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A Development of Textile Fabric Color Homogeneity Based on Computational Physics (Image Processing) with MATLAB

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ABSTRACT. The textile industry is currently moving towards to the fourth Industrial Technological Revolution. One of the applications of the industrial revolution 4.0 is in the field of computational physics. The application of applied physics especially computational physics on textile science can be initiated in analyzing the quality of fabric in the textile coloring process. This research focuses on a technique measuring the quality of fabric that occurred in the coloring process using the image processing technique by measuring the color space in the RGB (Red, Green, Blue) space as the length of colors vector of the fabric. In this study, the technique has been made using MATLAB 2009a software and Logitech *C525 HD webcam.* The result of this research shows that computational physics especially image processing by MATLAB can be implemented to measure and to determine the color quality of fabric accurately by comparing with the samples.

KEYWORDS**:** *Color space, Fabric, Image Processing, MATLAB R2009a*

INTRODUCTION

The textile industry is currently moving towards the fourth industrial revolution. The application of computational physics in the industrial era 4.0 in the study of textiles has been done by several researchers in theoretical physics, computational physics and material physics. Some researchers (Putra, Rosyid, & Maruto, 2016) (Putra, Maruto, & Rosyid, 2017) and (Herawati, Fauzi, & Putra, 2015) have examined the parameters of the quality of textile materials, especially textile yarns and textile fabrics by modeling mechanical properties. The application of physics in textile science has also begun to be introduced by several researchers and academics (Wijayono A. , Putra, Irwan, Iskandar, & S.Rohmah, 2017), (Wijayono, Putra, & Irwan, 2018), (Wijayono, Irwan, & Putra, 2018). The application of physics in textile science is as in the study of computational physics (especially image processing) which has been applied to the testing of textile materials such as yarn and fabric.

According to some researchers, digital image analysis techniques with visual sensors in the study of computational physics especially image processing have been widely applied in the textile field. In the field of textiles, digital images using software tools have been widely applied in several cases that require visuals as the main basis for measurements, such as fabric drape tests and yarn diameter tests (Millman, Acar, & Jackson, 2001) (Ozkaya, Acar, & Jackson, 2003), (Ozkaya, Acar, & Jackson, 2005) (Ozkaya, Acar, & Jackson, 2007), (Ozkaya, Acar, & Jackson, 2008), (Cybulska, 1999), (Anbarasan,

Upadhayaya, & Balasubramaniam, 2003), (Bellinson, 1940) , (Putra, Purnomosari, & Ngadiyono, 2016), (Wijayono, Putra, & Irwan, 2018) and (Wijayono, Irwan, & Putra, 2018).

The development of research on the use of computational physics (image processing) in the field of textiles has increased many researchers to study, although the application of computational physics in the measurement of several parameters of the quality of textile materials has been developed, in the test of the unevenness of dyed fabric colors, there has not been much research on the application of physics computation especially image processing in measuring the results of fabric quality, because until now the process of measuring color homogeneity still uses visual observation of the worker's eyes. Image Processing is a way of measuring, analyzing or processing signals with the input of an image and transformed into another image that has been processed as its output with a particular technique. (Suarga, 2005) and (Wijayono A. , Putra, Irwan, Iskandar, & S.Rohmah, 2017) explain that a discrete mathematics is a branch of mathematics that studies about objects whose values are different (distinct) and separate from one another. Digital computers generally work using discrete mathematics. Information stored and manipulated by the computer is in the form of discrete mathematics. Digital cameras capture images (analog) and then represent them in a discrete form of a collection of pixels or grids. Each pixel or grid is a discrete element of an image. One pixel is equivalent to 0.03 cm or 0.01 inch with a unit of length. The application of computational physics in particular image processing in the textile field has been carried out by several researchers (Millman, Acar, & Jackson, 2001) (Ozkaya, Acar, & Jackson, 2003), (Ozkaya, Acar, & Jackson, 2005) (Ozkaya, Acar, & Jackson, 2007), (Ozkaya, Acar, & Jackson, 2008), (Cybulska, 1999), (Anbarasan, Upadhayaya, & Balasubramaniam, 2003), (Bellinson, 1940) , (Putra, Purnomosari, & Ngadiyono, 2016), (Wijayono, Putra, & Irwan, 2018) and (Wijayono, Irwan, & Putra, 2018). Milman et.al. (Millman, Acar, & Jackson, 2001) stated that the digital analysis technique was successfully applied in calculating the interlace frequency of the texture yarn (nip), Ozkaya et.al. (Ozkaya, Acar, & Jackson, 2005) has also reported that image processing techniques have succeeded in measuring yarn diameter better. Some researchers (Ozkaya, Acar, & Jackson, 2007) and (Ozkaya, Acar, & Jackson, 2008) have succeeded in implementing computational physics processing especially image processing for the application in measuring hairiness in the yarn. The application of image physics analysis applications has also been reported by Cork, Cooke & Wild (Cork, Cooke, & Wild, 1996) in yarn twist and yarn angle measurements on woven fabrics.

