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Evaluation of print mottle in textile printing: Impact of printing methods on macro non-uniformities

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Introduction

Color plays a crucial role in creating a strong visual impression, influencing decisions in nearly every aspect of life. For textile products, color is often the initial factor that captures the consumer's attention and significantly impacts their purchasing decision (JiHyun, 2007).

Textile printing is both an art and a science, involving the decoration of fabric with vibrant patterns or designs.

While screen printing is the most common method used for textile materials, other techniques such as digital printing and thermal transfer are also employed.

According to Lindberg (Lindberg, 2004), while using all quality attributes is ideal for assessing print quality, a selection of specific attributes is often more practical in industrial settings. Lindberg found that print mottle and color gamut significantly influence image quality perception.

Petterson also emphasized the significance of print mottle in print quality, alongside color gamut, color shift, and sharpness (Petterson, 2005).

Print mottle, defined as the visual irregularities in print density affecting overall print quality, is considered one of the major issues in printing (Fahlcrantz, 2005; Kawasaki & Ishisaki, 2009).

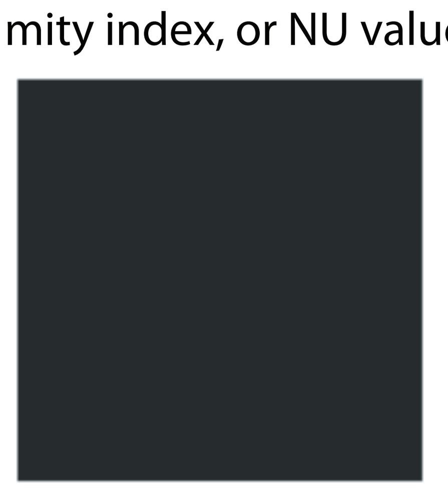
Print quality in any printing process depends on the process, ink, and substrate. Imperfect interactions among these factors can lead to unwanted effects like print mottle.

Problem Description

This research concentrates on examining print mottle. The key print mottle parameters under investigation include contrast, correlation, entropy, energy, and homogeneity. The findings indicate that a uniform grey level distribution, which corresponds to low print mottle, is characterized by low contrast, low correlation, low entropy, high energy, and high homogeneity (Chen, 1998; Hladnik & Lazar, 2011; Ružičić, et al., 2014).

Methods

This study involves four different textile printing techniques. The printing methods include DTF, DTG, screen printing, and screen transfer printing. The print mottle parameters under investigation are conducted by GLCM image processing. The GLCM image processing technique was utilized on the scanned printed samples using MATLAB software and a plugin developed by Uppuluri (Uppuluri, 2008). The macro non-uniformity of the surface is quantified also by the macro non-uniformity index, or NU value conducted by ImageJ software.



To obtain results, the study utilized solid tone patches of 16 x 16 cm (refer to Figure 1). This research opted for the 16 x 16 cm patches, as suggested by Jurič (Jurič, 2018).

Figure 1

Solid patch 16 x 16 cm

Results

The results from GLCM image processing are obtained in charts in Figure 2.

Figure 2

Macro non-uniformity parameters

The macro non-uniformity of the surface is quantified by the macro non-uniformity index, or NU value. Table 3 shows the macro non-uniformity results for the samples, as determined through image analysis with ImageJ software. The optimal macro non-uniformity value is zero; thus, results nearer to zero indicate less macro non-uniformity.

Table 1. Macro non-uniformity results conducted with ImageJ software.

Sample number	Sample label	NU mottle
1	SD-WB	15,6446
2	SD-B	8,5041
3	DTF-WB	1,8236
4	DTF-B	1,8941
5	ST-WB	1,2544
6	ST-B	1,3524
7	DTG-B	16,4383

Table 2: Sample overview

Sample number	Sample label	Printing techniques
1	SD-WB	Direct screen printing. Black over White. Curing with hot air.
2	SD-B	Direct screen printing. Black only. Curing with hot air.
3	DTF-WB	Digital inkjet printing on film. Black over White. Transfer and drying with a heated press.
4	DTF-B	Digital inkjet printing on film. Black only. Transfer and drying with a heated press.
5	ST-WB	Screen printing on film. Black over white. Transfer and drying with a heated press.
6	ST-B	Screen printing on film. Black only. Transfer and drying with a heated press.
7	DTG-B	Direct digital inkjet printing. Black only. Drying with a heated press.

