Introducing a new method for generating test targets to evaluate printing mottle

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Abstract

Printing mottle is one of the most important print quality factors. It is defined as measure of the appearance of unintended, periodic macroscopic fluctuations of lightness (macroscopic means: between 'spots' at distances > 1 mm). Mottle is caused by several phenomena. The non-uniformity absorption of ink, which may be because of the paper roughness or ink quality, may cause various degree of printing mottle. Print quality assessments are usually based on comparing test samples and references as a ruler of different quality samples. Therefore, it is important to prepare appropriate rulers for different quality metrics. There are methods like adding moisture to paper before printing to simulate printing mottle.

The present study introduces a new method for generating test targets to evaluate printing mottle. In this method, a set of noise patterns like Hermit and Value noises were used. By changing parameters like frequency and amplitude, we achieved different levels of printing mottle.

The experimental results show that with the proposed method, it is possible to generate different levels of mottle, which can be used to generate test targets and mottle rulers.

Introduction

The digital printing industry continues to grow, and a lot of effort is put into the development of new and improved technologies and products. With this increased growth the need for quality assessment also increases, for example to evaluate if new technologies outperform existing technologies, or to compare different products in order to find the best one.

Printing mottle is one of the most important print quality factors. It is defined as measure of the appearance of unintended, periodic macroscopic fluctuations of lightness (macroscopic means: between 'spots' at distances > 1 mm) [1]. Mottle is caused by several phenomena. The non-uniformity absorption of ink, which may be because of the paper roughness or ink quality, may cause various degree of printing mottle [2]. Print quality assessments are usually based on comparing test samples and references as a ruler of different quality samples.

The present study introduces a new method for generating test targets to evaluate printing mottle. In this method, a set of noise patterns like Hermit and Value noises were used.

Method

To achieve mottle noise pattern, different noises like Perlin noise, Hermite noise, value noise and their derivatives were studied. By changing parameters like frequency and amplitude, it was tried to reach different levels of printing mottle.

The comparison between real mottle pattern (sample showed in Figure 1) and noise imaged was done to confirm that the two types of standard Hermit and value noises can be used for simulating mottling effect.

To be more familiar with the proposed method a brief description of mathematics of Hermit polynomials and Value noise are given bellow.

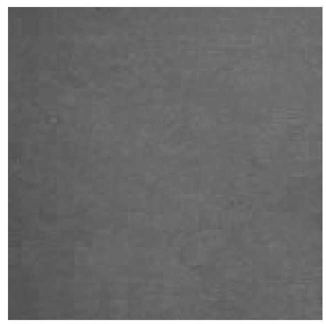

Figure 1. Sample of real print mottle pattern

Hermite polynomials

In mathematics, the Hermite polynomials are a classical orthogonal polynomial sequence that arises in probability [3]. There are two different ways of standardizing the Hermite polynomials: The "probabilists' Hermite polynomials" (1) and the "physicists' Hermite polynomials" (2).

$$He_n(x) = (-1)^n e^{x^2/2} \frac{d^n}{dx^n} e^{-x^2/2} \tag{1}$$

$$H_n(x) = (-1)^n e^{x^2} \frac{d^n}{dx^n} e^{-x^2} = e^{x^2/2} \left(x - \frac{d}{dx}\right)^n e^{-x^2/2} \tag{2}$$

These two definitions are not exactly equivalent; either is a rescaling of the other,

$$H_n(x) = 2^{n/2}\, He_n(\sqrt{2}x) \tag{3}$$

$$He_n(x) = 2^{-n/2}\, H_n\left(\frac{x}{\sqrt{2}}\right) \tag{4}$$

These are Hermite polynomial sequences of different variances. The notation He and H is that used in the standard references Tom H. Koornwinder, Roderick S. C. Wong, and Roelof Koekoek et al. (2010) [4] and Abramowitz & Stegun [1]. The polynomials Hen are sometimes denoted by H_n, especially in probability theory. As an example, the eleventh probabilists' Hermite polynomial (5) and the first six (probabilists') Hermite polynomials (Figure 2) are showed below.