Ozkaya, Acar, & Jackson (2003) states that the application of image processing is in the calculation of the twist of yarn using the Fourier transformation technique. Putra, Ngadiyono & Purnomosari (2016) states that digital image processing is a way for image analysis such as for analyzing area, shape, circumference and so on. Image processing is one form of signal processing in which an input is an image such as a photo or video frame, while an output from the image processing can be an image or a number of characteristics and a parameter relating to an input image. Generally in digital image processing, data processing involves an image as a two-dimensional signal and applies the signal processing technique standard to the image.

According to Putra, Ngadiyono & Purnomosari (2016), MATLAB is a software that can be used in image processing. MATLAB (MATrix LABoratory) is a software program that can be used to analyze and compute a numerical data and MATLAB is also an advanced mathematical programming language and is generally used in the case of computational physics, which uses the properties and form of the matrix. MATLAB is also a window-based computer programming language whose basic orientation is the matrix, but this program does not rule out the possibility of working on non-matrix problems.

In this study, the application of computational physics is examined as a test tool for the color of the textile fabric in the coloring process by measuring the size of the color and the color space that is fading on the fabric (striped color). The measurement of color space in this study uses the RGB color space (Red, Green, Blue) as in Figure 1. For Red has a color space value of (1,0,0), Green has a color space value of (0,1,0) and the Blue space value of (0,0,1) with black having a color space (0,0,0) with white being in the color space (1,1,1).

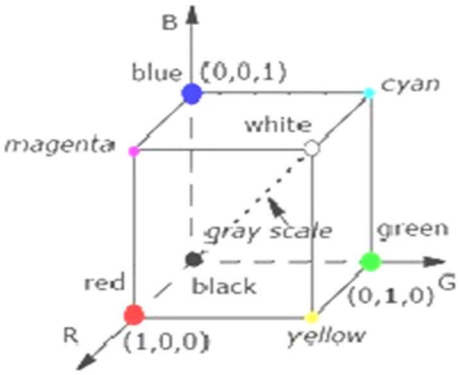

Figure 1 RGB Color Space (Wijayono A. , Putra, Irwan, Iskandar, & S.Rohmah, 2017)

RESEARCH METHODS

In this experimental method, tools and materials as well as work steps and image processing schemes in this study will be explained in this study to obtain a fabric quality test tool based on the color space and also the color homogeneity value. The tools and materials can be listed as: Logitech *C525 HD* webcam, two test fabrics, MATLAB R2009a Software, a set of computer. For the procedure of this research, it can be listed as: Test sample photo taken using Logitech C525 HD webcam, Photos edited using Photoshop software, Listing program that has been created, entered into the MATLAB works sheet software editor, Measurement of color and area of the image (object) is done in MATLAB software and the homogeneity of color along with the value of the color space are measured.

Digital analysis on two-dimensional fabric can be done with image analysis using MATLAB software, which is through image analysis that has been captured by the Logitech C525 HD webcam and then converted to a collection of real numbers on the matrix. Image processing system with MATLAB can be done systematically as follows: insert image, convert to gray image, do filtering and noise removal, change to a binary image, give the boundary area of the binary image to be measured, then the output will appear on the MATLAB screen. The recipe for the coloring process on this test sample cloth is shown in Table 1.

Table 1 Recipe of the coloring process used on the fabric of the test sample

Recipe of coloring process used	Fabric 1	Fabric 2
The wetting material (mL/L)	50	50
Na_2S (gram)	50	50
Na_2CO_3 (gram)	50	20
NaCl (g/L)	50	50
Coloring time (minutes)	30	30
Vlot	1:20	1:20
Coloring temperature(^oC)	80	80
Method	Standing bath	Standing bath

RESULTS AND DISCUSSIONS

In this study the measurement of fabric quality can be used two variables, namely, the similarity of colors and color unevenness in the area indicated there are different colors. The results of the process of taking fabric 1 with the Logitech C525 HD webcam can be shown in Figure 2. In fabric-1 color space measurement,

