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Woven Fabric Density Measurement Using Image Processing Techniques

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Abstract: A method of measuring the fabric density (weft pick per cm & warp per cm) of a woven fabric has been developed in this research. The fabric density of a woven fabric measured by capturing a digital image of the woven fabric to be examined by means of a digital microscope, converting the image into digital image information, storing the digital l image information in a digital memory and converting said information by a central processing unit into the fabric density information. The method was tested using 4 (four) woven fabric samples with different structures and densities. In order to validate the proposed method, the results were compared with the mean fabric density which was directly measured from the standard method. It has been found that the results between conventional and proposed method are not significantly different (with 0,95 significance value).

Keywords : image processing; weft pick per cm; warp per cm; woven fabric density

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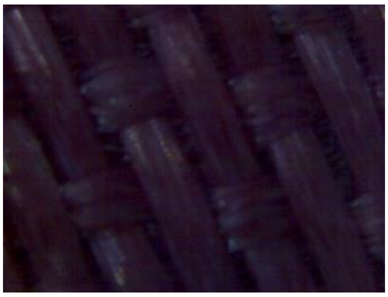
1. Introduction

There have been some conventional methods to measure fabric density. Conventional means of measurement usually require manual operations, which are time-consuming and readily make an operator's eyes really tired. Thus, it is highly desirable to develop an automatic counting system for fabric density. Image processing has been proved to be an efficient method of analyzing fabric structures [1-12]. There have been recent studies to measure the fabric density using fourier transform analysis [1,2]. The fourier transform analysis usually requires some advances in mathematical and programming. Other measuring methods uses co-occurrence matrix and gray line-profile [3,4]. In this research, the proposed image processing method to measure the fabric density is the counting pixel method. In this paper, we investigate the efficiency, accuracy and compare it with manual operation method procedure.

2. Materials and Methods

The basic weave structures (plain, twill and satin) are used in this study. Two samples of satin weaves, one sample of plain and one sample of twill weaves were collected for evaluating the performance of the proposed method. The characteristics of each fabric samples can be shown in Table 1.

Table 1. Characteristics of woven fabric samples

Sample code	Fabric Sample	Weave	Pattern	Density, yarn/inch (Warp X Weft)
S1		Satin	Solid	41 X 21
S2		Satin	Solid	37 X 28
S3		Satin	Solid	76 X 35
P1		Plain	Solid	33 X 24

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The digital images were captured by a digital microscope with 600 DPI resolutions. The resolutions used during capturing image are dependent on the fineness of the yarn in the fabric. The higher resolutions were required in the fabric of fine structure and the resolutions used for each sample are shown in Table 1. The resolutions can be formed by optimize the zoom feature on the digital microscope device.

Figure 1 shows the captured image of plain fabric (P1). As we see in Figure 1, black areas appear along the spacing between yarns. We use this property to find fabric density. These black areas are caused by the light transmitted through the fabric from the light source of the digital microscope. The boundary positions between yarns can be easily defined by measuring the yarn spacing on the digital image. The pixel counting method does not require a preprocessing or filtering technique in its measurement. The measurement of manual operation is based on SNI ISO 7211-2-2010 standard method.