$$He_{10}(x) = x^{10} - 45x^8 + 630x^6 - 3150x^4 + 4725x^2 - 945 \qquad (5)$$

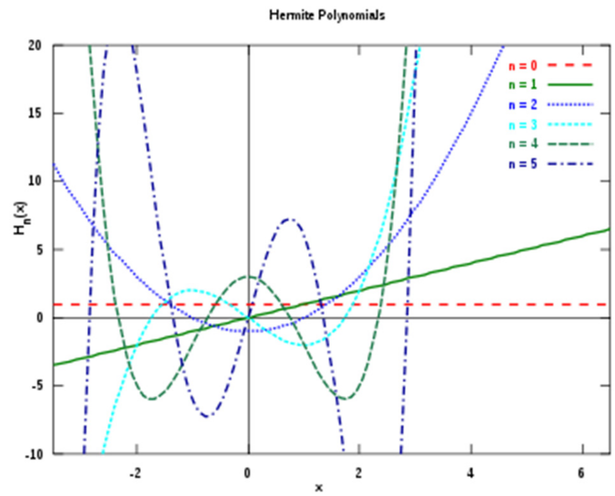

Figure 2. The first six (probabilists') Hermite polynomials

Value Noise

Value noise is a type of noise commonly used as a procedural texture primitive in computer graphics. It is conceptually different, and often confused with gradient noise examples of which are the Perlin noise and Simplex noise. This method consists of a creation of a lattice of points which are assigned random values. The noise function then returns the interpolated number based on the value of the neighboring lattice points.

To improve the quality of the generated noise, multiple octaves of this noise can be generated and then summed together. This technique produces results very similar to Perlin noise at the cost of lower quality while having a simpler algorithm. [5]

Results & Discussion

A computer application was developed to generate different kind of noises like hermit and value. For the best result, multiple octaves of each noise added together. A set of parameters like frequency, octaves and amplitude was exposed to allow better modification to generate different types of mottle.

The change of parameters like “noise Octaves”, “Amplitude”, “Frequency” and “Lacunarity” were studied to determine their influence in mottling effect. Some samples of different noise images with varying parameters showed in Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7.

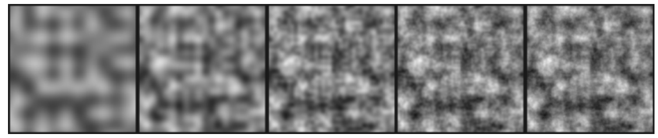

Figure 3.Sample of Hermite noise images with changing parameter of “noise Octave” from 1 (left image) to 5 (right images)

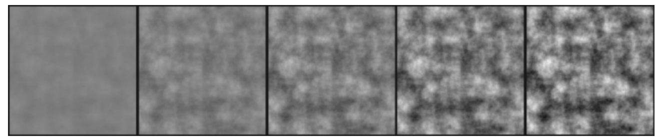

Figure 4.. Sample of Hermite noise images with changing parameter of “Amplitude” from 0.1(left image) to 1(right images)

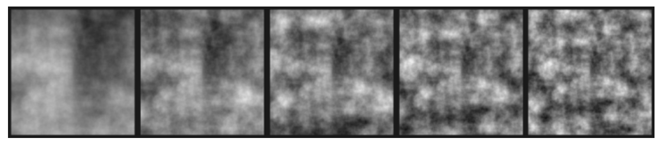

Figure 5. Sample of Hermite noise images with parameter “octave” of 7. Frequency increasing from left to right

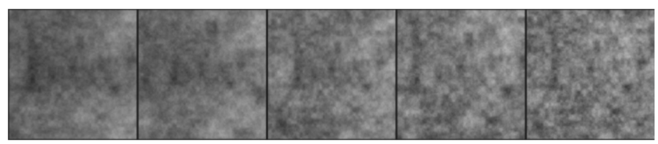

Figure 6. Sample of value noise images with changing parameter of “Frequency” from 0.2(left image) to 1 (right image)

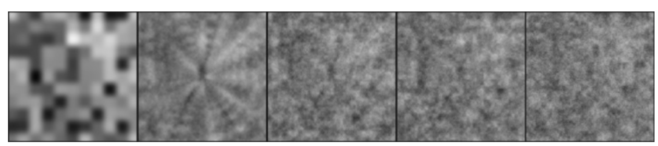

Figure 7. Sample of value noise images with changing parameter of “Lacunarity” from 1(left image) to 2.2 (right image)