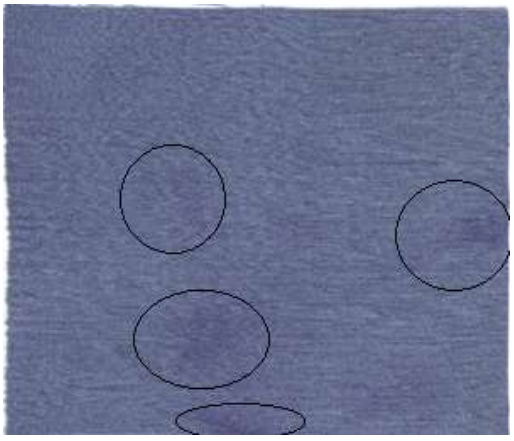

Figure 2 The appearance of fabric 1

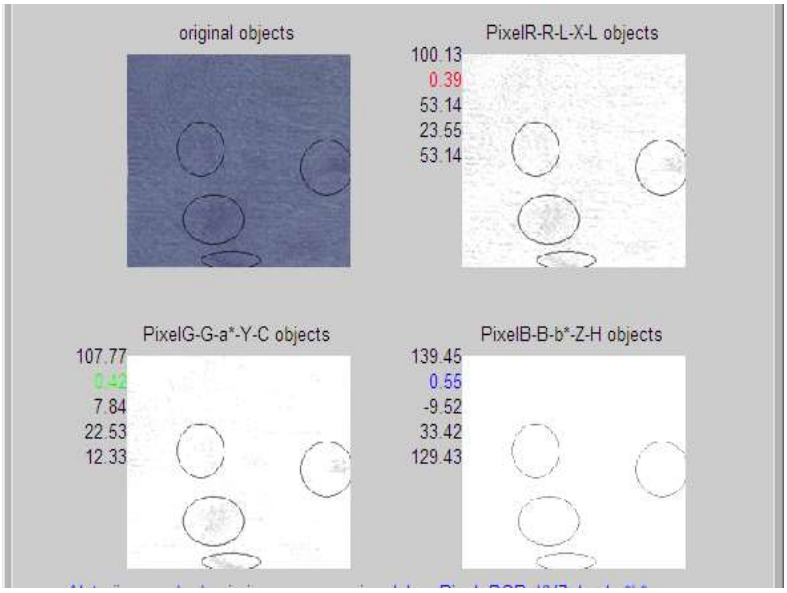

Figure 3 RGB Color space test for fabric 1

the RGB (Red, Green, Blue) color space value is used. For Fabric-1, the results of the RGB values can be shown as = (0.3927;0.4226, 0.5469).

Digital image results for color space can be shown in Figure 3. To measure the length of vector of the color space, ΔE, in RGB =(0.3927; 0.4226; 0.5469) to the black color (as the basic color space) RGB= (0,0,0) we can use Eq. (1) and Eq.(2).

$$\Delta E^2 = \Delta R^2 + \Delta G^2 + \Delta B^2 \quad (1)$$

$$\Delta E = \sqrt{\Delta R^2 + \Delta G^2 + \Delta B^2} = 0.795 \quad (2)$$

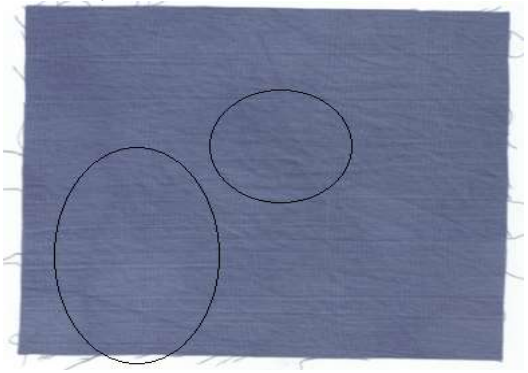

Figure 4 the appearance of fabric 2

The result of taking the image of fabric 2 by *Logitech C525 HD webcam* can be shown in Figure 4. In fabric-2 color space measurement, the RGB color space value is used. For Fabric-1, the results of the RGB values can be shown as = (0.3986; 0.4311; 0.5503). To measure the length of vector of the color space, ΔE, in RGB =(0.3986; 0.4311; 0.5503) to the black color (as the basic color space) RGB= (0,0,0) we can use Eq. (3) and Eq.(4).

