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Knitted Fabric Density Measurement Using Image Processing Techniques

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Abstract: A method of measuring the stitch density (course per inch and wale per inch) of a knitted fabric has been developed in this research. The stitch density of a knitted fabric measured by capturing a digital image of the knitted fabric to be examined by means of a digital microscope, converting the image into digital image information, storing the digital image information in a digital memory and converting said information by a central processing unit into the stitch density information. The method was tested using 3 knitted fabric samples with different densities. In order to validate the proposed method, the results were compared with the mean stitch 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).

Keywords: image processing; course per inch; wale per inch; stitch density.

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1. Introduction

There have been some conventional methods to measure stitch density of knitted fabrics and the most traditional one is the manual operation method. However, this measurement shows some drawbacks, which are time-consuming and tiring. Therefore, it is necessary to develop an automatic counting system for stitch density. Image processing has been proved to be an efficient method of analyzing fabric structures [1-14]. There have been recent studies to measure the fabric density using fourier transform analysis [1-4] which usually requires some advances in mathematical and programming. Other measuring methods use co-occurrence matrix and gray line-profile [5,6]. In this research, the proposed image processing method to measure the stitch density is the counting pixel method. In this paper, we aim to investigate the efficiency and accuracy of the method, and compare it with manual operation method procedure.

2. Materials and Methods

Knitted fabric structures are used in this study. The samples consist of three samples of rib knit structure, which are selected for evaluating the performance of the proposed method. The characteristics of each fabric samples are shown in Table 1.

Table 1. Characteristics of knitted fabric samples

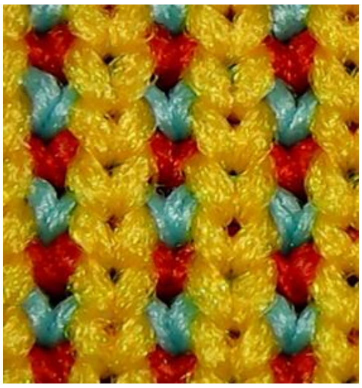
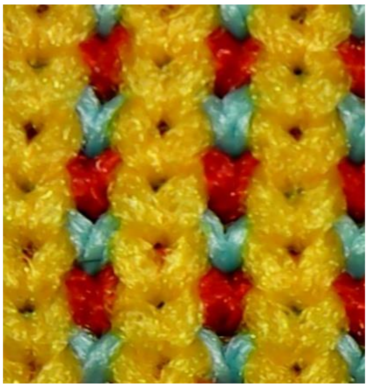
Sample code	**Fabric Sample**	**Structure**	**Pattern**	**Density, stitch/inch (Wale X Course)**
S1		Rib	Solid	28 X 12
S2		Rib	Solid	32 X 15
S3		Rib	Solid	26 X 14

Figure 1 shows the captured image of sample fabric (S1). As we see in Figure 1, black area appears along the spacing between yarns. We use this property to find stitch density. These black area 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 wale spacing and course spacing on the digital image. The pixel counting method does not require a preprocessing or filtering technique in the measurement. The measurement of manual operation is based on "SNI 0458:2013 Tekstil - Kain rajut pakan - Cara uji konstruksi" standards method.

