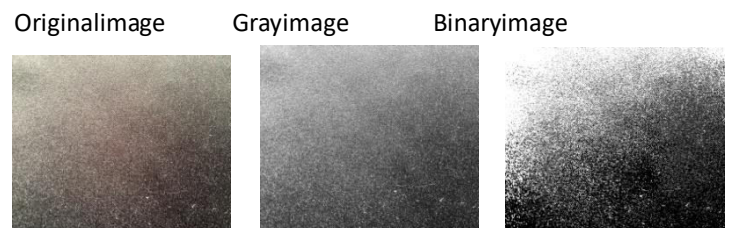
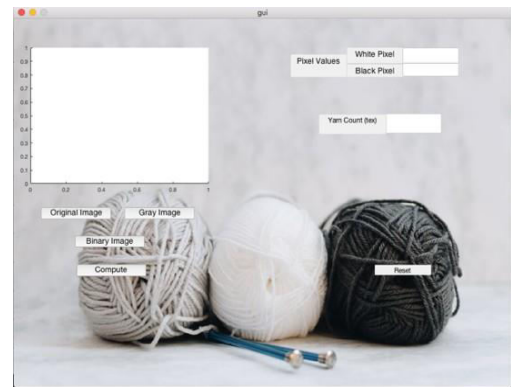


Figure5: Yarn image processing output

APPLYING FUZZY LOGIC SYSTEM FOR YARN QUALITY GRADING

This paper utilizes fuzzy logic system (FLS), for yarn surface quality evaluating and grading by taking the binary image pixel values of the yarn sample. At that point by applying fuzzy rules and numerical formulas, the calculated degree of membership of the input value (white pixels) used to choose the evaluation of yarn quality either good or bad, in view of their relative similarities with the standard one.

The basic step used to create a fuzzy logic membership function for yarn presentation, ranking, and classification is depicted in the next diagram:

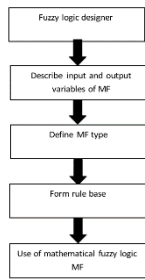


FIGURE 6: Strategies to develop FLS and MF for yarn grade classification

As shown in the diagram, to perform yarn quality grading by utilizing fuzzy logic, normally three phases must occur. First fuzzification which is utilized to adjust the membership values of a particular data collection or image pixel values. After the image information are changed to the membership function utilizing fuzzification, fitting fuzzy procedures will adjust the membership values. This can be a fuzzy rule-based approach, or a fuzzy integration approach and finally defuzzification, to get the output crisp value from the created expressive factors and fuzzy rules.

FUZZY LOGIC MEMBERSHIP FUNCTION

Type fuzzy into the MATLAB command line to open the fuzzy logic designer. The next step is to create a fuzzy membership mechanism by selecting and locating the input and output variables, as well as their definitions. In this investigation, single input variable which is white pixel value and single output variable which is yarn grade are utilized, to create the membership function of FLS for yarn quality grading classification. This project utilizes mamdani type of fuzzy inference system to develop fuzzy logic membership function and to achieve the yarn grading classification.

Variable	Parameters
A	(3.0, 3.0, 3.265, 3.794) * 10 ⁵
B	(3.265, 3.794, 4.25) * 10 ⁵
C	(3.794, 4.25, 4.85) * 10 ⁵
D	(4.25, 4.85, 5.0, 5.0) * 10 ⁵

Table2:variableandparameters

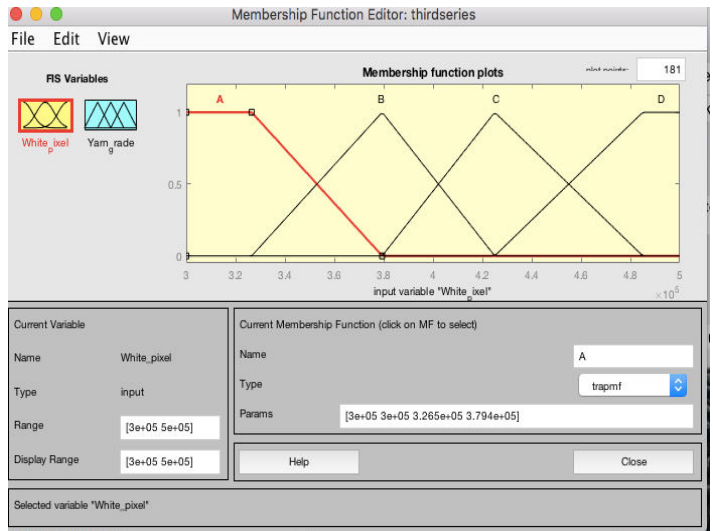


Figure 8: The input variables of MF for grading and classification

The output variable of consistency grade has four linguistics, and its universe of discourse is the same length as the input variables in order to have a membership function of the same width and form. The output vector is shown in the diagram below.