$$\Delta E^2 = \Delta R^2 + \Delta G^2 + \Delta B^2 \quad (3)$$

$$\Delta E = \sqrt{\Delta R^2 + \Delta G^2 + \Delta B^2} = 0.805 \quad (4)$$

Digital image results for color space can be shown in Figure 5. To find the value of the difference in the colors of the two fabrics, it can be measured the difference in the length of the two fabrics, written as in Eq. (5) and Eq. (6).

$$\Delta {E_{12}}^2 = \Delta {R_{12}}^2 + \Delta {G_{12}}^2 + \Delta {B_{12}}^2 \quad (5)$$

$$\Delta E_{12} = \sqrt{\Delta {R_{12}}^2 + \Delta {G_{12}}^2 + \Delta {B_{12}}^2} = 0.0109 \quad (6)$$

The color results show there is a difference in the value of the color space of 0.0109 with the fabric-1 space having a color space. In the study of measurement of unevenness in textile fabrics that have undergone a coloring process and have been processed through image capture using the Logitech C525 HD webcam and processed using Photoshop and MATLAB software, the results of data processing can be displayed as follows.

The formula used to find out the homogeneity of the coloring results in the test sample as in Eq. (7) and Eq. (8).

$$A = \frac{L_A}{L_P} \, x \, 100 \, \% \quad (7)$$

$$B = \frac{L_P - L_A}{L_P} \, x \, 100\% \quad (8)$$

which:

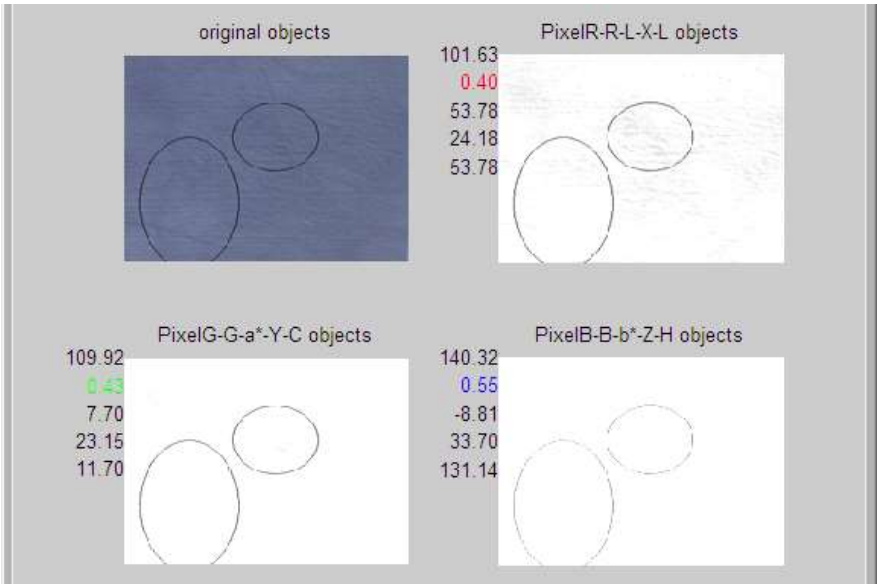

Figure 5 RGB Color space test for fabric 2

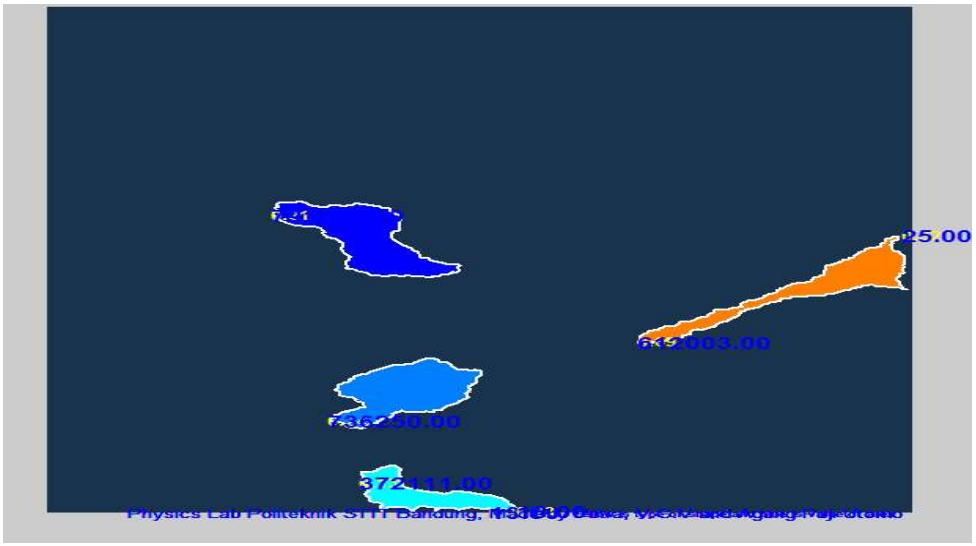

Figure 6 Results of calculations on the fabric 1 surface area (LA) with MATLAB software