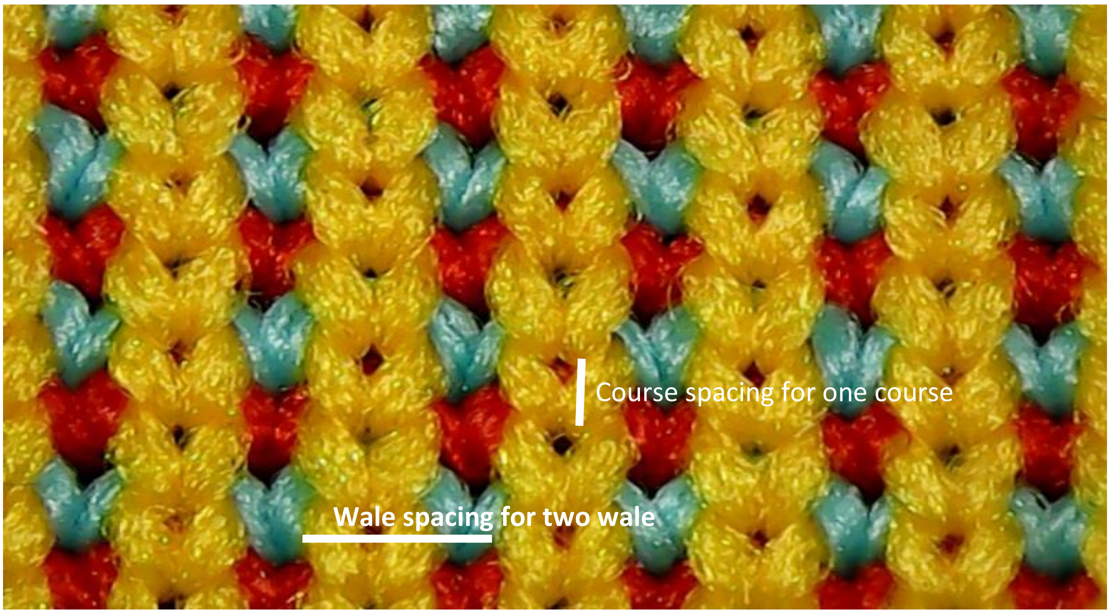


Figure 1. Captured image of knitted fabric (S2) using digital microscope device

3. Results

The results of each methods are compared (manual operation and pixel counting method) in this research. The comparison of stitch density between both methods for the fabrics are shown in Table 2.

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

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

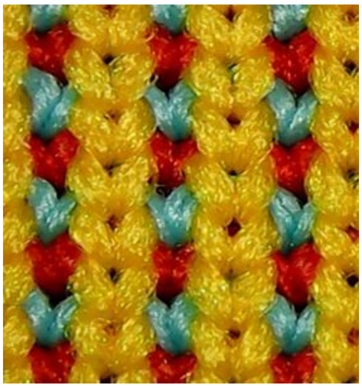
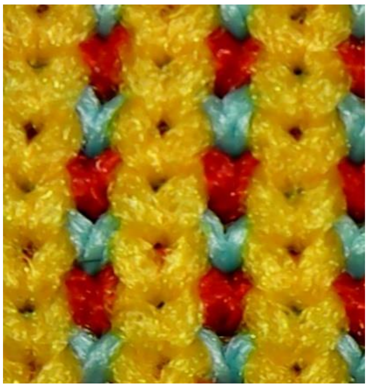
Sample code	Fabric sample	Manual Operation		Image Processing	
		Wale/inch	Course/inch	Wale/inch	Course/inch
S1		$\bar{x}$ = 28.6 s = 0.89442 CV% = 3.127	$\bar{x}$ = 12.8 s = 0.83666 CV% = 6.53	$\bar{x}$ = 28.07 s = 0.8681 CV% = 3.09	$\bar{x}$ = 12.08 s = 0.8056 CV% = 6.67
S2		$\bar{x}$ = 32 s = 0.83666 CV% = 2.61	$\bar{x}$ = 15 s = 0.44721 CV% = 2.98	$\bar{x}$ = 32.5 s = 0.5098 CV% = 1.57	$\bar{x}$ = 15.1 s = 0.4256 CV% = 2.82
S3		$\bar{x}$ = 26 s = 1.09544 CV% = 4.21	$\bar{x}$ = 14 s = 0.7071 CV% = 5.05	$\bar{x}$ = 26.88 s = 1.2668 CV% = 4.71	$\bar{x}$ = 14.91 s = 0.4902 CV% = 3.29

Table 3. The T-test results of knitted fabric stitch density between conventional and proposed method

The Independent T-test result of wale 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 course 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 wale 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	6.611	.398	-.39600	.43816	-1.44459	.65259

The Independent T-test result of course 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 wale 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	.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 course 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

4. Discussion

The result of this study shows that the pixel counting method yields equal result with the manual operation (the values are not significantly different with 0,95 significance value). All of the T-test result for all comparison shows the Sig. value are above 0,05, which means that the stitch density results between manual and proposed method are not significantly different.

5. Conclusions

We investigated the performance of pixel counting method to find the stitch density. We have discovered that the method gives us some benefits that cannot be obtained by 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 equal result with the manual operation measurement. It has been found that the fabric density measurement results between manual and proposed method are not significantly different (with 0,95 significance value). Thus, the proposed method, which is not time-consuming nor tiring, can be an alternative in measuring the stitch density of knitted fabrics.

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

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