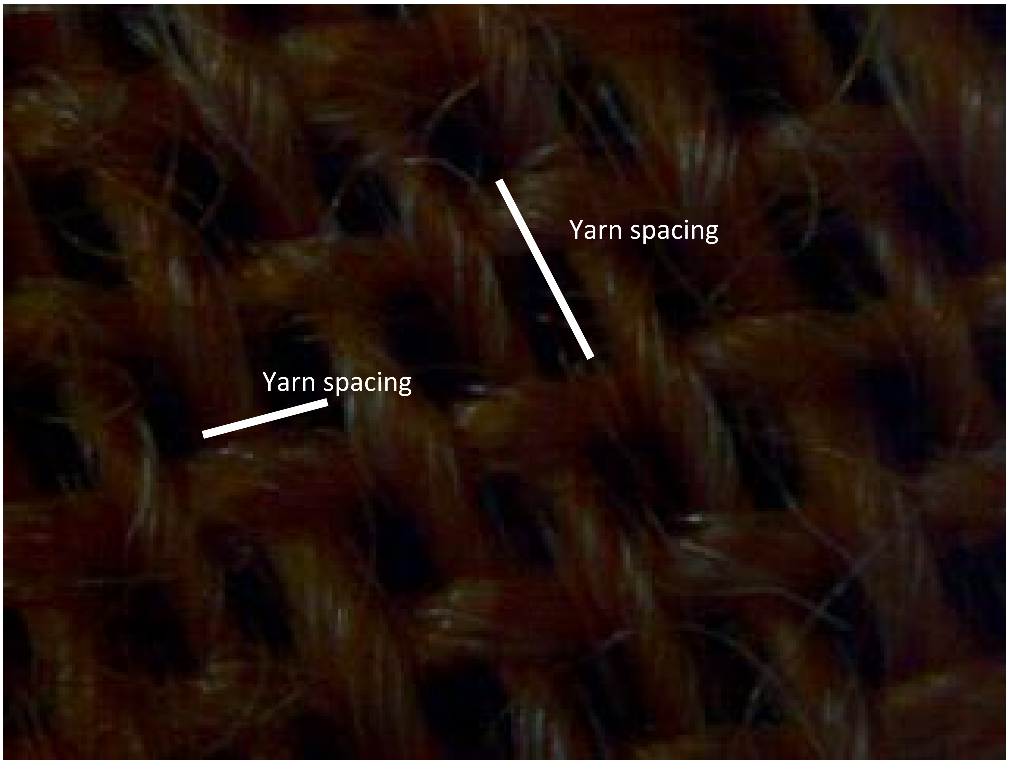

Figure 1. Captured image of plain fabric (P1) using digital microscope device

The yarn density could be measured by capturing the images of the fabric. The correlation between yarn spacing (α_{yarn}) and the yarn density (β_{yarn}) were formulated as below:

$$\beta_{yarn} = \frac{1}{\alpha_{yarn}} \quad (1)$$

Yarn spacing (α_{yarn}) were measured by counting the pixel number of the each yarn, and then converted to the unit of inch using the calibration method. The calibration shows the conversion multiplier of the image processing, in order to convert the yarn spacing (in pixel) to the yarn spacing (in inch).

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3. Results

The results of each methods (manual operation and pixel counting method) has been compared in this research. The comparison of fabric density between each method for the fabrics can be shown in Table 2.

Table 2. The result of fabric density using manual operation and image processing method

Sample code	Fabric sample	Manual Operation		Image Processing	
		Yarn/inch (Warp)	Yarn/inch (Weft)	Yarn/inch (Warp)	Yarn/inch (Weft)
S1		43	21	43.05	22.69
		42	23	42.11	22.08
		41	22	41.07	21.87
		41	22	42.43	23.19
		41	21	41.07	21.08
		$\bar{x}$ = 41.6	$\bar{x}$ = 21.8	$\bar{x}$ = 41.07	$\bar{x}$ = 21.08
		s = 0.89442	s = 0.83666	s = 0.8681	s = 0.8056
		CV% = 2.15	CV% = 3.83	CV% = 2.11	CV% = 3.82
S2		36	28	37.26	28.57
		37	28	37.81	28.89
		36	28	36.91	28.01
		37	29	37.50	28.89
		38	28	36.50	29.10
		$\bar{x}$ = 38	$\bar{x}$ = 28	$\bar{x}$ = 36.5	$\bar{x}$ = 29.1
		s = 0.83666	s = 0.44721	s = 0.5098	s = 0.4256
		CV% = 2.20	CV% = 1.59	CV% = 1.39	CV% = 1.46
S3		76	36	78.71	35.06
		76	35	77.12	35.87
		78	34	77.09	34.91
		76	35	75.14	34.55
		75	35	76.88	34.91
		$\bar{x}$ = 75	$\bar{x}$ = 35	$\bar{x}$ = 76.88	$\bar{x}$ = 34.91
		s = 1.09544	s = 0.7071	s = 1.2668	s = 0.4902
		CV% = 1.46	CV% = 2.02	CV% = 1.65	CV% = 1.40
P1		33	24	33.91	24.39
		34	23	33.13	24.11
		33	22	34.11	22.91
		34	24	33.77	23.11
		34	24	32.99	23.51
		$\bar{x}$ = 33.6	$\bar{x}$ = 23.4	$\bar{x}$ = 32.99	$\bar{x}$ = 23.51
		s = 0.54772	s = 0.89442	s = 0.494	s = 0.6341
		CV% = 1.63	CV% = 3.82	CV% = 1.50	CV% = 2.80

