Improvement of Digital Color Print in Preference by Adding 1/f$^{\alpha}$ Noise

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Introduction

Combination of high-resolution digital camera with high performance ink-jet printer results in noiseless prints. On the other hand, with disappearance of noise, we lost impression of space and texture which we get from complicated 3D structure of silver grains or dye clouds. In the preceding paper, we showed that addition of noise resulted in increase of score of preference under some conditions. We tested two noise application methods were tested: 1) A certain level of noise was added on a certain object by masking out of the other parts; 2) noise level was changed with image density. Noise was put showing a plateau of its level in the middle densities [1].

1/f noise was generally higher score than other types of noise. High-frequency (HF) noise brought about moire-like pattern, and HF noise samples were almost always worst. The samples obtaining especially high score were pictures of leaf, cloud, and wood, on which 1/f noise was applied. In the case of portrait, low level 1/f obtained high score. But the number of the person who does not accept texture of skin is not small. With samples of glossy objects like metal, application of every noise results in lowering of score. Noise application method 2) resulted in higher or same level of score as method 1). With method 2) realization of an automatic selection of the area, where noise will be applied, would be easier [2].

In the present paper, first we learned noise of silver halides photography by observing the image structures of silver image of black and white films and dye image of color films through a microscope, and by analyzing their type of noise. Silver image was close to white noise, while dye image to 1/f noise. Addition of 1/f noise of an appropriate α to some type of color print resulted in improvement of impression of space and texture.

Noise analysis of silver halide photography

1) Taking photographs of gray patches using FUJICHROME PROVIA 400F and FUJIFILM NEOPAN400 PRESTO;
2) Obtaining microscope photographs of the developed images at 400×;
3) Separating color image to c, m, and y image;
4) Obtaining power spectrum of silver particles and c, m, and y dye clouds.

In Fig.1 power spectra of c, m, and y image of a color reversal film are shown with that of a black and white film for comparison. Power spectrum of the black and white film was very close to that of white noise including wide range

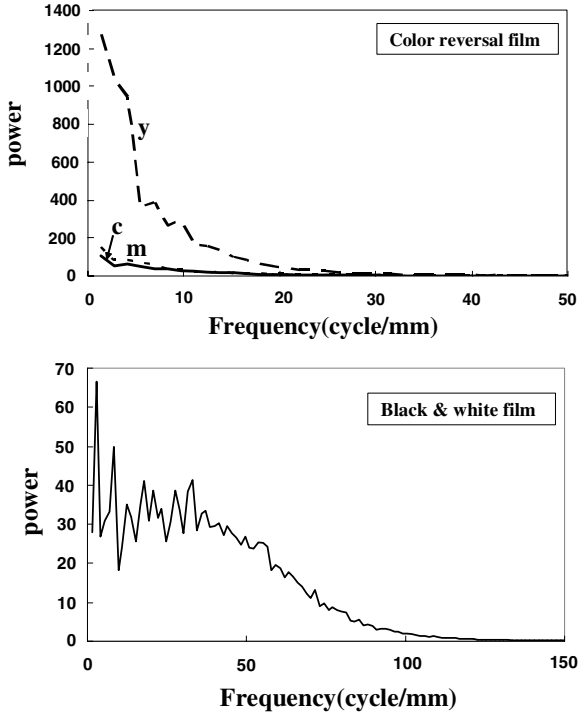


Fig.1 Power spectrum of silver halide photography

of frequency. On the other hand, power of color reversal film for all three colors was large and decreased exponentially with frequency. By plotting logarithm of power against logarithm of frequency we obtained straight lines. The slopes were -0.63, -0.88, and -0.99 for c, m, and y image, respectively.

Application of noise

We applied 1/f$^{\alpha}$ to lightness (gray noise) and to R, G, and B component (color noise) with a same α value.

Generation of 1/f noise

After the addition of white noise, brightness and R, G, and B components of a gray patch (digital value=128) were Fourier-transformed to obtain their power spectrum. It was

multiplied by $1/f^{\alpha}$, where f is frequency. The inverse Fourier transformed image was printed by an ink-jet printer. The α values of the printed images were checked by measuring the slope of curves showing logarithm of power plotted against logarithm of frequency. Figure 2 shows $1/f^{\alpha}$, α was changed between 0 and 2. With α=0 it is the same with white noise, and with increasing α island shape becomes more remarkable.