A = non-homogenous area of fabric
B = the homogenous area of fabric
L_P = the total area of the fabric
L_A = the total non-homogenous of fabric

Table 2 Data from the homogeneity analysis results of the coloring process on the fabric 1

The analysis of area	Area of L_A (px²)	Area of L_P (px²)	A%	B%
Dark blue	791454			
orange	612003			
Light blue	736250			
Green	372111			
Total	2511818	54109716	4.642	95.358

Results of digital image homogeneity image analysis using MATLAB software can be shown in Figure 6. The results of the calculation of fabric 1 homogeneity analysis that has been processed for coloring can be shown in Table 2. Based on observational data and based on calculations made using Eq (7) and Eq. (8). It was found that on the fabric of the 1st test sample. The percentage of uneven surface area was 4.64%, while the percentage of uneven surface area was 95.36%. The results of digital image analysis using MATLAB software can be shown in Figure 7. The results of the calculation of fabric 2 homogeneity analysis that has been processed for coloring can be shown in Table 3.

Based on observational data and based

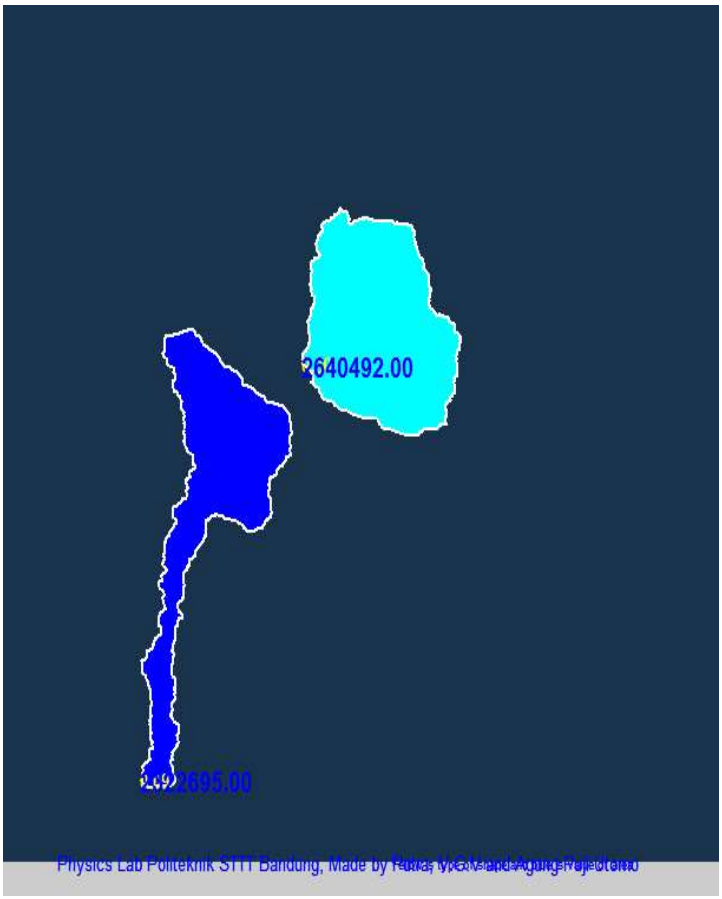

Figure 7 Results of calculations with MATLAB software on the surface area (LA) of the fabric 2

on calculations made using equations (1) and (2). It was found that on the fabric of the 2nd test sample. The percentage of uneven surface area was 5.29%, while the percentage of irregular surface area was 94.71%.

Table 3 Data from the homogeneity analysis results of the coloring process on the fabric 2

The analysis of area	Area of L_A (px²)	Area of L_F (px²)	A%	B%
Dark blue	791454			
Green	2640492			
Total	3431946	64921333	5.286	94.714

CONCLUSIONS

From the experiment to determine the width of the color homogeneity in a fabric with Image Processing using MATLAB, it can be concluded that the color homogeneity in the fabric can be determined by using Image Processing. Based on the experimental results it was found that the first fabric has a better homogeneity of 95.36% compared to the 2nd fabric which has a fabric homogeneity of 94.71%. Human visual test results show the same thing with tests using image processing. The difference in the color value of fabric-1 and fabric-2 is 0.0109.

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