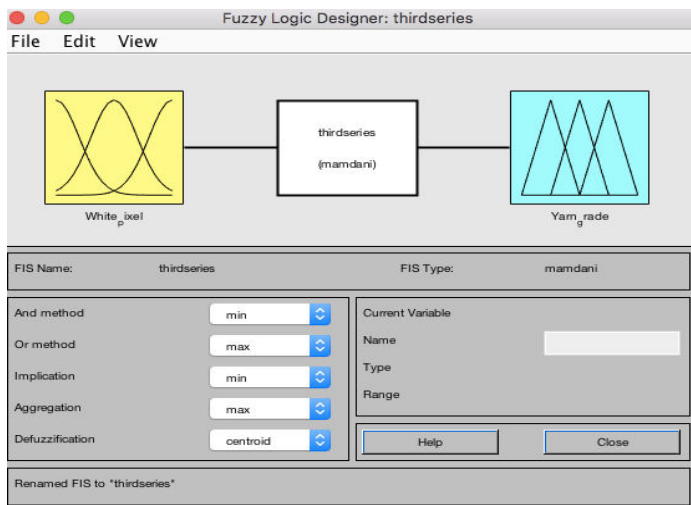


Figure 7: The starting fuzzy logic designer which contains the input and output

Here for yarn grading and evaluation we choose a trigonometric and trapezoidal shape of membership function. Membership functions determine how any point in the input space is mapped to an association value from 0 to 1. To create a feature of fluid logic membership, first select and identify the parameters (interval values) for input and output variables which used as a crisp value fuzzy set. In this project, we used from 25 to 16 tex yarn count range of four graded standard photograph pixel values to form input variable membership function, because the yarn samples belong in this count range. The input variable membership functions are ranging from 3*10⁵ to 5*10⁵, because the standard yarn image pixel values are belonging in this range.

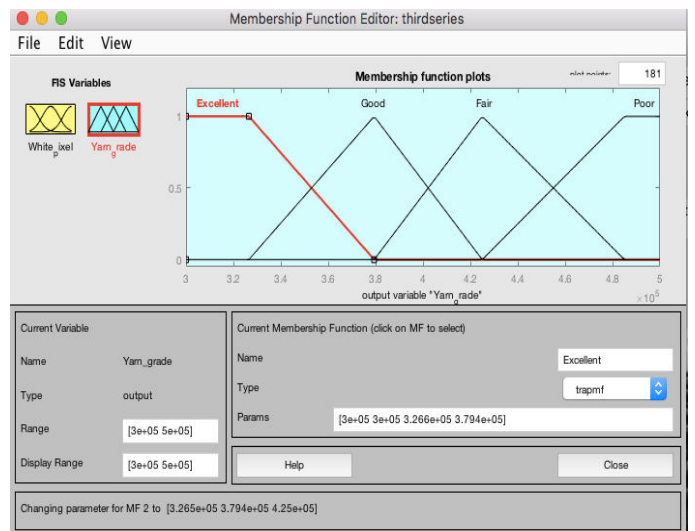


Figure 9: The output variables of MF for yarn grading and classification

Form rule base. This means that rules are created using the rule editor which define the logical relation between the variables input and output. In general, the rule editor allows you to create the rule statement based on descriptions of the input and output variables that are described by the Fuzzy Logic Designer. Totally in this studying we construct four fuzzy logic rules as follows:

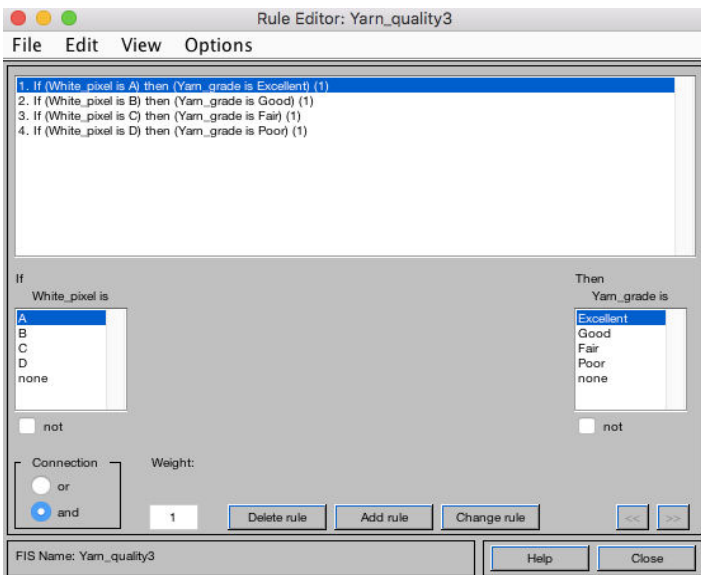


Figure 10: The if-then rules of input white pixel and output yarn grade in FLS

After the system defined and completed the fuzzy set variables, membership functions and rules become main applicable to calculate the output value and degree of membership. This process can be accomplished by importing the created fuzzy logic MF in the graphical user interface of MATLAB and apply membership function mathematical formula to evaluate and classify they yarn grade based on the output of yarn surface pixel values in image processing.

III. RESULT AND DISCUSSION

In MATLAB yarn image processing, to learn about yarn quality assessment and appearance grading system, first it must be begun by demonstrating a graphical user interface for the procuring of test pixel number creating process and to achieve the entire examination easily and rapidly. In the first result and discussion, absolutely to achieve the yarn image processing and pixel value creation test, the graphical user interface that contains the necessary GUI 'figfile' parts and the processed outputs is detailed as revealed below in the given figure.

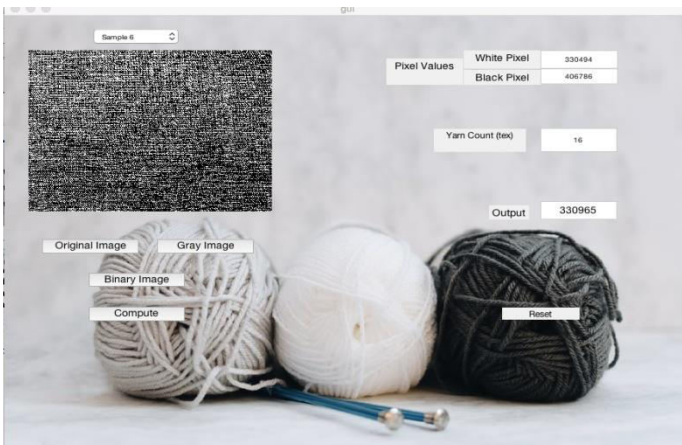


Figure 11: The general formulated GUI layout including yarn image processing outputs

After the yarn image processing and examining by utilizing diverse image processing steps in GUI, The output of binary image pixel values (white and black pixels) of all yarn samples after the yarn image processing and examination using various image processing steps in GUI are recorded in following table.

Sample Number	Yarn count (tex)	Output of binary image pixel values	
		White pixel	Black pixel
1	25	484096	253184
2	23	371770	365510
3	21.5	329350	407930
4	19.5	313782	423498
5	18	481935	255345
6	16	330494	406786

Table 3: Generated pixel values of binary image for each sample

By then in the subsequent discussion, we applied a fuzzy logic system for quality evaluation and grade classification system by utilizing the created fuzzy standards and mathematical equation of membership function dependent on the generated pixel values of the sample.

In this work, for final yarn appearance classification there are two prospects to acquire the final crisp values through total and defuzzification procedure of the created fuzzy rules. The first one is directly by utilizing the created fuzzy logic rule viewer. The fuzzy logic rule viewer easily demonstrates how each rule is connected to provide the final crisp value. The rule viewer shows a guide of the entire fuzzy control process. In the rule viewer tool toolbox, the number of rows portrays the number of rules and the number of segments for both input and output (N. Ahmed, 2003.). The developed rule viewer in this paper for both yarn image pixel input variable and grade rating output variable is seen in the figure below. By basically modifying the pixel numbers in the left base side of the input field, it shows the effect of the rules in right corner.