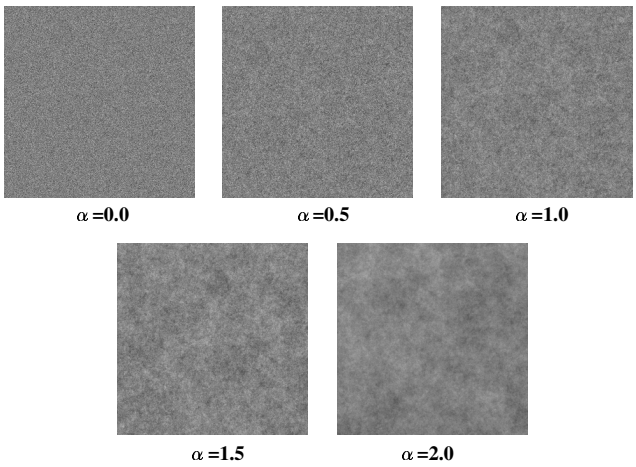


Fig.2 $1/f^{\alpha}$ noise

Substantial evaluation of noise added image

Output condition:

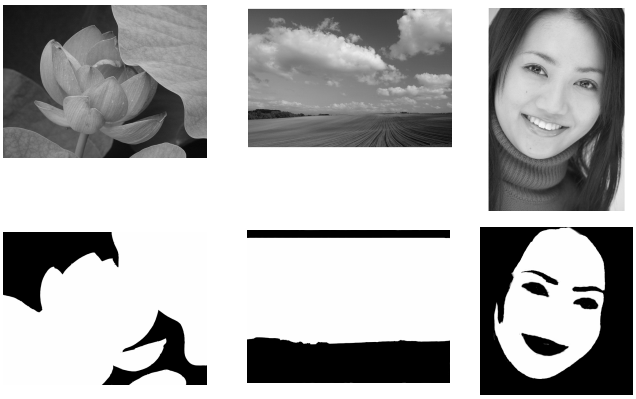
Printer: EPSON PX5500
Paper: Konica Minolta PhotolikeQP
Output RP: 200dpi

Subjective evaluation condition:

Panel: 14 students who are studying image technology.
Lighting: D50 luminance:700 lx
Observation distance: 30cm
Sample size: A4

Sample pictures:

The sample pictures for subjective evaluation are shown in Fig.3. $1/f^{\alpha}$ noise was added changing α and noise level.



Plant Sky Portrait

Fig.3 Top:Sample pictures for subjective evaluation
Above: Noise screening mask (shown in black)

Evaluation items:

"Select the best picture for expression of texture feeling"
"Select the most preferred picture"

Results and Discussion

Plant

In the case of gray noise, texture feeling increased with small α and low level, and large α and high level. We take different attitude to the noise effect. The former condition produces fine graininess and results in textural surface, on the other hand, the latter produces coarse graininess and gives 3D appearance. In preference, higher scores were obtained with higher α. It seems improvement of 3D appearance resulted in a king of preference. In the case of color noise, addition of low-level noise, especially with small α, resulted in improvement in texture feeling and preference. In the case of bright picture in color, color noise is not remarkable and results in increase in brightness.

Sky

Gray noise resulted in improvement in texture feeling and preference with lower noise level especially with larger α. Coarse graininess increases 3D appearance of cloud.
Addition of color noise to neutral color region like cloud does not result in any improvement, because color noise is very remarkable.

Portrait

Both of gray and color noise did not bring any improvement. Texture feeling and color noise on face skin seems to be not acceptable even with lower noise level.

Conclusion

・Addition of $1/f^{\alpha}$ noise improved subjective evaluation score of some pictures by selecting α and noise level.
・Color noise, which is generally not acceptable, was acceptable in the case of its low level addition to bright picture in color.
・Further investigation in which different α values for the R, G, and B components are used, is required.

References

[1]Y.Kashibuchi, N.Aoki, M.Inui, H.Kobayashi, "Improvement of Description in Digital Print by Adding Noise", J.Soc.Photogr.Sci. Tech.Japan, 66(5),471-480(2003).
[2] T.Sato, N.Aoki, M.Inui, H.Kobayashi: "Improvement of Digital Print in Preference by Adding Noise", NIP21, p.122, Baltimore (2005)