38.3: Hybrid Halftoning for Color Moire Reduction

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Abstract

A hybrid approach for the reduction of color moiré in four color printing is described. In this hybrid approach, periodic and non-periodic halftoning techniques are combined in order to reduce the intermodulation frequencies between the different color separations.

Introduction

One of the major problems in color printing is the occurrence of a distracting moiré between the different color separations. This moiré is not caused by image detail and can be observed in smooth regions of an image as well as in detail regions. The fundamental reason for this moiré lies in the "non-ideal" nature of "printing inks," be they offset inks, xerographic dry powder toner or ink jet inks. This non-ideal nature is connected to the overlap in the absorption spectra of the inks of the different color separations. Figure 1 gives a simplified portrayal of the situation; Figure la shows "non-ideal" overlapping of the absorption spectra of the cyan, magenta, and yellow ink, and Figure lb shows an "idealized" case with no spectral overlap.

In this idealized case, no interaction between the cyan, magenta, and yellow ink occurs and the problem of color moiré is eliminated. It should be noted, however, that such an "ideal" ink system

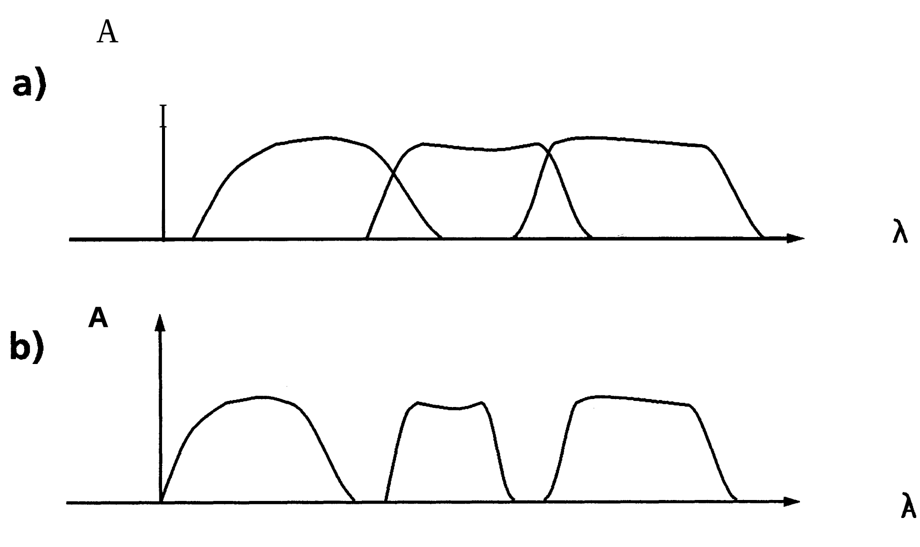

Figure 1. Moiré patterns in color prints result from inks with overlapping spectra, as shown in a). Ideal inks, b), with non-overlapping spectra, would not produce moirés.

is only ideal in terms of inter-separation moiré and it might be highly undesirable in terms of color reproduction and color gamut. Additionally, the black separation (commonly referred to as K for key) will always interact with all other separations, since its absorption spectrum, by definition, overlaps all the other spectra.

The inter-separation moiré problem being addressed here is different from the standard rosette patterns that are visible in conventional rotated screen printing. Our concern is with a much lower spatial frequency pattern that appears at 45° and is the result of an interference of the cyan, magenta, and black separations. The cyan and magenta screens produce a moiré pattern that beats with the screen used in the black separation. In conventional printing, this three-color interference is eliminated by using rotated screens at carefully chosen angles for each of the four separations. This arrangement still produces the individual components of the inter-separation moiré, but they all occur at the same frequency and angles, producing a zero-frequency "moiré" which is not visible to the eye.

In digital halftoning systems, as for example in digital xerographic printers, we are faced with the problem that arbitrary angle/frequency screens can not easily be produced on the discrete sampling raster. This very often leads to a slight misalignment between the cyan-magenta moiré and the black screen, resulting in a distracting interaction of the black screen with the cyan-magenta moiré.

Hybrid Halftoning for Moiré Reduction

As described in the previous paragraphs, the main cause for the distracting moiré in digital printers is the misalignment between the color separations caused by the finite resolution of the underlying discrete sampling raster. The misalignment that causes the main in-

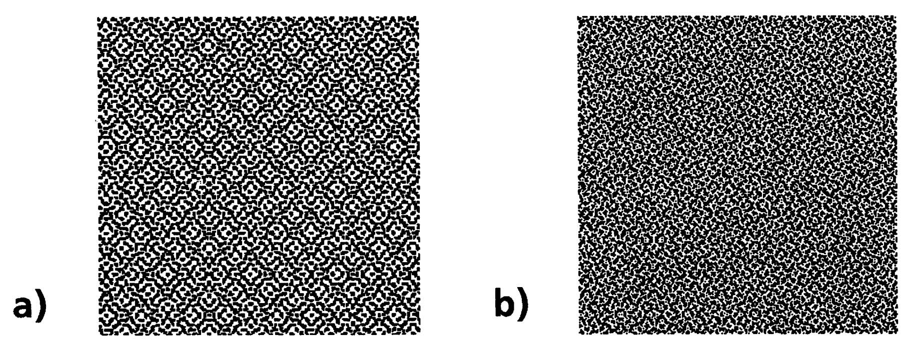

Figure 2. The pattern in a) simulates a moiré pattern between the cyan, magenta and black separations. The moiré pattern is best seen when the page is held at arm's length. In b), a stochastic screen has been substituted for the black separation.

teraction is the misalignment of the black separation in respect to the cyan-magenta moiré. One way to reduce this alignment problem is to incorporate a non-periodic halftoning scheme in the black component. The cyan, magenta and yellow separations of the print will still be produced with a conventional halftoning screen, maintaining the advantages of conventional screening from print stability to customer familiarity. The black separation, however, will use a scheme that does not produce a moiré with the already determined cyan, magenta and yellow screens.

Figure 2 shows an example of the suggested method. In Figure 2a, three standard halftoning screens were superimposed, simulating the cyan, magenta and black screen. For simplicity, all three separations were printed in black. The moiré between the components is visible, especially when the patch is viewed at a distance slightly larger than normal viewing distance. There are approximately four cycles across the image in the moiré pattern. Figure 2b shows the same patch, this time using a non-periodic halftoning scheme for the black separation. The moiré is strongly reduced, if not eliminated, in comparison to Figure 2a. (The printing process used to reproduce this paper has not been calibrated to guarantee equal reflectance for the two patches.)

Summary

Hybrid halftoning schemes offer a good compromise between conventional and stochastic halftoning. By incorporating conventional screens in the cyan, magenta and yellow separation and a stochastic screen in the black separation, it is possible to reduce the moiré, compared to conventional digital screening, while maintaining several of the stability aspects of conventional screens. Most of the print-structures are clearly above the resolution limits of the output device, aiding in the page-to-page stability of the colors. Lateral shifts of the individual separations do not cause severe color changes, since the individual separations exhibit the pseudo-random overlap, common in rotated screen printing.