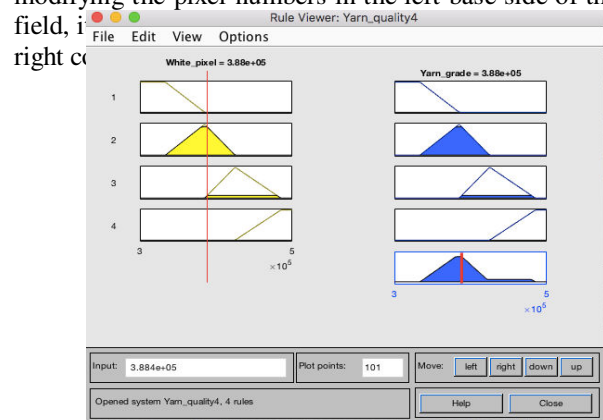


Figure 12: Rule viewer of the input white pixel and output yarn quality grade variables

By taking the examined pixel values of each yarn count sample, the aggregated sample output is shown in the following table.

Sample number	Yarn count (tex)	Sample pixel value	Aggregated Sample output
1	25	484096	473560
2	23	371770	371613
3	21.5	329350	331838
4	19.5	313782	328148
5	18	481935	470881
6	16	330494	333262

Table 4: Yarn sample pixel value and output variable crisp values

Each yarn count sample surface appearance can be measured using this application, and the final production will be shown in the generated GUI interface, as shown in the figure below. The effect (21.5 tex) of a yarn count sample from sample 3 is seen below, and the other sample result values can be processed similarly.

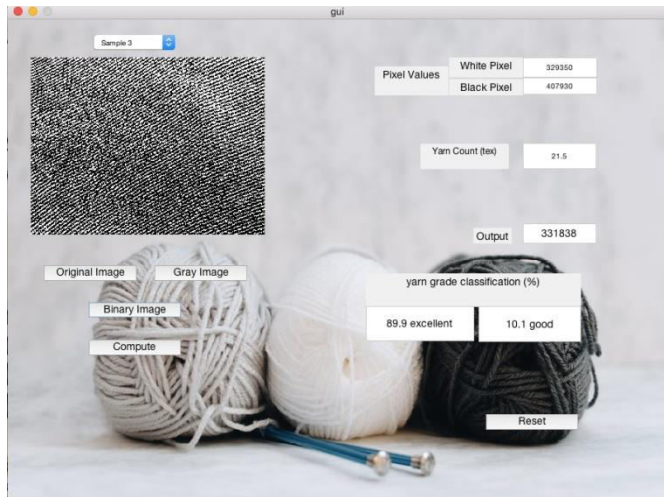


Figure 13: Final assessment result in the developed GUI layout

Finally, the yarn surface appearance description and classification result can be finish up as appeared in table below. The descriptive terms (excellent, fine, fair, and poor) that we used to depict the yarn appearance and grade arrangement in this analysis will replace the regular letters (A, B, C, and D) respectively. Since consistency evaluators used these descriptive terms rather than letters to measure the cotton surface appearance in the yarn processing industry.

Sample number	Yarn count (tex)	Yarn appearance grade classification	
		Manually	Matlab yarn image processing
1	25	D	19.1% fair & 80.9% poor
2	23	B	14.7% excellent & 85.3% good
3	21.5	A	89.9%excellent & 10.1% good
4	19.5	A	96.9% excellent & 3.1% good
5	18	D+	23.5% fair & 76.5% poor
6	16	A	87.2% excellent & 12.8% good

Table 5: Yarn quality grading result and its contrast with the

From the results and discussions, it is possible to calculate and analyze yarn quality measurement and appearance grading through MATLAB image processing and a fuzzy logic system membership function based on the shaped pixel values. The result of this study is more exact than conventional approaches because it translates the entire yarn surface region in quantitative value (pixels) and records a percentage of the result rather than a "+" sign after the letter, which can lead to misinterpretation by humans.

I. CONCLUSION

This paper used MATLAB tools for yarn image processing to establish the closer view area or white pixel values, and a fuzzy logic scheme (FLS) to determine and characterize the yarn surface appearance using numerical equations of

triangular and trapezoidal membership functions.

The yarn quality checker gives the same assessment for which has diverse yarn surface appearance with a comparable yarn count by using the normal ASTM (D-2255) technique.

In yarn manufacturing industry, numerous qualities assessing techniques are accessible to decide the yarn evenness, However, some of them are time-consuming, and the determining outcome is dependent on the quality checker's abilities, while others are less arbitrary and high-speed, costly, and need considerable maintenance during the damaging period due to their increasingly fragile and effectively damageable components. As a result, using MATLAB image processing and a numerical equation of fuzzy logic membership function, this study suggested a basic strategy for modifying yarn appearance.

This studying has an incredible commitment to the textile yarn fabricating company by evacuating the tedious of yarn appearance testing strategies they can get precise yarn appearance grading result rather than the manual testing strategy restriction.

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