Figure 3 shows scanned samples prepared for GLCM analysis using MATLAB and ImageJ software

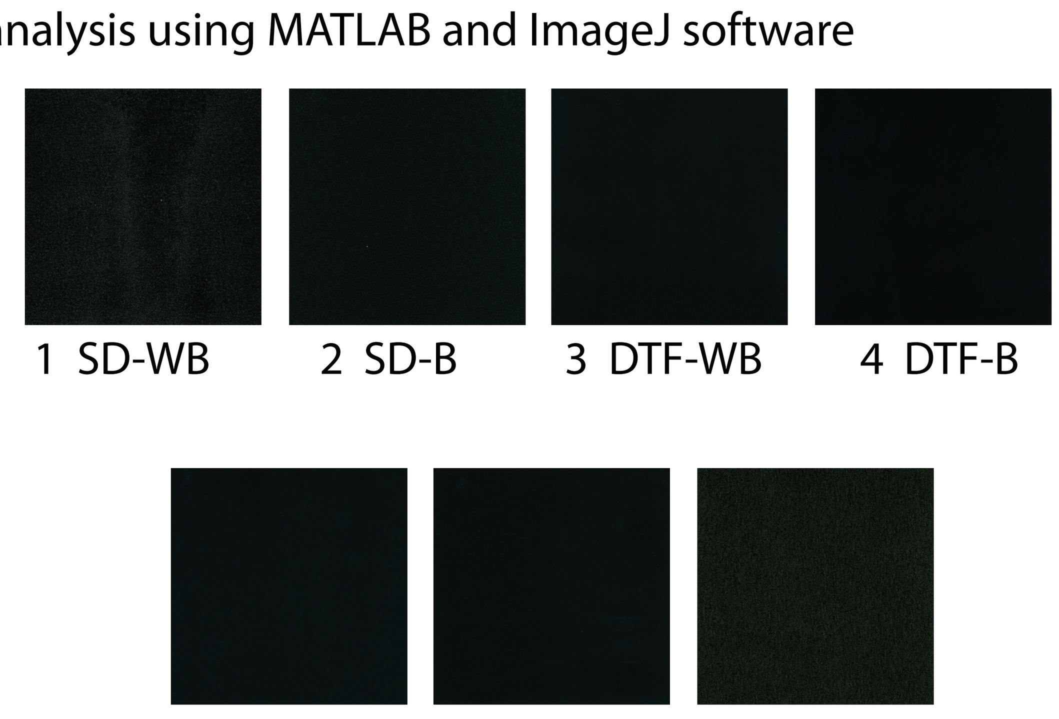


Figure 3

Scaned samples 500 x 500 px

Discussion / Conclusion

Samples 1 SD-WB and 7 DTG-B show high values for both contrast and entropy, indicating unevenness and macro-non-uniformity. Samples 3-6 are very uniform, with low contrast, high energy, and low entropy, suggesting that their surfaces are quite consistent. Samples 3-6 have very low values for contrast and entropy, along with high values for energy and homogeneity, which indicates high macro-uniformity and simple textures. Sample 7 DTG-B has the highest entropy, the lowest homogeneity, and the highest contrast, indicating the greatest surface unevenness and texture complexity.

Considering the NU values from Table 1, it is evident that Samples 1 SD-WB, 2 SD-B, and 7 DTG-B have very high surface non-uniformity values, which characterise them as having significant surface unevenness and texture complexity. In contrast, Samples 3 DTF-WB, 4 DTF-B, 5 ST-WB, and 6 ST-B have relatively low and uniform values, indicating that they are quite consistent and even.

Summarising all of the above, the following conclusion can be drawn: Printing techniques that use transfer foil (such as screen transfer and DTF) in samples 3-6 yield consistent results in terms of macro non-uniformity parameters. It can be concluded that the method of transferring images and fixing the ink through temperature and pressure, which is common to both screen transfer and DTF techniques, plays a significant role in achieving favourable results regarding macro non-uniformity. In contrast, direct printing techniques that use hot air drying or fix the ink through temperature and pressure tend to leave surface irregularities caused by the weaving of the cotton fabric. Consequently, the direct printing method exhibits poor macro non-uniformity results and leads to a pronounced print mottle effect, which can negatively impact colour reproduction quality.

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