Generated images also blended together using “Overlay” blending mode (6) to achieve more mottling effect patterns. Figure 8 shows an example of overlay blending mode.

$$f(x,y) = \begin{cases} 2ab, & if\ a < 0.5 \\ 1 - 2(1-a)(1-b), & otherwise \end{cases} \qquad (6)$$

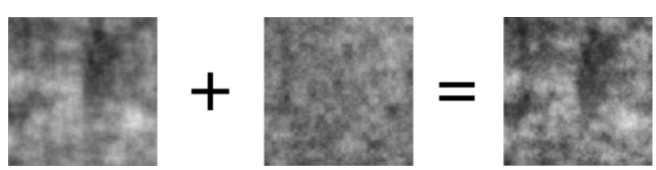

Figure 8. Sample of overlay blended image

In this way, the Mottle metrics can be obtained from the resulted images. Generated images were also studied with ISO/IEC DTS 24790 Mottle measurement method, and also visual comparison to ensure the generated texture matches the mottle effect. The ISO/IEC DTS 24790 takes a scanned image, perform a wavelet preprocess to remove background and other types of unwanted noises except mottle.

As an example, Figure 9 and 10 show 4 mottle samples generated with the proposed method together with the corresponding mottling degrees computed by ISO/IEC DTS 24790. As indicated, the obtained images are also good simulations of real mottles based on visual assessment.

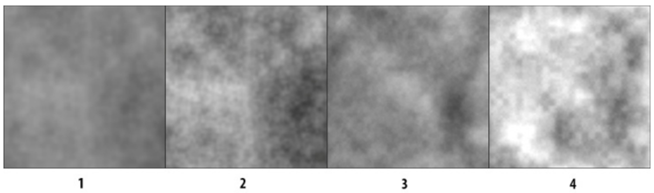

Figure 9. Different levels of mottle generated with this method.
(1) Octaves = 5, Frequency = 0.1, Amplitude = 0.32, Lacunarity = 2.2,
(2) Octaves = 6, Frequency = 0.15, Amplitude = 0.72, Lacunarity = 2,
(3) Frequency = 0.3, Amplitude = 0.3, Lacunarity = 1.5,
(4) Frequency = 0.3, Amplitude = 1, Lacunarity = 2.8,

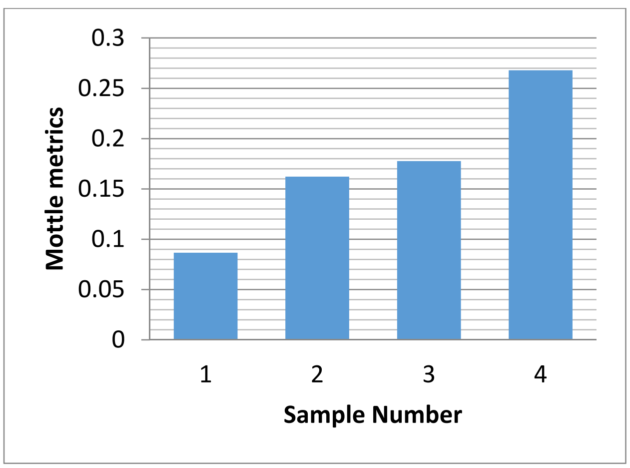

Figure 10. ISO/IEC DTS 24790 mottle metrics of Sample images in Fig. 9

Conclusion

This paper presents a new method for generating different degrees of Mottle. The developed software uses different noise algorithms like Hermite and Value noise to simulate mottling effect. In this method, changing the parameters like frequency, amplitude, noise octave and lacunarity can help to achieve different mottling effects.

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Author Biography

Ali Azin is currently studying his MSc in Printing Science and Technology at Institute for Color Science and Technology with the Center for Image Processing in Printing technology. In BSc he worked on detecting painting defects using image processing. In particular he is interested in Color science, Painting and Printing inspections, Image Processing and Programming. Ali has an undergraduate degree in Color Science and Technology at AmirKabir University of Technology.

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