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In order to validate the proposed method, the results were compared with the mean fabric density directly measured from the standards methods. It has been found that the results between conventional and proposed method are not significantly different (with 0,95 significance value). The T-test results between conventional and proposed method can be shown in Table 3. The Independent sample T-test result performed by SPSS Statistics 17.0 software.

Table 3. The T-test results between conventional and proposed method

The Independent T-test result of warp density of sample (S1) from image processing and manual operation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	.006	.939	-.621	8	.552	-.34600	.55744	-1.63145	.93945
	Equal variances not assumed			-.621	7.993	.552	-.34600	.55744	-1.63165	.93965

The Independent T-test result of pick density of sample (S1) from image processing and manual operation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	.015	.906	-.735	8	.483	-.38200	.51944	-1.57982	.81582
	Equal variances not assumed			-.735	7.989	.483	-.38200	.51944	-1.58012	.81612

The Independent T-test result of warp density of sample (S2) from image processing and manual operation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	1.198	.306	-.904	8	.393	-.39600	.43816	-1.40640	.61440
	Equal variances not assumed			-.904	5.611	.398	-.39600	.43816	-1.44459	.65259

The Independent T-test result of pick density of sample (S2) from image processing and manual operation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	.000	.992	-1.782	8	.113	-.49200	.27612	-1.12874	.14474
	Equal variances not assumed			-1.782	7.981	.113	-.49200	.27612	-1.12901	.14501

The Independent T-test result of warp density of sample (S3) from image processing and manual operation

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Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	.014	.909	-1.052	8	.324	-.78800	.74900	-2.51519	.93919
	Equal variances not assumed			-1.052	7.837	.324	-.78800	.74900	-2.52147	.94547

The Independent T-test result of pick density of sample (S3) from image processing and manual operation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	.071	.797	-.156	8	.880	-.06000	.38479	-.94732	.82732
	Equal variances not assumed			-.156	7.123	.880	-.06000	.38479	-.96669	.84669

The Independent T-test result of warp density of sample (P1) from image processing and manual operation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	.511	.495	.055	8	.958	.01800	.32988	-.74272	.77872
	Equal variances not assumed			.055	7.917	.958	.01800	.32988	-.74411	.78011

The Independent T-test result of pick density of sample (P1) from image processing and manual operation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TetalPercm	Equal variances assumed	.943	.360	-.420	8	.685	-.20600	.49032	-1.33669	.92469
	Equal variances not assumed			-.420	7.210	.687	-.20600	.49032	-1.35862	.94662

4. Discussion

In this study, we have found that the pixel counting method shows the equal result with the manual operation (the value are not significantly different with 0,95 significance value). All of the T-test results for all comparisons show the Sig. value are above 0,05, which means that the fabric density results between manual and proposed method are not significantly different.

5. Conclusions

We investigated the performance of pixel counting method to find the fabric density. We have discovered that the method gives us some benefits that cannot be obtained from manual operation. The pixel counting method does not require a preprocessing or filtering technique in its measurement. Above all, the result of proposed method measurement shows the equal result with the manual

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operation measurement. It has been found that the fabric density results between manual and proposed method are not significantly different (with 0,95 significance value).

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Author Contributions: Andrian Wijayono, Taufik Munandar and Ryan Rudi designed, performed validation of experiment and wrote the paper; Valentimus Galih Vidia Putra designed the image processing methods.

Conflicts of Interest: The authors declare no conflict of interest.

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